Montana State University

11th Annual

Earth Sciences Colloquium

April 21, 2016
Schedule of Events

9:00 am – 12:00 pm  Student Oral Presentations  
SUB Ballroom B  

1:00 pm – 2:30 pm  Professional GIS Panel  
SUB Room 233  

2:30 pm – 4:30 pm  Student Poster Session  
SUB Ballrooms B, C, D  

4:30 pm – 5:30 pm  Distinguished Guest Lecture by Dr. Stern  
SUB Room 233  

5:30 pm – 6:00 pm  Social Hour  
SUB Ballrooms B, C, D  

6:00 pm – 7:00 pm  Dinner and Earth Sciences Departmental Awards  
SUB Ballrooms B, C, D  

7:00 pm – 8:00 pm  Keynote address, Dr. Greg Stock  
SUB Ballrooms B, C, D
Welcome to the 11th annual Earth Sciences Colloquium! Our students work hard all year on research activities in the broad array of disciplines we offer in Earth Sciences. We have had students making time lapse videos of avalanches, conducting environmental work among Native American communities, mapping geological structures in the Rockies, investigating dinosaur reproduction, documenting structural features on Mars, and many other activities. These students range from freshman to 4th year PhD students. The Colloquium provides a venue through which these students can share their research, gain experience in the communication of scholarship, and learn what their peers have been doing! Please enjoy the slate of presentations and posters!

The department would like to thank the corporate sponsors and alumni who have funded student projects, awards, and the colloquium dinner. We further appreciate the support from this group by providing internships and employment to our students. We also thank the department’s newly formed/reformed Advisory Board for taking time to come spend two days learning about our student activities and the departments vision for the future. We look forward to their input on directions or pathways to achieve this vision. This Colloquium is completely organized by students so we owe huge thanks to the organizing committee and all student participants. There is great reward in winding down our academic year by celebrating the successes of our students. I, personally, thank all of you for making my first year at MSU so enjoyable.

All the best,

Mary S Hubbard
Department Head and Professor, Earth Sciences
Welcome from the Earth Sciences Colloquium Chair

Hello, and thank you for attending the 2015 Earth Sciences Colloquium! I would like to extend my greatest thanks on behalf of this year’s planning committee for your participation and support. This event is an opportunity for interdisciplinary collaboration across our university with a primary intent to showcase student research. I am happy to announce that students from Land Resources & Environmental Science, History, and Ecology will be joining those from Earth Science in presenting their research this year.

We would like to thank our sponsors for their financial support, as well as our Keynote Speaker, Dr. Greg Stock, for taking his valuable time away from his beautiful home in Yosemite National Park to participate in our event. Special thanks also to Ms. Melody Bechberger, an MSU Earth Sciences Alumn, for continuing her role in our annual event; your workshops have been an invaluable addition to the Colloquium.

Most importantly, I’d like to offer my deepest gratitude to the other graduate students comprising this year’s Colloquium Planning Committee for your imagination, enthusiasm, and friendship. Even with a full schedule comprised of teaching, research, thesis/dissertation writing, and coursework, you continued to show up with smiles on your faces and gold-star attitudes. I am honored to have had the opportunity to work with you all. It is an understatement to say you all made my job easy, and that without each of you, this event would not have been possible. Thanks for a great year.

With warm regards,

[Signature]

Danika Holmes
2016 MSU Earth Sciences Colloquium Chair
Colloquium Committee

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Sarah Nottingham -- Lahar hazards in Washington State
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Thomas Pausch -- A Geospatial Analysis of Sedimentary Provenance of the Lower Belt Group within Southwest Montana
Nicholas Rolstad -- Sediment-Hosted Copper Deposit Potential of East-central Idaho
Zach Scheunemann -- Yellowstone National Park Wildlife Probability Map
Margaret Sizemore -- Morphometric Analysis of Extensional Faulting in the High Peruvian Andes Using a Geographic Information Systems Approach
Bailey Scott -- Using GIS to determine landslide susceptibility of the Madison Range in Southwestern Montana
Valerie Sigler -- Assessing the impacts of traffic to Oaks Disposal Services in Lindsay, Montana
Mikayla Struble -- Convergent Evolution and Functional Morphology of the Raptorial Foot: Behavioral Implications for Dinosauria, Oviraptorisauria
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New tools for understanding and mitigating rockfalls in Yosemite National Park

The soaring cliffs of Yosemite National Park draw more than four million visitors each year, but rockfalls from these cliffs pose considerable hazard and risk. This talk will summarize the geomorphic history of Yosemite Valley, review recent notable rockfalls there, and describe how the application of new analytical tools such as airborne and terrestrial laser scanning, high-resolution photography, cliff monitoring, computer simulations, and cosmoenic exposure dating provide quantitative data that improve understanding and mitigation of rockfalls in this iconic park.

Greg Stock is the first-ever Park Geologist at Yosemite National Park. He has B.S. and Ph.D. degrees in geology and earth sciences, and is a licensed professional geologist in California. Greg's research interests are primarily in geomorphology, focusing on fluvial, glacial, and hillslope erosion. Greg has authored or co-authored more than 50 scientific papers and abstracts on Sierra Nevada geology, and is co-author of the book Geology Underfoot in Yosemite National Park. He lives in Yosemite Valley with his wife and daughter.
Oral Presentation Abstracts

Nick Bergmann -- Understanding Mariel: Cuba’s New Deepwater Port and Special Economic Zone
On December 17, 2014 United States President Barack Obama announced the restoration of full diplomatic relations with Cuba. After over fifty years of hostility between the two countries, the agreement indicated that the United States and Cuba were ready to move beyond old Cold War animosities and build new mutually beneficial associations. Cuba’s shifting relationship with the United States is also indicative of Raúl Castro’s interest in economic liberalization. As an attempt to increase its national GDP, the Cuban government has reformed its economic laws to attract more foreign direct investment. Although unwilling to move towards full economic liberalization, Cuba has invested one billion dollars in port upgrades and commercial infrastructure in Mariel. Located only 45 kilometers west of Havana, the new Mariel Special Economic Zone is the focal point of the government’s liberalization experiment. In this presentation, I attempt to establish a framework for understanding the ways in which the new Mariel Special Economic Zone will affect Cuba’s national economy, the local people and culture of Mariel, and the ecological integrity of the area. First, I trace the history and background of the Mariel development project, while paying particular attention to the changing role of Cuba’s political and economic climate. Secondly, I provide an overview and analysis of the scholarly literature on special economic zones (SEZs). Thirdly, I use world-systems theory to place SEZs within the larger framework of global capitalism. Ultimately, I argue that the existing body of SEZ literature offers several worthwhile conceptual approaches to framing research on Mariel.

Rob Briwa -- Envisioning the Melancholic Sublime of Pierre Magnan’s Provence
Place-defining novelists craft powerful geographic imaginaries and crystallize otherwise ephemeral aspects of place—namely, a distinct sense of place. Critically acclaimed and locally popular Bas-Alpin writer Pierre Magnan (1922-2010) identified himself as “the last true singer of Provence,” and he recognized the power of literature to invoke a regional sense of place. His works define Provence as a region marked by a melancholic sublime. This research uses the occurrence of toponyms in Magnan’s texts to better define the geographic peripheries and hearths of what he defines as Provence. It builds on this initial step by drawing on close readings and qualitative coding of regional imagery as it appears in a selection of Magnan’s works; such methods crystallize a distinct Provençal sense of place. Magnan’s heavy use of regional imagery associated with a vast, timeless, enigmatic, and powerful nature combine with his images of rural cultural landscapes that are writ into deep time, intimately associated with a sense of loss, and imbued with mystery and danger. What emerges from this blending of regional imageries is a sense of place which taps into Burkeian notions of the sublime as an aesthetic experience and invokes a sense of melancholy.

Kerri Keller Clement -- Phantoms on the Land: Ghost Trails in Yellowstone National Park and the Myth of Wilderness
Yellowstone National Park is a landscape of ghosts, with a plethora of purposefully unmapped trails in the sea of wilderness. These pathways and the associated maps that silence them, unveil the lost stories of the manufacturing of a wild Yellowstone. Early Park administrators constructed a distorted cartographic narrative of a wilderness, one safely devoid of Native Americans and teeming with wildlife and geysers, ready for consumption by Euro-Americans. In comparing the contemporary landscape archive with cartographic sources that span early Euro-American fur trappers to the Army
period in the Park, this paper traces the construction of Yellowstone wilderness through the emphasis on blank *terra incognita* landscapes. *Ghost trails*, present on the land but not depicted on maps, were an attempt by the mapmakers to create and control a uniform wilderness within the confines of Park boundaries. Maps by William Clark, John Dougherty, and Jim Bridger, along with exploration maps by W.W. de Lacy, administrative maps by P.W. Norris, and road maps by the Army Corps of Engineers, expose trail erasures that solidified a Euro-American wild Park. In revealing these cartographic exorcisms, we gain a better understanding of the formation of the Park and its resulting mythology as a remote wilderness, along with the materialization of power over the region’s complex identity. *Ghost trails* expose traces of human values, notions of territoriality, and power over identity that attests to the complexities of demarcating and constructing Yellowstone National Park as a wilderness area.

Jacob D. Gardner and James G. Schmitt -- Mineralogic Evidence of Preservational Conditions in the Oligocene Canyon Ferry Insect Lagerstatte, Southwest Montana

The Oligocene Canyon Ferry insect lagerstatte, exposed in outcrops of clayshale in the Cenozoic Bozeman Group along the Canyon Ferry Reservoir shoreline in southwest Montana, has been tentatively inferred from taxonomic associations to record deposition of fossil-bearing horizons in a lacustrine setting characterized by significant volcaniclastic sediment input. In order to begin assessing this interpretation, we utilized x-ray diffraction (XRD) and scanning electron microscope (SEM) methods to determine the bulk mineralogical content as well as the elemental composition of the clayshales and fossils preserved within them. Our XRD results revealed that the clayshales consist primarily of quartz and interstratified illite-montmorillonite clay minerals. This suggests that deposition in this environment was dominated by terrigenous siliciclastic input along with the diagenetic alteration of volcanic ash. Our SEM results revealed an abundance of diatoms comprising the fossiliferous laminae. Analysis of the diatoms reveals them to be composed of quartz. The fossil insects possess an elemental composition identical to that of the clayshale sediment matrix and are interpreted as clay mineral films. These results suggest a complete replacement mode for preservation of the insect fossils with a strong controlling influence of diatomaceous biofilms rather than burial in volcanic ash driving insect accumulation, entombment, and subsequent fossilization. Absence of carbonate minerals suggests that the insects accumulated in a ponded water setting dominated by relatively persistent input of suspended terrigenous clastic sediment with biogenic carbonate production lacking. The presence of diatoms also suggests rapid entombment of and/or minimal diagenetic alteration of the lagerstatte fossil assemblage.

Rachel E. Jensen and Jean L. Dixon -- Meteoric 10Be in Lake Cores as a Measure of Climatic and Erosional Change

Utilization of meteoric 10Be as a paleoenvironmental proxy has the potential to offer new insights into paleoprecipitation records and paleoclimate models, as well as to long-term variations in erosion with climate. The delivery of meteoric 10Be to the surface varies with precipitation and its strong adsorption to sediment has already proven useful in studies of erosion. Thus, it is likely meteoric 10Be concentrations in lake sediments vary under both changing climate and changing sediment influx. Assessment of the relative importance of these changes requires the comparison of 10Be concentrations in well-dated lake cores with independent paleoenvironmental proxies, including oxygen isotope, pollen, and charcoal records, as well as variation in geochemical composition of the sediments. Blacktail Pond details 15,000 years of climatic change in the Yellowstone region. We
develop a new model framework for predicting meteoric $^{10}$Be concentrations with depth in the core, based on sedimentation rates of both lake-derived and terrigenous sediments and changes in the flux of meteoric $^{10}$Be with precipitation. Titanium concentrations and previously determined $^{10}$Be concentrations in wind-derived loess provide proxies for changing delivery of $^{10}$Be to the lake by terrigenous sources. We use existing paleoenvironmental data obtained from this core and the surrounding region to develop models for changing rainfall across the region and predict meteoric $^{10}$Be delivery to the lake by precipitation. Based on a suite of $\sim$10 models, sedimentation rate is the primary control of meteoric $^{10}$Be in the Blacktail Pond core unless terrestrial input is very high, as it was post-glacial in the early Holocene when the lake experienced a high influx of loess and terrigenous sediments. We used these models to inform sample selection for $^{10}$Be analysis along the Blacktail pond core. Core sediments are processed for meteoric $^{10}$Be analysis using sequential digestions and standard extraction procedures. $^{10}$Be concentrations will be used to test the suite of model predictions, and validate the application of meteoric $^{10}$Be concentrations as a proxy for changing erosion and precipitation.

Crystal Nielsen -- Mapping Landslide Susceptibility in Big Sky, Montana
The area around Big Sky, Montana is susceptible to mass movements, particularly landslides. Heavy rainfall, or seismic activity, along with characteristics of the land that contribute to slope instability, could initiate a landslide. Developing and building on areas that have a high risk of movement is the central concern of this project. Creating a landslide susceptibility map will help provide insight to those looking at development, or looking to buy property from a particular area of Big Sky. This can help communicate whether or not a piece of land is safe to build on, or if structural reinforcement is enough to avoid damage in the event of a landslide. To achieve a successful susceptibility map, a statistical approach will be used to relate multiple predictor factors to a measure of landslide occurrence. Factors that affect the stability of slopes, which include geomorphology, topography, geology, land use, hydrology, and land cover, will be compiled into factor maps with assigned weight values. The weighted factor maps will be combined to create the susceptibility map, and divided up into classes based on level of hazard. Validation of the model will compare existing landslide distribution, and landslides predicted by the model. If it is accurate, the areas of observed landslides in the Big Sky region will coincide with areas that have high susceptibility values in the resulting susceptibility map.

Sylvia Nicovich--Latest Pleistocene to Holocene river terrace deformation within the southernmost extent of the Little Salmon Fault zone; geomorphic insights to fault termination and rupture history, Van Duzen River, Northern California

The southern Cascadia subduction zone (CSZ) of northwestern California exhibits northeast-directed contraction, transitioning to north-northwest directed translation within the broad San Andreas fault (SAF) transform margin to the south. The Little Salmon fault (LSF) is one of the southern-most, active thrust faults within the onshore fold and thrust belt of the CSZ, and lies proximal to the transition from compressional to dextral stress across the Mendocino triple junction (MTJ). Thus, it is an ideal location to characterize strain associated with this complex region of transitional stress regimes. High precision topographic data (LiDAR) enabled detailed mapping of geomorphic features otherwise obscured by dense vegetation of the area. The Van Duzen fault (VDF), a northwest trending mole track scarp, sub-parallel and south of the main splay of the LSF is observed on LiDAR imagery. This fault exhibits up-to-the-northeast offset and traverses several Van Duzen River terrace risers and
treads that range from Pleistocene to potentially Holocene in age. A shallow, exploratory trench was 
hand-excavated across the VDF. The shallow, roughly 1.5 m-deep, 16 m-long trench exposed 
imbricated gravels that dip into the base of the trench in the upper end. Coring within the lower end 
of the trench mapped the southern extent of the unconsolidated, clast-supported gravel deposit 
revealing vertical separation of 2.5 m, displaying an up-to-the-northeast step. The linear map 
expression of the VDF across river terraces of varying elevation and age suggests that the fault may 
be relatively steeply dipping. Exposed offset bedrock display reverse offset along the VDF, but with 
no stratigraphic constraint to measure offset. River terraces are some of the youngest geomorphic 
features within the study area. By constraining a sequence of relative ages for terraces associated with 
the Van Duzen River, in combination with regional uplift assumed to be equivalent to incision rates, 
rough terrace ages have been determined. Slip rates calculated from estimated net slip along the VDF 
and inferred terraces ages range from ~ 0.05 to 0.5 mm/yr. The west-northwest orientation of the 
compressional faults and folds within the study area suggest SAF-parallel compression, possibly near 
the transition from transform to compressional tectonic regimes.

Kristin K. Smith, Julia H. Haggerty -- Impacts from Unconventional Oil and Gas Development on 
Agriculture Landowners

How are farmers and ranchers affected by oil and gas development? Using findings from a literature 
review, as well as supporting data from interviews with nineteen Extension specialists, I will identify, 
describe, and categorize the socio-economic impacts experienced by agriculture landowners who have 
allowed unconventional oil and gas development on their land.

Unconventional oil and gas development offers unique challenges and opportunities to agriculture 
landowners. As large landowners, farmers and ranchers may benefit from large lease and royalty 
payments, allowing new investments into their business; challenges, however, may include decreases 
in agriculture production, uncertainty over legal terms and negotiations, and struggles to find labor in 
an increasingly competitive labor market, amongst others. While a growing amount of research has 
studied the socio-economic impacts of energy development, research about localized impacts to 
farmers and ranchers is scarce. Thus, farmers and ranchers frequently make decisions about energy 
development on their land without fully understanding the array of costs and benefits.

I will begin this presentation with a review of the literature on oil and gas development impacts to 
agriculture landowners. I will then compare and contrast the literature with results from interviews 
that I performed with Extension specialists in counties experiencing on-shore oil and gas 
development. As agriculture service providers, Extension agents are frequently in direct contact with 
agriculture operators and therefore have a good pulse of the on-the-ground impacts. Using both the 
literature review and data from these interviews, I will identify the spectrum of costs and benefits that 
farmers and ranchers experience from energy development while also pointing out unanswered 
questions for future research.

Kevin Surya--Assessment of the Origins of Avian Active Flight

The origins of active flight in birds of the clade Avialae has been extensively debated and remains 
unresolved. The overarching theories for explaining the origins are the arboreal, or trees-down theory, 
and the cursorial, or ground-up theory. While the arboreal theory has had little alteration, the cursorial 
theory has undergone significant modifications. The flapping motion that was once thought to act as 
either propeller, insect net, or stabilizer while running and jumping, is now considered to play major
roles in the wing-assisted incline running and the most recently proposed stability-flapping models. This study reexamines the plethora of research related to both the arboreal and cursorial theories, along with the evidence that supports them. Due to the diversity of pathways in terms of morphology, biomechanics, and phylogeny, most of which revolve around *Archaeopteryx lithographica*, it is feasible to propose that all models are plausible. This results in the importance of considering all of the models for any future research regarding the origins of avian active flight.

Kyle Van Peursem, Jordy Hendrikx, Karl Birkeland, Dan Miller -- Validation of a Coupled Weather and Snowpack Model at Bridger Bowl Ski Area

Predicting avalanche danger depends heavily on the knowledge of snowpack structure and the current and forecasted weather conditions. In remote and data sparse areas, this information can be difficult, if not impossible, to come by making avalanche forecasting extremely challenging. Through numerical modeling of seasonal mountain snow cover, forecasters can obtain a better picture of the snowpack structure and avalanche potential in these data sparse areas. In this study, the Weather Research and Forecasting (WRF) model was run and coupled with the snow cover model, SNOWPACK, over Bridger Bowl Ski Area in Montana and a simulated snowpack for the 2014-2015 winter season was produced. The simulated snowpack was then compared to 19 manual snow profiles dug throughout the winter to assess the accuracy of several different parameters including total snow height, snow water equivalency, snow crystal type and size, temperature, hand hardness, density, as well as snow stability. Additionally, data from a co-located weather station was used to force the SNOWPACK model and the results were compared to those from the WRF driven simulation. During this study, the WRF model over-forecasted precipitation, which led to a higher simulated snow depth throughout most of the winter. However, the WRF-SNOWPACK model chain did reasonably simulate the snowpack stratigraphy that was observed throughout the season including weak faceted snow in November, the formation of various melt-freeze crusts in late January/early February, and the transition to an isothermal snowpack in late March. Statistical analysis showed the simulation driven with WRF model input was only slightly less accurate in most categories than the simulation driven with observed weather data. Overall, the model chain showed potential as a useful tool for avalanche forecasting but advances in numerical weather and avalanche models will be necessary for wide-spread acceptance and use in the snow and avalanche industry.

**Poster Abstracts**

Bridget Baker--Fire Line Placement Using GIS

This poster uses GIS to explore the most beneficial areas to create fire lines in a pine beetle forest. The analysis was implemented in Hyalite canyon area of the Gallatin National Forest just outside Bozeman, Montana. To find the best placement for fire lines in the forest several variables were evaluated including amount of beetle kill, proximity to infrastructure, stand density, and slope. This infrastructure was found through the use of spatial layers including elevation, slope, land cover, beetle kill derived from land class, canopy density, roads, and structures. The data was then evaluated together to create an area of interest and then analyzed to create a corridor for a fire line. The results of this analysis will be displayed on a poster with the final product of the analysis resulting in a map.
The poster will also include charts and graphs with supporting material such as stand density, species composition and class (beetle kill or not). This information would be interesting to foresters, firefighters, fire ecologist, The Forest Service, Conservation Corps, private timber companies, and property owners.

**Kathryn Bills -- The Institutional Context of Reclamation: Changing Landscapes of Energy**

Communities that experience rapid oil and gas development are susceptible to a variety of environmental and socioeconomic impacts. Considering the typical boom-bust dynamics experienced by resource-dependent locales, a community that once had a vibrant oil and gas centered economy will eventually see a drastic slow down or halt to operations due to resource exhaustion, price volatility or otherwise. In light of this pattern, there is a need to mitigate potential impacts through carefully crafted policy. Policies pertaining to resource extraction are enacted at all scales: federal, state and local. This poster will provide the institutional context of reclamation by synthesizing existing federal, state, and local policies around reclamation of oil and gas landscapes in two states in the U.S. West; Montana and Wyoming. In doing so, a comprehensive view of required reclamation will be portrayed. Oftentimes such information is found in disparate locations resulting in a muddled understanding of how much, and the type of reclamation that is mandated. Additionally, assembling all reclamation policies pertaining to the oil and gas industry allows questions, omissions and concerns to become apparent. Reclamation policy pertaining to oil and gas landscapes in two U.S. states will be presented, and achievements and implications will be identified.

**Logan Cain--Cordillera Blanca Detachment Channel Lithology Analysis**

The Cordillera Blanca Detachment (CBD) is a major normal fault bounding the western flanks of the Cordillera Blanca, the highest range in the Peruvian Andes. Prominent fault scarps and triangular facets indicate that the fault has a history of significant slip during the last 12,000 years (Holocene), but it is unclear whether past events ruptured the entire 200-km-long fault, or smaller segments. Constraining the dimensions of past ruptures is important for forecasting the magnitude of future earthquakes on the fault. This poster will examine drainage lithology along the different segments of the CBD in conjunction with channel profiles and knickpoints. Channel profiles were extracted using the MIT stream profiler and streams and knickpoints were identified using elevation vs. distance and gradient vs. drainage area plots of the stream profiles. Drainage lithology will be overlaid with the stream and knickpoint data. Further analysis will attempt to classify knickpoints based on the geological and geomorphological processes that created them in order to focus on those that evolved from fault slip. Examining the lithology of the individual drainages will aid in that endeavor by allowing us to determine the role lithology plays in the channel evolution of the CBD. Once completed, these data and analyses can used to determine how the Cordillera Blanca landscape responds to sudden seismic events like earthquakes and rapid increases in fault slip rate.

**Taylor Eder-- Preventing Conflict within Grizzly Bear Corridor Habitat in Montana**

Grizzly bears are opportune expedient apex predators that consume everything from berries to cattle. Grizzlies take advantage of food sources wherever they are presented. Farms and ranches with livestock are a vulnerable target for grizzlies and this often leads to conflict. Through the use of GIS, potential grizzly corridors can be identified. Corridors will be analyzed using a cost surface that will be developed using GAP Land Cover data, a digital elevation model, and transportation data. The raster's will be classified on an ordinal scale with 1 being high suitability and 10 being unsuitable. Map
algebra will then be utilized to weight the raster’s according to their relative importance based on the peer reviewed literature. From the resulting cost surface a least cost path from one core habitat to another can be identified. Once these areas are identified and combined with county parcel data, ranchers can be made aware that they reside in grizzly territory and can implement more sustainable management practices. These grizzly corridors can then also be identified as areas where restrictions on trapping and use of specific poisons could be implemented. The implementation of these practices will attempt to minimize conflict between apex predators (such as grizzlies), ranchers, farmers, trappers, wildlife organizations, and the general public. The results of this analysis will help inform the Natural Resources Defense Council in a rule making petition to prioritize safer management practices for grizzlies. These practices and restrictions act as an umbrella that will benefit many animals that occur in the same habitat. Methods as well as results are currently in the process in GPHY 484.

Ryan Evans -- The Utilization of GIS to Map the Soil Loss Impacts of Flood Irrigation
The conservation and management of valuable soil is of the utmost importance for agriculture sustainability. Soil loss, from erosion, is a major contributor to the degradation of prime agricultural land. The focus of this project is the mapping of high-risk soil loss/erosion areas, within regions deemed prime farmland. The high-risk areas will be developed as a result of the impacts generated by both the practice of flood irrigation and natural factors. The study region for this project will be the agricultural land of the Flathead Reservation, specifically the surface/flood irrigated lands located near the foothills of the Mission Mountain Range.

Aaron Feldhaus, Dr. Jean L Dixon--Short-term effects of variable snowpack on chemical and biophysical weathering
Snowpack variability influences hydrologic conditions that modulate the physical and chemical processes of underlying soils. The Greater Yellowstone Ecosystem (GYE) has witnessed a significant decline in snowpack over the past 5 decades (Brookshire and Weaver, 2015) and the 20th century witnessed almost unprecedented reductions in snowpack across the North American Cordillera (Pederson et al., 2011). Changing snowpack in mountainous systems due to climate change may therefore significantly affect soil evolution and weathering intensities.

Understanding the effects of variable snowpack on soil function is hampered by the lack of long-term studies that provide baseline data that isolate snowpack control, and relatively little is quantitatively known about how snowpack influences soil chemistry and evolution, nutrient release, and physical weathering. Using a 47-year snowpack manipulation experiment in the GYE, I will test the hypothesis that variable snowpack affects soil chemical and physical evolution on decadal temporal scales. This project will provide novel insight into the controls on soil evolution and the degree of soil resilience under relatively short-term climatic and hydrologic changes.

Michael G. Frothingham, Colin A. Shaw, Chester A. Ruleman -- Proterozoic structural relations within a three-part system of dike intrusion, batholith emplacement, and shear zone deformation at mid-crustal depths near Leadville, Colorado
Proterozoic rocks exposed in the Sawatch Range of central Colorado record ~1.4 Ga intracontinental deformation that is broadly contemporaneous with the recently identified Picuris Orogeny in northern New Mexico. Updated geologic mapping of the Homestake Reservoir 7.5’ quadrangle near Leadville, Colorado constrains the structural geometry of dike intrusion, batholith emplacement, and shear zone
deformation. Mesoproterozoic ultra-potassic dikes intrude Paleoproterozoic gneiss along pre-existing metamorphic foliations. Mesoproterozoic St. Kevin batholith intrudes gneiss and truncates ultra-potassic dikes and includes abundant rafts of host rock, inherited foliations near contacts, and flow foliations. Mesoproterozoic mylonite and pseudotachylite of the Homestake shear zone deform Paleoproterozoic and Mesoproterozoic host rocks. These relations indicate a potentially linked kinematic system of mid-crustal deformation that represents intracontinental effects of the Proterozoic assembly of southern Laurentia.

Holt Hancock, Jordy Hendrikx, Hanne Christiansen -- Snow drift and avalanche activity in the high-arctic maritime snow climate of Svalbard, Norway

Fieldwork methods and preliminary results from a Spring 2015 on the island of Spitsbergen in Svalbard, a Norwegian archipelago in the high-arctic, are presented. The main objective of this research is to understand and characterize the redistribution of blowing and drifting snow in the unique high arctic maritime snow climate of Svalbard by addressing the following research questions: 1) How can snow drift processes on Svalbard be modeled to create control plans to reduce the impact of drift events on infrastructure throughout the island? and 2) To what extent do observed drift events influence avalanche activity on the island? This presentation introduces the snow drift problem on Spitsbergen, displays the location(s) of the Spring 2015 fieldwork, and presents the preliminary results of the field campaign. The primary result displayed is a map of snow depth on Platåberget. The snow depth surface displayed on the map is interpolated from snow surveys taken on the plateau between May 20th and May 29th, 2015. These surveys consisted of snow depth observations taken every 10 m along four one km transects (displayed), supplemented by over 700 snow depth measurements taken with a SnowHydro GPS probe spaced approximately 10 m apart in a semi-random grid across the study area. Future work will use these maps as validation for snow distribution modelling and statistical analyses.

Rudolph Hummel -- “Butting Heads” Over Potential Agonistic Behaviors in Pachycephalosaurs

For decades, paleontologists have debated the use of the large domes atop the heads of pachycephalosaurid species. The most prevailing hypothesis is that the dome was used in agonistic combat for sexual selection. There are several types of proposed agonistic behavior. Three will be discussed here: head-buttting, flank-buttting, and head-shoving. Examination of the scientific literature and available evidence indicates that if pachycephalosaurids exhibited agonistic behaviors, both head-buttting and head-shoving are realistic models, while flank-buttting appears unlikely.

Rachel E. Jensen and Jean L. Dixon -- Meteoric 10Be in Lake Cores as a Measure of Climatic and Erosional Change

Utilization of meteoric $^{10}$Be as a paleoenvironmental proxy has the potential to offer new insights into paleoprecipitation records and paleoclimate models, as well as to long-term variations in erosion with climate. The delivery of meteoric $^{10}$Be to the surface varies with precipitation and its strong adsorption to sediment has already proven useful in studies of erosion. Thus, it is likely meteoric $^{10}$Be concentrations in lake sediments vary under both changing climate and changing sediment influx. Assessment of the relative importance of these changes requires the comparison of $^{10}$Be concentrations in well-dated lake cores with independent paleoenvironmental proxies, including oxygen isotope, pollen, and charcoal records, as well as variation in geochemical composition of the sediments. Blacktail Pond details 15,000 years of climatic change in the Yellowstone region. We
develop a new model framework for predicting meteoric $^{10}$Be concentrations with depth in the core, based on sedimentation rates of both lake-derived and terrigenous sediments and changes in the flux of meteoric $^{10}$Be with precipitation. Titanium concentrations and previously determined $^{10}$Be concentrations in wind-derived loess provide proxies for changing delivery of $^{10}$Be to the lake by terrigenous sources. We use existing paleoenvironmental data obtained from this core and the surrounding region to develop models for changing rainfall across the region and predict meteoric $^{10}$Be delivery to the lake by precipitation. Based on a suite of ~10 models, sedimentation rate is the primary control of meteoric $^{10}$Be in the Blacktail Pond core unless terrestrial input is very high, as it was post-glacial in the early Holocene when the lake experienced a high influx of loess and terrigenous sediments. We used these models to inform sample selection for $^{10}$Be analysis along the Blacktail pond core. Core sediments are processed for meteoric $^{10}$Be analysis using sequential digestions and standard extraction procedures. $^{10}$Be concentrations will be used to test the suite of model predictions, and validate the application of meteoric $^{10}$Be concentrations as a proxy for changing erosion and precipitation.

Clay Kincer

With the changing global climate we expect to see some responses such as rising sea level, warming sea temperatures resulting in changing weather patterns, however another impact of the changing global climate will be an increasing number of landslides. According to the Intergovernmental Panel on Climate Change we can expect more precipitation along with more storm events to accompany this shift in global climate.

Landslides are most commonly caused by precipitation that saturates the soil causing greater loads. Saturated soil cannot support as much weight due to decreased cohesion and increased pore pressure. Since the world is expected to experience increased precipitation over the next century an increase in landslide occurrence can also be expected. This increase in landslide occurrence will likely cause more monetary damage than in the past due to the further development of infrastructure that will accompany our expanding population.

This project’s purpose is to develop a model for which different climactic scenarios could be applied to a region in order to simulate landslide frequency. Elevation data, land cover data, along with modeled climatic conditions will be parameterized and input into a model which will identify areas of possible hazard. The target area of this project is Gallatin County in Southwest Montana, particularly mountain roads and roads with significant undercuts.

Natali Kragh, Rachel Jensen, Dr. Jean Dixon -- Utilizing Lake Cores to Examine Past Geomorphic Alteration in Yellowstone National Park

Cores from Blacktail Pond in Yellowstone National Park have been extensively used to study past environments of southwestern Montana. Topics like fire, vegetation, ecology, precipitation, and temperature fluctuations have all gained meaningful insight to their histories based on data collected from these cores. However, the cores have much more information to give, specifically regarding geomorphic alteration that has occurred in the Blacktail Pond area since the end of the Pleistocene. Over the course of a semester, sediment geochemistry was utilized to determine sediment source variation throughout the lake cores. The authors conducted a series of carbonate dissolutions, titrations, and loss on ignition analysis. These tests provided a thorough understanding of the chemical, mineralogical, and organic makeup of the core. Results show that at some point in the
Holocene, sediment source changed dramatically from a siliciclastic terrigenous source to an in-situ biogenic carbonate source. This switch suggests that landscapes altered quickly then stabilized following the deglaciation of the Yellowstone Ice Cap.


A railroad causeway across Great Salt Lake, Utah (GSL) has restricted water flow since its construction in 1959, resulting in a higher salinity North Arm (NA; 31.4% salinity) and a lower salinity South Arm (SA; 11.8% salinity). Here, we characterized carbonate microbialites collected from the SA and the NA to evaluate the effect of increased salinity on microbialite community composition and abundance, and to determine if the communities present in the NA are still actively precipitating carbonate or if they are remnant features from prior to causeway construction. SSU rRNA gene abundances associated with the NA microbialite were 3 orders of magnitude lower than those associated with the SA microbialite, indicating that the latter community is more productive. SSU rRNA gene sequencing and functional gene microarray analyses indicated that SA and NA microbialite communities are distinct. In particular, abundant sequences affiliated with photoautotrophic taxa including cyanobacteria and diatoms that may drive carbonate precipitation, and thus still actively form microbialites, were identified in the SA microbialite; sequences affiliated with photoautotrophic taxa were in low abundance in the NA microbialite. SA and NA microbialites comprise smooth prismatic aragonite crystals. However, the SA microbialite also contained microspar calcite which is typically formed as a result of biological activity. Collectively, these observations suggest that NA microbialites are remnant features and indicate that the associated communities are no longer actively precipitating carbonate minerals. Moreover, the results suggest a role for cyanobacteria and diatoms in carbonate precipitation and microbialite formation in GSL.

Taylor Lonsdale -- Montana State University Bicycle Parking Analysis

Campuses across the United States are increasing their efforts to deploy sustainable science. Sustainable transportation plays a significant role in overall sustainability. Increasing the number of people choosing to ride bicycles for transportation is a major component of sustainable transportation. The presence of facilities that make cycling convenient is an essential factor affecting the viability of bicycling as transportation. Increasing evidence suggests that providing abundant, high quality bicycle parking will lead to increasing numbers of people choosing bicycles for transportation. Location of bicycle parking is a growing concern in urban planning.

As part of Montana State University’s sustainability efforts, MSU is developing a Bicycle Master Plan for the Bozeman campus. An important component of this plan is recommendations to improve bicycle parking. These recommendations are based on a detailed analysis of bicycle parking supply and demand on the MSU campus. Data on existing bicycle parking locations and capacities were obtained from MSU’s Campus Planning Design and Construction (CPDC). Building locations and occupancies were also obtained from CPDC. ArcGIS tools were used to analyze this spatial data. Analyses included comparison of parking supply adjacent to each building with the demand from the buildings. The outcome is a clear understanding of the location and quantity of existing bicycle parking and the location and quantity of parking demand. Additionally, the analyses were used to identify optimal
locations for large, centralized, covered bicycle parking. These analyses informed the recommendations of the MSU Bicycle Master Plan which will provide recommended improvements to campus bicycle parking.

Melissa A Manning -- Snow Accumulation & Dynamics Research, Comparing The Effect of Aspect On Weak Layer Formation Within a Snowpack.

The purpose of this research project was to compare the effect of aspect on weak layer formation within a snow pack. The research was conducted along the Beehive Basin northwest ridge line, located in the Madison mountain range just outside of Big Sky, Montana. The field data for this research consisted of 16 total stability tests conducted along the test walls of 4 snow pits approximately 10m apart. To compare aspect, two of the pits were dug on the east facing ridge aspect and two pits were dug on the west aspect. The tests performed included propagation, compression and penetration. The result features include an ArcGIS illustrating GPS location points, and topographic contours as well as a statistical analysis using R programming to determine the variability between the north and west aspect. This data can be used to, indicating variability by rating snow strength and structure in late season intermountain conditions.


The purpose of this study was to conduct a statistical analysis on the current AAG research trends in the geographic subfield of energy. The American Association of Geographers (AAG) is a non profit scientific and education society that connects the dominate academic among special interest groups through journals of significant interest. This data collected from this analysis demonstrates an increased interest in renewable, clean and free energy. The topics trending relate to how energy is cultivated and its associated economic, political and social policies. This analysis also considered the global dependency on oil, environmental conservation and the current innovation of clean energy technologies.

Crystal Nielsen -- Mapping Landslide Susceptibility in Big Sky, Montana

The area around Big Sky, Montana is susceptible to mass movements, particularly landslides. Heavy rainfall, or seismic activity, along with characteristics of the land that contribute to slope instability, could initiate a landslide. Developing and building on areas that have a high risk of movement is the central concern of this project. Creating a landslide susceptibility map will help provide insight to those looking at development, or looking to buy property from a particular area of Big Sky. This can help communicate whether or not a piece of land is safe to build on, or if structural reinforcement is enough to avoid damage in the event of a landslide. To achieve a successful susceptibility map, a statistical approach will be used to relate multiple predictor factors to a measure of landslide occurrence. Factors that affect the stability of slopes, which include geomorphology, topography, geology, land use, hydrology, and land cover, will be compiled into factor maps with assigned weight values. The weighted factor maps will be combined to create the susceptibility map, and divided up into classes based on level of hazard. Validation of the model will compare existing landslide distribution, and landslides predicted by the model. If it is accurate, the areas of observed landslides in the Big Sky region will coincide with areas that have high susceptibility values in the resulting susceptibility map.
Chance Noffsinger and Cathy L. Cripps -- Assessment of the diversity of endophytic fungi in red and green needles of whitebark pine (*Pinus albicaulis*) in Montana

Endophytic fungi can be defined as living within a plant for at least part of their life cycle without causing apparent disease, and some are considered mutualistic. It has been postulated that fungal endophytes might induce resistance to white pine blister rust (*Cronartium ribicola*), a pathogen responsible for the massive destruction of these 5-needle pines in North America. Our preliminary study revealed a diversity of endophytic fungi (33 isolates) in the needles of whitebark pine with limited sampling. The current project is assessing this diversity of endophytes in needles of whitebark pine by sampling twenty mature whitebark pine trees across four high elevation treeline sites in southwestern Montana. Needles are surface sterilized either with an alcohol-flame method or an alcohol soak method and plated onto PDA agar media. Endophytes are being isolated as they grow out from the needles. Endophyte diversity will be compared between sites, trees, methods, and between green and red needles to see if the endophyte community changes on senescence.

Results will be presented in terms of morphotypes per treatment, and if possible molecular identification using NCBI blast to determine the best species match for ITS region sequences. This research will provide insight into the diversity of endophytes in whitebark pine and results could lead towards application of endophytes to nursery seedlings as a possible defense against rust or the mountain pine beetle.

Sarah Nottingham -- Lahar hazards in Washington State

Cement-like debris flows, known as lahars, are one of many hazards triggered by volcanos but they do not have to occur during an eruption. Sometimes they happen before or even years after such an event due to destabilization of the terrain, mostly in combination with heavy rainstorms. Water of any kind (i.e. lake, glacier) is a major component and needs to be present to form a lahar so only certain volcanos are at risk. This project is attempting to create scenarios of hypothetical lahar flows off of volcanos in Washington State. The USGS monitors volcanos and their activities are closely in the United States. The eruption of Mount St. Helens in May 1980 produced a lateral blast and two lahars killing fifty seven people. Other volcanos like Mt. Rainier which are located closer to highly populated areas threaten millions of people. With good aerial data (DEMs from ASTER or SRTM) and certain models (LAHARZ, MST, etc.), scenarios can be produced and can offer critical information, especially for evacuation and zone planning authorities.

Global warming and increasing geothermal activity on the volcano itself cause the glaciers to recede and areas under permafrost to destabilize (Huggel et al. 2003 and 2007, Schneider et al. 2003). These factors can change possible lahar volumes of recent studies and should be considered in every model.

Grace Parker, Adam Fetherston, Sarah Benjaram, Aaron Feldhaus, Anneline Ferstad, Sondre Lunde, Rachel Jensen, Erik Schnaderbeck -- Using river longitudinal profiles and geomorphic indices to evaluate regional tectonics of the Solukhumbu district, Nepal

River longitudinal profiles of a fluvial network in the Solukhumbu district of eastern Nepal show distinct geomorphic boundaries interpreted as manifestations of regional tectonic forcing. Tributaries along the Dudh Kosi River in Nepal will be evaluated using 30-meter DEM data in ArcGIS to delineate physiographic transitions (PT) that represent abrupt spatial gradients in erosion and rock uplift rates. Hill slope analysis along with stream power analysis will be completed to understand
hillslope angles, topographic trends, and channel morphology. Past and current glacial extent will be mapped to provide information on transition zones between glacial-dominated and fluvial-dominated valleys. Previous studies document a PT ~200 km west of the Dudh Kosi River suggesting a surface-breaking fault exists ~ 20 km south of the Main Central Thrust (MCT) fault in northern Nepal. Results from this study will provide data to help better understand the aforementioned PT. This study will provide important insights into the neotectonic evolution of the eastern Nepalese Himalayas and may lead to a better model for extracting tectonic histories from longitudinal river profiles.

Thomas Pausch -- A Geospatial Analysis of Sedimentary Provenance of the Lower Belt Group within Southwest Montana
The portion of the Belt Basin found within southwestern Montana contains a thick succession of Mesoproterozoic sedimentary strata. However, it is not well understood what Precambrian cratonic provinces served as sources of detrital sediment throughout the depositional history of the Belt Basin and there is no geospatial database of the extensive geochronological work conducted in the region. In order to better understand the spatial relationships between source and detrital sediments, a suite of georeferenced zircon ages from the Lower Belt Group and surrounding Precambrian basement have been compiled for this study. Zircon is an accessory mineral formed during the crystallization of mafic to felsic magmas whose incorporation of U and Th, but exclusion of initial Pb make it an ideal candidate for dating. Using a GIS, these georeferenced radiometric ages will be appended to lithology within the Belt Basin. This map will act as an aid to provenance studies and will illustrate the correlation between the detrital siliciclastic strata within the Belt Basin and the cratonic terranes from which the sediment was sourced. This project will also create a framework geospatial database that can be supplemented with additional Precambrian and Belt Basin zircon data.

Nicholas Rolstad -- Sediment-Hosted Copper Deposit Potential of East-central Idaho
Copper deposits associated with metasedimentary rocks occur in the Blackbird mining district as well as other scattered current and former mine sites throughout east-central Idaho. GIS analysis of the geological features associated with known Cu deposits in the region can help provide insight into other areas that may have a high potential for sediment-hosted Cu deposits. Using the statistically based Weights-of Evidence (WofE) approach, weights are assigned to a number of categorical ‘indicator’ rasters based on their spatial associations with known Cu occurrences. These indicators include layers based on the location of: metasedimentary rocks, the Apple Creek formation, the Gunsight formation, faults, magnetic anomalies, and cobalt geochemical anomalies. Weights are assigned to each indicator layer individually and then all indicator layers are combined, based on their classified weights, to create a final mineral potential map (MPM). ArcGIS is used for analysis and map creation while the add-on Arc-SDM is used to run the statistical calculations used in WofE. The final mineral potential map shows the qualitative potential for finding sediment-hosted Cu deposits in the region.

Zach Scheunemann -- Yellowstone National Park Wildlife Probability Map
The purpose of this project is to look at wildlife presence in relation to hiking trails and roads in Yellowstone National Park. While working near the park I noticed there was a lack of information available to tourists as to where to see certain kinds of animals. This map will provide visitors of the park a clear and easy way to comprehend where species specific animal siting’s are most likely. The maps will encompass many of the popular hiking trails as well as the major roads running through the
park. There will be various GIS techniques employed to reach the final product included weighted overlay and interpolation methods. This project will be very beneficial to tourists in the park and provide a greater overall experience in one of the great ecosystems of the world today.

Margaret Sizemore -- Morphometric Analysis of Extensional Faulting in the High Peruvian Andes Using a Geographic Information Systems Approach

The great “White Mountains” or Cordillera Blanca mountain range of Peru is of scientific interest to researchers due to the 200-km fault that defines the western boundary of the range. Despite the research which has been conducted along the range, there is still a lot to be discovered about the history of the fault within the past 12,000 years. Geographical Information Systems (GIS) techniques have been applied to areas with similar geomorphology as the Cordillera Blanca Detachment (CBD) fault, however; the literature does not suggest that these methods have been used when analyzing the CBD. This research project uses previously collected data and newly acquired GIS data to further understand the geology and geomorphology of the area. By gaining an understanding of this information, it is possible that the general age of the fault could be discovered and the magnitude of future seismic activities could be predicted for the defined area. A geological map of the region was compiled and zonal statistics were analyzed using GIS to learn about the facets along the CBD. This research is in conjunction with another project that is using a GIS method of stream profiling to understand the evolution of the fault and the geomorphic response of the landscape. Upon completion of this research, the data produced can be used to determine how the Cordillera Blanca landscape has responded to seismic activities in the past and a general age of the fault.

Bailey Scott -- Using GIS to determine landslide susceptibility of the Madison Range in Southwestern Montana

The Madison Range in southwestern Montana is well known for having a high landslide susceptibility. Often, weighted overlay methods are used to calculate that susceptibility based off of a variety of factors including precipitation, lithology, soil type, climate, slope, distance from drainage, vegetation, distance from faults, etc. The aim of this project is to compare at least three different weighted overlay methods to determine which is the most efficient in determining the slope stability of the Madison Range. The most efficient equation will be found through comparison of the three generated maps to a geologic map of landslide deposits and Google Earth images. Faults will not be used as part of the weighted overlay but will be shown in the map to determine possible cause for the landslide. Determining the most accurate weighted overlay equation will help when assessing landslide susceptibility in other ranges similar to that of the Madison.

Valerie Sigler -- Assessing the impacts of traffic to Oaks Disposal Services in Lindsay, Montana

Residents in Lindsay, Montana worry about the 2013 opening of Buckhorn Energy Oaks Disposal Services, a landfill designated for the disposal of solid waste from crude oil and natural gas drilling and production activities. Its proximity to South Fork Deer Creek, residential homes, ranches and farms increases the concerns. Several of the issues troubling residents include: potential environmental risks and health consequences from transportation spills, potential surface contaminations, the disposal of naturally occurring radioactive materials (NORM), the increased traffic on rural roads and subsequent noise and dust, as well as the application of magnesium chloride to the road surfaces. Community residents acknowledge the necessity of this type of landfill, but feel it is imperative that disposal sites be selected carefully. Citizens are searching for solutions to minimize spill contamination and to
reduce the impact of trucks transporting waste to the landfill which is open 24 hours a day, seven days a week. This research seeks to explore solutions to minimize the impacts of Oaks Disposal traffic on affected stakeholders. Using GIS applications, features such as water sources, roads, locations of residential homes and agricultural lands will be identified on thematic maps. Constraints created by buffers and spatial analysis will be used to assess possible solutions which could address the citizens’ concerns.

Mikayla Struble -- Convergent Evolution and Functional Morphology of the Raptorial Foot: Behavioral Implications for Dinosauria, Oviraptorisauria

The birds of prey, or raptors, are a unique group; it is composed of three unrelated lineages of birds which all arrived independently at very similar body plans, stemming from the raptorial footing behavior in which birds interact with their environment with their feet, not their beaks. In associated with this footing behavior, the shortening, or abbreviation, of specific proximal phalanges in the foot is highly characteristic of raptors. The patterns of abbreviation we see indicate several complex trends, which we aim to explore in four distinct approaches: 1. what foot morphologies signify general raptorial behavior? 2. What foot morphologies are unique to each group of raptor? 3. What foot morphologies are specific to dietary or ecological niches? 4. When and in what order did the morphologies we see today originate? Raptorial convergent evolution has been difficult to study because of the uncertainty with which we have understood Avian phylogeny, but with the modern age of genetics, the Avian phylogenetic tree has been rigorously reorganized and finally offers scientists a well-supported view into the history of bird, and raptorial, diversity. Here we present data recounting these trends and regress them back into the Avian phylogenetic tree to follow patterns of abbreviation and shed light on the evolution of predatory behavior in Aves. This research has additional and significant implications for oviraptors, a group of feathered and beaked dinosaurs, which display similar morphological trends. We offer the suggestion that some genera of oviraptors occupied a raptorial-like niche in the Cretaceous.

Kevin Surya -- Assessment of the Origins of Avian Active Flight

The origins of active flight in birds of the clade Avialae has been extensively debated and remains unresolved. The overarching theories for explaining the origins are the arboreal, or trees-down theory, and the cursorial, or ground-up theory. While the arboreal theory has had little alteration, the cursorial theory has undergone significant modifications. The flapping motion that was once thought to act as either propeller, insect net, or stabilizer while running and jumping, is now considered to play major roles in the wing-assisted incline running and the most recently proposed stability-flapping models. This study reexamines the plethora of research related to both the arboreal and cursorial theories, along with the evidence that supports them. Due to the diversity of pathways in terms of morphology, biomechanics, and phylogeny, most of which revolve around Archaeopteryx lithographica, it is feasible to propose that all models are plausible. This results in the importance of considering all of the models for any future research regarding the origins of avian active flight.

Jordan Toles -- Speleogenesis of Mill Creek Crystal Cave

The aim of this project was to compile a history of passage formation in the Mill Creek Crystal Cave system by interpreting field observations made within the cave. Crystal Cave is a significant cave that has formed in limestone of the Meagher formation in the Montana Absarokas. Cave passages are observed to have two distinct directional trends, both parallel (E/W) and orthogonal (N/S) to the Mill Creek drainage. The cave exhibits evidence of a complex history that can be accounted for by
Alyx Vissotzky -- Prime Pheasant Habitat Weighted Index for Fairweather Fishing Access, Clarkston, Montana
This poster will display a GIS created weighted index determining prime pheasant habitat for Fairweather Fishing Access in Clarkston, Montana. A weighted index is a valuable tool for habitat prediction and can be used to help educate the public to further conservation efforts. Fairweather Fishing Access is roughly 2.7 sq km (610 ac) of state land that borders the Missouri river and is 26 km (16 mi) north of Logan, MT. This land is habitat for pheasant, whitetail deer, ducks, geese, and numerous other species. The weighted index was achieved by creating a weighted overlay of raster data classes. These classes include, but are not limited to: cover, feed, crop, riparian area, fence/roads. Most of the class’s data have been digitized from a 2015 aerial photograph from the Montana State Clearing House. A map displaying the weighted index visualizes and communicates prime pheasant habitat factors to help further conservation efforts and education.

Aaron Wipf – How bikeable is Bozeman? A quantitative geospatial assessment
Bikeability mapping using GIS can help city governments strategically plan long-term development infrastructure in an ad hoc and incremental fashion. Although Bozeman seems to already be bike friendly, future growth and expansion will likely necessitate a more in-depth plan to maximize the benefits provided by the city’s bike network. A map showing impedance values along road networks and their environment obtained from state and city GIS datasets will allow planners to reach destinations of interest in Bozeman’s MSU campus, Main Street, or shopping centers) from all parts of Bozeman. These analyses would be coupled with growth models to show how easy or difficult it is to reach destinations in Bozeman’s bike network will generate a map showing impedance values along road networks and their environment obtained from state and city GIS datasets. As an input for broader bikeability analyses that will show how easy or difficult it is to reach destinations in Bozeman’s bike network will generate a map showing impedance values along road networks and their environment obtained from state and city GIS datasets.

Matthew Yaeger -- Exploring the Relationships Between Plume Volcanism, Grabens, and Elevated Features: An Interplanetary Comparative Approach
Grabens and heavily-cratered mountain ranges with wide curved rifts are structural features which are associated with major volcanic centers on Mars, though their origins are not well understood. This study aims to explore their origins through a comparative study with parallel features on Earth. The
grabens come in several forms. Some, called fossae, are long, thin, and shallow and tend to be somewhat linear but often broken and staggered. Others are in the form of catena (chains of pit craters). Both of these kinds of grabens can exist on their own, but I have found that catena often form at the bottoms of fossae. There is also a third kind of graben that is thin, deep, and linear. After observing different stages of catena development within fossae, it is starting to seem that this third kind of graben is not distinct but rather forms from the deepening of a fossa due to catena forming inside. This is supported by similar studies that suggest that the fossae and catena form from the same process (dilational faulting) and catena form when the fault reaches a certain depth and the underlying material is loose enough to allow collapse. Creation of loose weak sediment may result from hydrothermal serpentinization, which I plan to search for using methane emission maps of Mars and by researching the possible occurrence of serpentinite under catena on Earth. There are several other theories of catena formation including dike emplacement and withdrawal. I plan to compare these theories by investigating catena on Earth in Kilauea’s rift zones, Craters of the Moon, and Israel and Jordan near the Afar Triple Junction.

Dionne Zoanni -- A discourse analysis of oil and gas development on the Fort Peck Indian Reservation, MT

Environmental justice literature has shown that low-income and/or minority communities face a disproportionate chance of exposure to environmental contamination and health risks, as well as a lower chance of benefiting from natural resource development and policy. This research will examine a particular case of oil and gas development on the Fort Peck Indian Reservation in northeast Montana, where the disposal of produced water via injection wells has led to the contamination of 15-37 billion gallons of groundwater within the aquifer that had historically been the only source of drinking water for reservation community members. By examining the discourses of outside interest groups around this issue, this research seeks to answer the following questions: What are the different and often conflicting discourses constructed by outside agencies, corporations, consultants and environmental groups, how do these discourses reflect the different goals and interests of each group, and how do they effect the decision-making processes of the tribal government and stakeholders in the development of oil and gas on the reservation? In addition, what are the possible scenarios that result from these decisions, and how could they potentially impact environmental health, the community’s quality of life, and future resource development on the reservation? Results will contribute to the fields of resource geography and environmental justice by providing a case study of the effect outside interest groups have on decision making-processes within Native American tribal government, and will also benefit Fort Peck community members as they make decisions regarding future resource development on the reservation.