Schedule of Events
April 13, 2017

8:00 am – 12:30 pm  Student Oral Presentations
SUB Ballroom B

12:30 pm – 1:30 pm  Lunch Break

1:30 pm – 3:00 pm  Professional GIS Panel
SUB Room 235

3:00 pm – 5:00 pm  Student Poster Session
SUB Ballrooms B, C, D

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

5:30 pm – 6:30 pm  Dinner and Earth Sciences Departmental Awards
SUB Ballrooms B, C, D

6:30 pm – 7:30 pm  Keynote address, Doug Chabot, Director of the
Gallatin National Forest Avalanche Center (GNFAC)
SUB Ballrooms B, C, D
## Table of Contents

Welcome from the Earth Sciences  Student Colloquium Chair ........................................... 5  
Welcome from the Earth Sciences Department Head ................................................................. 6  
2017 Colloquium Committee ...................................................................................................... 7  
Keynote Speaker: Doug Chabot ................................................................................................. 8  
Oral Presentation Abstracts ........................................................................................................ 9  

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>KATIE EPSTEIN</td>
<td>Vision’ to Reality: Emerging Public Opinion of Collaborative Management in the Greater Yellowstone Ecosystem</td>
<td>9</td>
</tr>
<tr>
<td>ROB BRIWA &amp; NICK BERGMANN</td>
<td>Reconciling Centennial Visions of the National Park Service</td>
<td>9</td>
</tr>
<tr>
<td>DIONNE ZOANNI</td>
<td>Traditional Ecological Knowledge and Water Governance at Fort Peck Reservation, MT</td>
<td>9</td>
</tr>
<tr>
<td>KATIE BILLS WALSH</td>
<td>Keeping up with Colstrip: 2017 Legislative Developments and the Status of Montana’s Largest Coal-fired Power Plant</td>
<td>10</td>
</tr>
<tr>
<td>KRISTIN K. SMITH</td>
<td>Infrastructure &amp; Sugar Beets: A Revised History of Sidney, MT .......................................</td>
<td>10</td>
</tr>
<tr>
<td>WILLIAM NANAVATI</td>
<td>Human-Environment Interaction in Patagonia ..........................................................................</td>
<td>11</td>
</tr>
<tr>
<td>Xiangmei Li</td>
<td>Assessment of Regional Social-Ecological System Resilience between Two Grassland Management Patterns: A Case Study from the Tibetan Plateau</td>
<td>11</td>
</tr>
<tr>
<td>Lazaro Willian Vinola</td>
<td>Fossil Record of the Rock Iguana Cyclura (Family: Iguanidae) in Cuba: Implications for its Systematics, Paleocology and Paleodistribution</td>
<td>12</td>
</tr>
<tr>
<td>Kevin Surya</td>
<td>Pelvic Sexual Dimorphism in Modern Birds (Aves: Neornithes) and its Evolutionary Relationship with Relative Egg Size</td>
<td>12</td>
</tr>
<tr>
<td>Richard Carr</td>
<td>Population Study of a Fossil Fish Assemblage from the Jurassic Sundance Sea with Remarks on Paleodistribution and Taphonomic Environment</td>
<td>13</td>
</tr>
<tr>
<td>Jacob Gardner</td>
<td>The Big Bowfin of Glacier: Biodiversity and Preservation of Eocene Fish in Northwestern Montana</td>
<td>13</td>
</tr>
<tr>
<td>Sylvia Nicoovich</td>
<td>An Earth Processes Approach to Understanding Martian Alluvial Fan Dynamics</td>
<td>14</td>
</tr>
<tr>
<td>Neal Maguire</td>
<td>The Impact of Pore Fluid Pressure on Brittle Deformation as Demonstrated by the Beer Can Experiment</td>
<td>14</td>
</tr>
<tr>
<td>Title</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>WHITNEY ADAMS - Backcountry Campsite Impacts Across the Absaroka-Beartooth Wilderness: 1994-2016</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>EMMA BODE - Microplastic Pollution in the Gallatin Watershed: Exploring Potential Sources through GIS</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>ISABELLE BRENES AND KEVIN SURYA - Pelvic Sexual Dimorphism in Modern Birds (Aves: Neornithes) and Its Evolutionary Relationship with Relative Egg Size</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>LAUREN BROGDEN - Shortest and Safest Routes to Local Breweries</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>HELEN KAY DAILEY - Assessing Eggshell Pigment Fossilization Potential with Artificial Aging</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>IAN DODDS - Spatial Assessment of the Environmental Effects of Coalbed Methane in the Powder River Basin</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>STEVEN FEAGLER - Examining Differences in Perception and Reality of Distance/Elevation Using GIS</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>KENDALL FRANKS - Surface Interpolation of Weed Presence in Wheat Fields for Use in Precision Agriculture</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>TOBIAS GOLDMAN - Mining Contaminants in Groundwater Within Paradise Valley, Montana: In Response to Multiple Future Proposed Mines</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>CHARLES CONNOR HAWORTH - Incorporating the ATES to Create a Terrain Model of Beehive Basin</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>ERIN HESS - Greenspace and Recreational Accessibility Analysis in Bozeman, Montana</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>ERIN HESS - Cadastral Database Management</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>KIMBERLY KORZYM - When Levees Fail: Chesterfield Commons Case Study</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>NATALI KRAGH - Sunken Forest Landslide: Characterization of Movement and Morphology Over Time Using Remote Sensing Techniques</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>NATALI KRAGH - Examining Isotope Scavenging Efficiency of Various Wet Depositional Processes in the Rocky Mountains</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>NATALI KRAGH - A Comparison of “Bulk Composition“ Determined by Energy Dispersive Spectroscopy and Surface Composition Determined by Auger Electron Spectroscopy of Naturally Occurring Sulfide Minerals</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>SAM LEUTHOLD - A Comparison of Remote Sensing and GIS Methodologies for Predicting Soil Salinity Hazard</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>NEAL MAGUIRE - Statistical Integration of Spatial Datasets in a Predictive Model for Copper Occurrences in Western Montana</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Author</td>
<td>Title</td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>NOELLA MINER</td>
<td>Analyzing City Transportation Variables to Compute a New City Bus Route in Bozeman, MT</td>
<td></td>
</tr>
<tr>
<td>GRACE NICHOLAS</td>
<td>Deciphering the Preparatory and Triggering Factors Responsible for Post-glacial Slope Failures: Insights from Landslide Age and Morphology in Yellowstone National Park</td>
<td></td>
</tr>
<tr>
<td>GARRETT QUIGLEY</td>
<td>Traffic Incident Mapping in Bozeman, MT using GPS-Based Geocoding</td>
<td></td>
</tr>
<tr>
<td>COLIN QUINN</td>
<td>Rough Around the Edges: A Preliminary Spatial Analysis of Hillslope Roughness and Sediment Storage in the Bitterroot Mountains, Montana</td>
<td></td>
</tr>
<tr>
<td>NICHOLAS ROLSTAD</td>
<td>Creating an Interactive Geologic Map: Wah Wah Mountains North and Tule Valley, Utah</td>
<td></td>
</tr>
<tr>
<td>ERICH SCHREIER</td>
<td>Oreamnos americanus Habitat in Montana</td>
<td></td>
</tr>
<tr>
<td>JOHN SYKES</td>
<td>Using GPS Tracking to Analyze Terrain Use of Lift-Access-Backcountry Recreationists on Saddle Peak, Bridger Mountains, Montana</td>
<td></td>
</tr>
<tr>
<td>DAVID WADE</td>
<td>Tracking Levels of Arsenic in Wells Over Time: Gallatin County, MT</td>
<td></td>
</tr>
<tr>
<td>BILL WALOWITZ</td>
<td>FARSITE as a Historical Modeling Tool</td>
<td></td>
</tr>
</tbody>
</table>
Welcome from the Earth Sciences Student Colloquium Chair

Hello, and thank you for attending the 2017 Earth Sciences Student 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 the goal of showcasing student research. I am happy to announce that students from Land Resources & Environmental Science and Ecology will be joining those from Earth Sciences in presenting their research this year.

We would like to thank our Keynote Speaker, Doug Chabot for giving his valuable time to participate in this event. Special thanks also to Ms. Melody Bechberger, an MSU Earth Sciences Alumna, for continuing her role in our event; your workshops have been an invaluable addition to the Colloquium.

We would like to thank the following sponsors for their financial support:
- Barnard Construction
- ASMSU
- Susan Dougherty
- Wild Bear Adventures
- John and Ramona Baden, Foundation for Research on Economics and the Environment (FREE)

I’d like to offer my deepest gratitude to the other graduate students on this year’s Colloquium Planning Committee for your enthusiasm, dedication and friendship. Even with a full schedule comprised of teaching, research, thesis/dissertation writing, fieldwork, 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 that you all made my job easy, and that without each of you, this event would not be possible. Thanks for a great year!

With warm regards,

Kathryn Bills Walsh
2017 MSU Earth Sciences Student Colloquium Chair
Welcome from the Earth Sciences Department Head

Welcome to the 12th 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 fourth-year PhD students. The Colloquium provides an avenue 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 Advisory Board for taking time to 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 Hubbard
Department Head and Professor of Structural Geology and Tectonics
Earth Sciences, Montana State University
A heartfelt thank you to fellow graduate student Mike Frothingham for coordinating poster printing with Selby's, who graciously provided poster printing at no cost to our student presenters.

Join Us for the 2018 Colloquium

The Earth Sciences Student Colloquium is an important opportunity for our undergraduate and graduate students to share their research and practice their professional presentation skills. We invite you to become part of this long-standing tradition at Montana State University with the 13th Annual Colloquium. Email us for information about becoming a sponsor, donating to the silent auction, and/or volunteering on the steering committee at msu.earthsciences.colloquium@gmail.com.

Thank you for supporting Montana State University’s undergraduate and graduate students in the Department of Earth Sciences!
Keynote Speaker: Doug Chabot

The Twin Arcs of Climbing and Avalanche Forecasting

Doug Chabot is the Director of the Gallatin National Forest Avalanche Center (GNFAC), which provides avalanche, snowpack, and mountain weather information to the public and offers basic avalanche education. For this year’s Colloquium, he will discuss his experiences as an avalanche forecaster and climber.

Doug received his B.A. in Outdoor Education from Prescott College in 1986. From 1990 to 1999 he worked as a professional ski patroller at Bridger Bowl Ski Area in Bozeman, Montana. Doug is also a mountain guide and climber. He has been on numerous climbing expeditions to Alaska, Nepal, India, Afghanistan, Tajikistan, and Pakistan, resulting in many first ascents and new routes. In 2011, Doug co-founded Iqra Fund, a nonprofit doing education work for girls in northern Pakistan (www.iqrafund.org).
Oral Presentation Abstracts

KATIE EPSTEIN - 'Vision' to Reality: Emerging Public Opinion of Collaborative Management in the Greater Yellowstone Ecosystem

In the Greater Yellowstone Ecosystem, the most established avenue for collaborative resource management is the Greater Yellowstone Coordinating Committee (GYCC), a coordinating body comprising local units of the four federal land management agencies in the region. Coordinating ecosystem-scale land management activities has been a primary concern of the GYCC since its inception and has been the source of intense public scrutiny, especially following the 1991 ‘Vision Exercise’ which sought a coordinated ecosystem management plan for the region. As collaborative processes remain an important tenet of modern resource management, we revisit current public opinion surrounding interagency collaboration in the Greater Yellowstone. Using Q-method and semi-structured interviews we identify three distinct stakeholder typologies which show reduced polarity in public opinion despite lingering roadblocks towards acceptance in key stakeholder groups. We consider the emergent public opinions and offer recommendations for future collaborative interagency management and programs.

ROB BRIWA & NICK BERGMANN - Reconciling Centennial Visions of the National Park Service

Postcards are cultural texts that capture and convey visions of specific geographic imaginations. The power of these objects to act as normative forms of visual rhetoric shape the ways in which people understand places and the institutions involved in their governance. Nowhere, perhaps, are these powers better illustrated than in the National Park Service's (NPS) postcard collection commemorating its 100th anniversary. Comprised of 59 color postcards, this collection constructs a visual narrative of the national park system grounded in traditions of romanticism and wilderness. It also represents a departure from the NPS’ dominant discourse of diversity and accessibility found in its other media promotions. Through a comparative examination of these narratives, this paper identifies the self-reflective and oft-contradictory meanings of the National Park Service Centennial. In order to uncover competing narratives, we performed a visual content analysis of the postcard collection and found five overlapping visions representing the National Parks in the public geographic imagination. This methodology contributes to ongoing discussion within geography seeking to understand how place identity is crystallized in visual imagery. We then examined how the National Park Service articulates its centennial goals through selected policy documents, reports, and public speeches, and identified the NPS’ infrastructural and mission-oriented goals for the future. Ultimately, we argue that a critical analysis of points of convergence and divergence found in the latent messages of the postcards and the NPS policy narrative reveals meaningful contradictions and offers insights into areas where the messages might be better reconciled.

DIONNE ZOANNI - Traditional Ecological Knowledge and Water Governance at Fort Peck Reservation, MT

The Fort Peck Indian Reservation is located in northeast Montana and is home to the Assiniboine (Nakona) and Sioux (Dakota) Tribes. Conventional oil and gas development and the disposal of
produced water 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. Although the tribes are aware of the contamination plume, exploiting newly accessible shale resources has become a viable option as the tribes continue to try to alleviate the high unemployment and poverty rates of tribal members. Even so, tribal members and authorities also understand the importance of ecological health in fostering a healthy community. A strong movement of cultural resurgence has been in motion, with tribal members looking to traditional knowledge in order to guide the future of the community and create community cohesion. Traditional ecological knowledge (TEK) has been heralded throughout contemporary governance literature as an important dynamic resource for indigenous communities that deal with difficult decisions involving resource management. Using a TEK framework and interviews with tribal members, this research seeks to answer the following questions: 1) What is the TEK that surrounds water and its use for the Assiniboine and Sioux tribes? 2) How is TEK reflected and incorporated into the existing tribal water governance structures at Fort Peck? 3) How does unconventional oil and gas development fit within the tribes' TEK framework, specifically in terms of the production and disposal of produced water (brine)?

KATIE BILLS WALSH - Keeping up with Colstrip: 2017 Legislative Developments and the Status of Montana’s Largest Coal-fired Power Plant

The uncertainty surrounding the status of Colstrip, the second largest coal-fired facility west of the Mississippi River, has been heavily publicized and politicized over the 2015 and 2017 Montana legislative sessions. The most pressing questions concern the potential decommissioning of generators 1 and 2, the oldest of Colstrip’s four generating units, that were constructed in the mid-1970s. Per a settlement between Colstrip’s operators and prominent environmental organizations after litigation over Clean Air Act compliance, units 1 and 2 must be retired by July 1, 2022. However, legislative developments indicate that these units may be shut down as early as late-2017. This research utilizes analysis of policy, legislative history, and relevant documents to understand the status of Colstrip and its most likely future. Policy analysis regarding requirements for coal plant decommissioning and remediation are summarized and analyzed based on the latest reclamation science and policies of other states in the Northern Great Plains (WY, ND, SD). It has been found that since Colstrip 1 and 2 are no longer economically viable due mostly to market factors, the likely result is the shutdown of those units well before the 2022 deadline despite the best efforts of many (i.e. legislators, lobbyists, Colstrip community groups etc.) to keep the plant fully functioning until the deadline. Decommissioning is an ambiguous process and current policy mandates require improvement to ensure complete environmental remediation and consideration of the full scope of economic and social impacts that would likely result from the closure of Colstrip 1 and 2.

KRISTIN K. SMITH - Infrastructure & Sugar Beets: A Revised History of Sidney, Montana

Richland County is the largest producer of sugar beets in Montana, and the Sidney Sugars factory in Sidney, the county seat, is a cornerstone of the community’s identity. Yet, the county’s semi-arid climate is not well suited to the crop. While sugar beets require an average of 22-28 inches of water during the growing season, Sidney only receives 13.5 inches of rainfall annually. This
presentation explores how sugar beets came to be a staple crop in the county with a focus on how the Lower Yellowstone Irrigation Project enabled irrigated farming. Using a combination of historical documents, photographs, maps, literature, socioeconomic data, and my own participant observations, I examine the history of sugar beets in Sidney with the goal of contributing to the growing revisionist literature on the history of the American West. This approach builds from the assumption that capitalism has modified and shaped landscapes and settlement patterns and, as such, the historic political economy has everyday impacts on the present. Further, the infrastructure that enabled sugar beets creates a path dependency that continues to (re)define the community’s identity, politics, and economic opportunities. The history of sugar beets in Sidney illustrates how globalization and capitalism have shaped and continue to shape this rural city in the American West, while also pointing out the idiosyncratic moments of history that cannot be explained by the political economy.

WILLIAM NANAVATI - Human-Environment Interaction in Patagonia
The Patagonian forest-steppe ecotone along the eastern Andes of Argentina is one of the most striking vegetation boundaries in the world. This ecotone has been dynamic, shifting in location and composition depending on levels of moisture and disturbance - primarily, fire. Although Native American populations have inhabited Patagonia and used fire throughout the Holocene, there is still much debate regarding the extent to which humans altered vegetation before Euro-American settlement at the end of the 19th century. To address this knowledge gap, I integrate the results of new pollen and charcoal analyses with published paleoecological, archaeological, and ethnographic data.

Pollen and charcoal analyses from Lago Fontanito (44.90 S, 71.56 W; 1110 m) and Lago Mosquito (42.49 S, 71.40 W; 550 m) are broken into three cultural periods: (1) before Native American population growth (before 5050 BC; 7000 BP); (2) Native American population growth (5050 BC Æ ’ AD 1880; 7000-70 BP); and (3) after Euro-American settlement (after AD 1880, 70 BP). Before the Native American population growth, changes in vegetation were closely associated with warmer and wetter trends in climate, transitioning from steppe to a closed Nothofagus forest by 7000 BP. After 7000 BP, co-occurring growth in Native American population and increased climate variability make difficult the separation of natural and anthropogenic drivers of vegetation change. Following Euro-American settlement, land-use is signaled by a decrease in Nothofagus, increased fire activity until the adoption of fire suppression in the 1940s, and the introduction of non-native species.

XIANGMEI LI - Assessment of Regional Social-Ecological System Resilience between Two Grassland Management Patterns: A Case Study from the Tibetan Plateau
Over the past two decades, two different grassland management patterns, the multi-household management pattern (MMP) and single-household management pattern (SMP), developed on the Tibetan Plateau. By using resilience-driven thinking, this paper compares the outcomes of the two management patterns by measuring the resilience of four categories: grazing, ecological, economic, and social systems. This paper assesses four categories of multi-dimensional impacts on smallholder communities with 20 metrics including grazing space, transhumances, water
sources, vegetation (cover, biomass, species richness), soil, expenditure, infrastructure, health, assistance, social relations, culture inheritance, and institutional arrangements for the social system. The results show that the MMP exhibits a greater and more equitable utilization of various natural resources. Each system of the MMP scenario has a relatively higher level of resilience. This problematizes assumptions about resilience – namely, that the contracting of grasslands to private entities on the Tibetan Plateau may not bring high resilience. However, the maintenance of traditional management practices, social networks, trust, well-connected family relations, and highly efficient informal institutions could reduce the risk of unsustainable development of ecological and social systems.

LAZARO WILLIAN VINOLA - Fossil Record of the Rock Iguana Cyclura (Family: Iguanidae) in Cuba: Implications for its Systematics, Paleoecology and Paleodistribution

The West Indies is one of the areas with the highest biodiversity and high number of endangered species. Endemic to this region is the genus of Rock Iguanas, Cyclura. This genus has been studied as a model to understand the dispersion and speciation processes that took place in this group of islands. The discovery of new fossils remains from five Pleistocene-Holocene deposits in western Cuba suggest the presence of a form of Cyclura larger than C. nubila that coexisted with this species. Morphological comparison with all Cyclura species and histologic comparison with C. nubila were used to assign the remains to C. lewisi. This taxon is the most endangered species Cyclura and is only known from Grand Caiman. Interspecific competition, extirpation, and response to human modification of both taxa have further implications for the conservation. Remains of C. lewisi in Cuba indicate a wider distribution in the past and places Cuban as a most suitable center origin, instead of Gran Caiman as was supposed. The extirpation of the biggest taxa agree with previous studies on lizards, where the risk of extinction and extirpation is strongly positively correlated with increasing body size and insularity. At the same time recent studies have pointed out the occurrence of C. lewisi haplotype in specimens of C. nubila from Cuba. This result, along the cooccurrence of fossils of lewisi and nubila in three localities, plus the existence of some intermedium specimens on those localities, is interpreted here as possible evidences of ancient hybridization between species.

KEVIN SURYA - Pelvic Sexual Dimorphism in Modern Birds (Aves: Neornithes) and its Evolutionary Relationship with Relative Egg Size

Pelvic evolution from non-avian to avian dinosaurs (modern birds) is often assessed biomechanically, with functions ranging from weight-carrying, ventilation, and locomotion/flight. Recently, reproduction has been hypothesized to have constrained and shaped pelvic morphology along this lineage. Opening of the pelvis by separating the pubes is thought to have allowed an increase in relative egg size and changes in the egg shape. Since reproductive ability would be advantageous for females, pelvic dimorphism may have evolved in this group. Pelvic dimorphism and its correlation with reproduction in non-avian reptiles and mammals have been extensively studied, but not in modern birds. We are currently investigating pelvic size dimorphism using a multiple regression on representative species from the major group of modern birds (n=30). This will test if there is a significant difference in pelvis dimensions between sexes after accounting for body size. We will also use phylogenetic regression to test for a correlation between dimorphism
and relative egg size. Completion of this study will not only result in a better understanding of how the avian pelvis evolved, but also of how sexual selection modifies skeletal anatomy. The outcomes of this research may produce a reliable method for determining the sex of extinct dinosaurs, which has been a major hurdle to paleobiological research.

RICHARD CARR - Population Study of a Fossil Fish Assemblage from the Jurassic Sundance Sea with Remarks on Paleodistribution and Taphonomic Environment

During the Middle and Late Jurassic period, the continent of North America was divided by a shallow inland sea which extended from the Arctic Ocean to Northern New Mexico. Today the deposits of this sea are represented by the Sundance Formation and associated limestones and shales throughout the central western U.S. The use of ammonite index fossils suggest that the age of this formation spans from the Bathonian to the Oxfordian. Many well preserved specimens of large marine reptiles are known from the Sundance Sea; however, relatively little attention has been given to the fish taxa from this seaway. Fieldwork conducted by the Museum of the Rockies has produced a large collection of fossil fish from the Sundance Formation. These fish are commonly preserved as mostly complete and articulated, though highly compressed, body fossils. Interestingly, pigment is preserved in the orbits of nearly every fossil, and in some cases, external scales are preserved intact while the internal skeleton is completely absent and vice versa. Based on visible cranial and scale morphology, these fish are tentatively identified as Hulettia americana. This represents the first occurrence of this taxon in Montana. In the near future, statistical, histologic and micro-CT analysis will be conducted in an attempt to determine the age of individual specimens and examine the variation in this fish assemblage. These fossils offer insight into the paleodistribution of this species and also the local paleoenvironment by indicating the marine environments this species once inhabited.

JACOB GARDNER - The Big Bowfin of Glacier: Biodiversity and Preservation of Eocene Fish in Northwestern Montana

In the summer of 2014, two undergraduate students from Montana State University collected a large fish fossil (USNM 618000) from an insect site in the Eocene Kishenehn Formation (43.5 Ma) of northwestern Montana. The large-bodied fish fauna in this formation is understudied due to a preservation bias towards small fish and insects. These large-bodied fish, such as amids (bowfins), are only known from fragmentary remains from which taxonomic resolution is only diagnosable to the family level. Here we describe the first nearly complete amiid fossil from the Kishenehn Formation. We assign this specimen to the genus Amia based on the presence of pointed coronoid teeth, a long and narrow parasphenoid tooth patch, and a long preural region. The assignment of this specimen to the species level is more challenging. It exhibits a unique combination of features, including a total of 91 centra (like Amia calva), 8 ural centra (like A. scutata and A. pattersoni), and a concave ventral margin on the first postinfraorbital (like A. hesperia). USNM 618000 also exhibits a unique feature, a spade-shaped rostral; however, the discovery of more specimens is necessary to verify that this feature is not due to preservational effects. This new specimen enhances the known biodiversity of large-bodied fish from this formation. The size of USNM 618000 (~59cm length) is also anomalous for its completeness in comparison to the size of the more abundantly collected Amyzon (sucker fish; < 8cm), which casts doubt on the validity of a preservation bias towards small species.
SYLVIA NICOVICH - An Earth Processes Approach to Understanding Martian Alluvial Fan Dynamics

Alluvial fans of Earth typify depositional environments thought to pervade Mars. With the advent of satellite imagery to capture the exposed Martian surface, planetary geomorphologists have been enabled to interpret surficial processes of genetic landscapes through comparison to those present on Earth. Analogues may be drawn from our terrestrial home, especially in arid regions, and applied to our red neighbor. In combination with acting as a Martian analogue, the San Luis Valley of southern Colorado is an ideal natural laboratory to assess the role of glaciation on alluvial fan development. This high elevation desert valley is bound to the east by the Sangre de Cristo Mountains, a precipitous range with multiple drainage basins that source alluvial fans of the piedmont. These fans are sourced from drainage basins with different levels of glacial influence; those that have hosted moving ice and those that have not. Sedimentary and morphometric analysis of the debris-flow alluvial fans of the western flank Sangre de Cristo Mountains serve as an added instrument to investigate probable geomorphologic processes on Mars, including those effected by cryogenics. This project lays the observational framework for the effects of alpine glaciation on fan sedimentation to be scrutinized while bolstering the breadth of space-related studies, including landscape interpretation of Mars through remote sensing information.

NEAL MAGUIRE - The Impact of Pore Fluid Pressure on Brittle Deformation as Demonstrated by the Beer Can Experiment

One of the problems facing 20th-century structural geologists was to explain how large thrust nappes could be transported long distances without being crushed under their own weight. In 1959, Hubbert and Rubey presented their famous “beer can experiment” to illustrate the hypothesis that movement of large thrust sheets along low-angle faults could be facilitated by high fault zone fluid pressure beneath thick sedimentary overburden. This is made possible because increases in pore fluid pressure within a block reduce its frictional resistance to fracture through reduction of the block’s effective normal stress and the critical shear stress needed to induce slippage along a plane. Performing the beer can experiment involves placing a chilled, inverted beer can on a glass plane that has been coated with a thin film of liquid and inclined to 1°. As air trapped inside the can warms, internal pressure increases and the can begins to slide. Since this research was first published, the effects of high fault zone pore fluid pressure have been observed in the basal decollements of the Barbados Ridge accretionary complex and northwestern Taiwan’s fold-thrust belt (Westbrook and Smith, 1983; Suppe and Wittke, 1977). Increased pore fluid pressure from military underground chemical-waste disposal was also cited as the cause of the mid-1960’s Denver earthquakes (Healy, 1968; Hsieh and Bredhoef, 1981). Locations of highly porous zones with anomalously high pore fluid pressure within accretionary complexes have been interpreted from low-velocity regions in seismic reflection profiles (Cobbeld et al., 2009). Critical taper wedge mechanics have been used to show that the weak basal decollement of the Niger Delta is the result of high pore fluid pressure (Bilotti and Shaw, 2005). Pore fluid pressure remains an important consideration when analyzing the occurrence of faults and fractures.
Poster Abstracts

WHITNEY ADAMS - Backcountry Campsite Impacts Across the Absaroka-Beartooth Wilderness: 1994-2016
The Wilderness Act of 1964 created a National Wilderness Preservation System that is managed by various federal agencies for the protection of wild areas. The designated wilderness is meant to preserve a natural environment largely unaffected by man, as well as provide recreation opportunities, so monitoring human impact is vital. The Custer-Gallatin National Forest has inventoried backcountry campsites within the Absaroka-Beartooth Wilderness of Montana and Wyoming five times from 1994 - 2016 as a method of monitoring human impact in the wilderness. Information about vegetation and mineral soil loss, tree damage, and other human impacts were collected at over 1,000 campsites for each inventory. This information is used to generate campsite impact scores that can be compared across sites over the observed period. These scores can be analyzed across the wilderness through the use of GIS. Historical trends and current problem areas will be identified through hotspot analysis. Campsites within a 500 ft. buffer of stocked lakes will be identified to assess the correlation between stocked lakes and campsite impact scores. Maps identifying areas of highest impact as well as statistical charts showing impact trends will be created to aid Forest Service wilderness management decisions.

EMMA BODE - Microplastic Pollution in the Gallatin Watershed: Exploring Potential Sources through GIS
Breakdown and dispersal of plastic pollution throughout the world’s aquatic environments is a widespread and alarming environmental problem. Microplastics (MP), plastic pieces smaller than 5 mm, have been documented in all the world’s oceans as well as in urban and alpine freshwater environments. A focus of this emerging field studies MP in freshwater ecosystems to determine sources and mechanisms of plastic transport from terrestrial to marine environments. Urban runoff is a recognized source of freshwater MP pollution. At the headwaters of the Missouri River, the Gallatin watershed provides a unique opportunity to observe the effects of urbanization on freshwater MP levels. Through Adventure Scientists’ Gallatin Microplastic Initiative, volunteers monitor MP concentrations at 33 locations along the Gallatin River, the East Gallatin River, and Hyalite Creek. This study further analyzes the Adventure Scientist data. Linear regression is used to show the relationship between the impervious surfaces within the contributing area of each sample point and the average MP pollution level measured at that location. Inverse distance weighted interpolation of river volume between established USGS monitoring stations normalizes the collected MP concentrations across water volumes. Impervious surface data of the study area was generated via supervised classification of NAIP areal imagery. The results of this study reveal if the relative amount of impervious surface within the contributing area of each sample location influences MP levels in the Gallatin watershed. Determining MP sources will allow managers to regulate MP pollution within the Gallatin Valley.
ISABELLE BRENES AND KEVIN SURYA - Pelvic Sexual Dimorphism in Modern Birds (Aves: Neornithes) and Its Evolutionary Relationship with Relative Egg Size

Pelvic evolution from non-avian to avian dinosaurs (modern birds) is often assessed biomechanically, with functions ranging from weight-carrying, ventilation, and locomotion/flight. Recently, reproduction has been hypothesized to have constrained and shaped pelvic morphology along this lineage. Opening of the pelvis by separating the pubes is thought to have allowed an increase in relative egg size and changes in the egg shape. Since reproductive ability would be advantageous for females, pelvic dimorphism may have evolved in this group. Pelvic dimorphism and its correlation with reproduction in non-avian reptiles and mammals have been extensively studied, but not in modern birds. We are currently investigating pelvic size dimorphism using a multiple regression on representative species from the major group of modern birds (n=28). This will test if there is a significant difference in pelvis dimensions between sexes after accounting for body size. We will also use phylogenetic regression to test for a correlation between dimorphism and relative egg size. Completion of this study will not only result in a better understanding of how the avian pelvis evolved, but also of how sexual selection modifies skeletal anatomy. The outcomes of this research may produce a reliable method for determining the sex of extinct dinosaurs, which has been a major hurdle to paleobiological research.

LAUREN BROGDEN - Shortest and Safest Routes to Local Breweries

Getting from point A to point B is an everyday task faced by many. Finding the shortest and safest route to your destination is important in moving through your day to day tasks. In Bozeman, Montana, breweries are becoming increasingly popular, and finding safe and quick routes for driving, biking, and walking to them is important. In this study, the shortest and safest routes to local breweries from Montana State University were found. Shown here are the optimal routes for the three forms of transportation: driving, biking, and walking. Through a network analysis, different factors that come into play when determining whether one route is safer than another can be looked at. Some important factors may include the type of road used, as well as the width of the road. A network analysis can also be used to find the shortest routes from point A to B (campus to a specific brewery). Our results will show the shortest and safest routes for either driving, biking, or walking from Montana State University to local breweries. The methods used in this study to find optimal routes are relevant in many other situations, and can even be extended in this study by utilizing local bus system routes.

HELEN KAY DAILEY - Assessing Eggshell Pigment Fossilization Potential with Artificial Aging

Modern bird eggs are unique from those of reptiles in that they may be naturally colored via pigment. This coloration has a variety of uses in bird reproduction, from egg camouflage to heat regulation. Recently, evidence was found to support the presence of pigment in fossilized dinosaur eggs. The purpose of this study is to determine the likelihood of pigment preservation in eggshell that has undergone fossilization. Two aspects of the fossilization history of eggshell are considered: pre- and post-burial conditions. Pre-burial conditions include exposure to sunlight and meteoric water. Sunlight is simulated using a UV lamp, while meteoric water is simulated using dry ice in distilled water, producing carbonic acid. Post-burial conditions consist of exposure to
temperatures which are either much higher than expected during fossilization, or that are expected. Emu eggs are used to test the preservation potential of biliverdin, the pigment responsible for blue-green coloration. Brown chicken eggs are used to test the preservation potential of protoporphyrin IX, the pigment responsible for brown coloration. White chicken eggs are used as a control. Preservation potential is assessed by comparing the presence of pigment in unaltered eggshell to the presence in eggshell altered either by only pre-burial conditions or by both pre- and post-burial conditions. This is done using high performance liquid chromatography (HPLC) and histological thin-sectioning. HPLC provides chemical identification of pigment. Histology provides visual comparison of coloration and structural changes across conditions. Results will aid in ascribing color to fossilized eggshell and expand knowledge about dinosaur reproduction.

IAN DODDS - Spatial Assessment of the Environmental Effects of Coalbed Methane in the Powder River Basin
This research project concerns oil and gas wells in the Powder River Basin (PRB), and specifically focuses on orphaned coalbed methane (CBM) wells and how they relate to split estate property ownership and their effect on environmental factors. An orphaned well is a well which has been abandoned and is inactive and generally no longer associated with any particular company. The scope of this project will not be limited to orphaned wells and will attempt to assess environmental effects of all mining in the PRB, specifically Campbell and Sheridan Counties. The Powder River Basin is a region encompassing Northeastern Wyoming and Southeastern Montana with longstanding resource dependence and vast coal deposits and coalbed methane reserves. The PRB is an agriculturally dependent region that relies on clean environmental assets such as surface water for irrigation, livestock, and other uses. This sort of environmental assessment will be useful to aid in an ongoing discussion between extractive industries and other stakeholders in the PRB. An abundance of data concerning natural gas development and spatial features in the Powder River Basin exists online for access on a number of geospatial hubs and clearing houses. This data can be brought into ArcGIS and will provide the means for spatial overlay and analysis of wells, infrastructure and environmental features. Final products and deliverables will be in the form of extracted statistics and informational maps. Maps will be provided in large poster size for presentation and overall aesthetics.

STEVEN FEAGLER - Examining Differences in Perception and Reality of Distance/Elevation Using GIS
On hikes, especially on unmarked trails, it is easy for hikers to miscalculate their distance traveled and elevation gained. This research aims to determine if canine companionship influences the discrepancy between perceived and actual distance/elevation traveled by hikers since the company of a dog is shown to have numerous psychological benefits and because error in perception of distance can be influenced by psychological factors. To do this, 25 hikers (13 with dogs) were given Garmin GPS units (in sealed cases) at the M and Drinking Horse trailheads before starting hikes of varying distances and elevations. Upon return, hikers were asked how many miles they had traveled and their maximum elevation gain. The tracks, (recorded at 5-second intervals) along with a 1/3 Arc-second digital elevation model were input into ArcGIS and measured for actual distance traveled and elevation gained. The percentage difference between the perceived and actual distance/elevation for all hikers was then calculated. Paired t-tests and Welch two sample t-tests
performed in R revealed that there is no significant difference between perceived and actual distance/elevation among hikers with and without dogs who participated in the research. In addition to contributing to the existing body of knowledge on the psychological effects of canine companionship, these results may serve as an aid in municipalities’ decisions impacting the allowance of dogs and other domestic animals on trails.

**KENDALL FRANKS - Surface Interpolation of Weed Presence in Wheat Fields for Use in Precision Agriculture**

There exists a growing interest in variable rate applications in precision agriculture (PA) that limits herbicide to areas where weeds are present. Mapping weed population distributions and environmental attributes represent the first steps in creating an effective weed management plan for a producer or researcher. However, obtaining all-encompassing weed presence and absence maps through technologies such as on-board sensors and unmanned aerial vehicles can be an enormous financial burden to farming operations. One alternative is to utilize surface interpolation through a geographic information system (GIS) to provide a reliable predictive map based on randomly sampled weed presence points in a field. Here we show the ability of kriging to predict weed occurrence in un-sampled areas of a field depending on soil moisture, available nitrogen, and aspect. Individual surfaces for these key inputs will be interpolated and combined using a weighted overlay. Three weight scenarios are presented to communicate which of the previously mentioned inputs one has the largest influence on weed presence. The results are confirmed through cross-validation, which will compare the prediction accuracy of known data points to the prediction of unknown points. These methods will help refine weed mapping models available in PA and reduce the cost and aggressiveness of weed management plans.

**TOBIAS GOLDMAN - Mining Contaminants in Groundwater Within Paradise Valley, Montana: In Response to Multiple Future Proposed Mines**

There are two new mines being proposed by Lucky Minerals Inc and Crevice Mining Group LLC near areas upstream of Paradise Valley, Montana, on the Yellowstone River. There are numerous local and environmental concern on the negative impacts that these two new mines could have on human and environmental health, especially on the groundwater in the areas near the Yellowstone River. There are a multitude of mines that have been developed near Gardiner, Montana down toward Paradise Valley. This study, using GIS methodology, explores the effects that this past mining has had and currently has on the downstream groundwater. It aims to better understand the magnitude that two additional new mines could have on the surrounding and downstream environment. In this analysis, groundwater quality is examined through the use joining well data acquired from the Montana Bureau of Mines with the well’s spatial counterpart. The wells will be intersected with the main watershed and upper watersheds that make up Paradise Valley up to the headwaters of the Yellowstone River. This water quality data is divided into different categories containing concentrations of different types of potentially hazardous heavy metals (lead, arsenic, copper, etc.) as well as pH values for each of the wells determining if a well is dangerously acidic or basic. These categories (including pH) are then displayed spatially and within tables to determine patterns of contamination within Paradise Valley from upstream seepage of the contaminants from past mines.
CHARLES Connor Haworth - Incorporating the ATES to Create a Terrain Model of Beehive Basin

Beehive Basin in Southwest Montana is a popular year-round backcountry recreation area for both tourists and residents. In the winter and spring seasons, there is an abundance of avalanche terrain which recreationists must travel through. While the Gallatin National Avalanche Forecasting Center issues avalanche forecasts and advisories based on weather and field observations, it is up to the users to apply those forecasts into their terrain selection and decision-making. Experienced users are familiar with evaluating terrain; beginners are not and may be unaware of the risk. To assist recreationists, I will create a terrain model that maps the greater Beehive Basin area using parameters generated by Avalanche Terrain Exposure Scale (ATES), which was originally created to communicate public avalanche risk. This model will classify the terrain based on characteristics identified by the ATES into three classes; [1] Simple, [2] Challenging, and [3] Complex. These terrain classifications can be combined with the Avaluator decision-making aid, a graphic model that illustrates the occurrence of incidents as a function of terrain and avalanche hazard that day, to help inexperienced users make informed decisions when travelling in the backcountry. While there is GIS terrain analysis used to identify topographic polygons, the most important method will be the use of field observations to determine areas with an elevated avalanche hazard exposure. The result of this work will be a map indicating the ATES zoning at the trailhead that winter backcountry travelers can use to gain knowledge of the terrain and plan their route throughout the area.

Erin Hess - Greenspace and Recreational Accessibility Analysis in Bozeman, Montana

Greenspace and outdoor recreation areas are important to the health and well-being of every community. However, the spatial distribution of these spaces is often inequitable in terms of access. Geographical information systems (GIS) and network analysis are powerful tools for accurately measuring access. This study analyzes accessibility of all urban parks and recreational points of access in Bozeman, Montana for differing demographics, including race, age, and income. A network analysis was run in ArcMap using Bozeman roads, with geometric centroids of census blocks as the points of destination, and park and trailhead access points as the origins. Service areas for each park were created based on the park type. Demographic statistics within and outside of service areas were compared to analyze equitability of greenspace access. Service area results are overlaid on demographic data within the census blocks to spatially analyze who has access to greenspace in the Bozeman area, and visualize if access is equitable.

Erin Hess - Cadastral Database Management

The cadastral database is used to define ownership, dimensions, and the location of land parcels. It is an incredibly valuable resource in assessing land ownership and land ownership changes. These ownership trends are important in analyzing land-use and land-management changes over time as they relate to wildlife management. However, the database contains many errors as it is currently maintained. Entries in the database often name the same owner differently for two parcels, making it difficult to understand patterns of ownership without extensive and tedious manual data management. This research compares different automated methods of identifying land
ownership in the Paradise Valley. Large, private parcels were selected and then homogenized in a GIS based on varying attributes with the goal of identifying all parcels under each landowner in the Paradise Valley. The results are mapped to visually compare the error rate of each method. After initial homogenization, the data are manually edited and cross-checked to 100% accuracy. The results demonstrate methods of expediting cadastral data management to accurately identify all land parcels that are maintained by the same owner.

KIMBERLY KORZYM - When Levees Fail: Chesterfield Commons Case Study
In 1993 one of the largest and most costly floods in US history overtook the Mississippi River basin. In total the flood spanned nine states and caused more than $15 billion in damages. Despite a regular cycle of floods, the floodplains of Missouri continue to be developed, shielded by levee walls. However, levees do not guarantee safety in a flood event and many factors can cause a levee to fail. This project focuses on the Chesterfield Commons, a shopping district over 2 million square feet in size and 1.5 miles in length located on Missouri River floodplains. The aim is to present flood scenarios of a highly developed floodplain to analyze the extent of damage possible when a levee fails. For this study, flood inundation is mapped for the Chesterfield Commons area at 50, 100, 250, and 500-year flood recurrence levels with and without levee protection. The type of levee failure for these scenarios will be a simplified wall-breach event in which a hole will open the levee up to flood waters. The full extent of all possible failure scenarios for the Monarch Chesterfield levee system is not included. The project highlights the risk of building on floodplains despite today’s increased chances of a large flood event due to global warming.

NATALI KRAGH - Sunken Forest Landslide: Characterization of Movement and Morphology Over Time Using Remote Sensing Techniques
The Taylor Fork, located in southwest Montana, has only been thoroughly studied two times. Both previous studies focused on mapping the geology and glacial till that make up the valley, and were completed through field work. Today, technology can be utilized to characterize a landscape outside the field and can aid in better understanding the mass movement within the Taylor Fork. This project focused specifically on the Sunken Forest Landslide, a 1.5 mile long landslide located in the northeastern end of the Taylor Fork Valley. Using remote sensing techniques, we interpreted aerial photographs and analyzed the terrain within the landslide. Aerial photographs provided insight to overall acreage variance and head-scarp movement from 1947 to 2015. They also exhibited the ephemeral accumulation of water near the toe due to reactivation events. Terrain analysis gave roughness and curvature estimates, as well as an overall volume calculation for the landslide, pre- and post-reactivation in 2010. The results generated from applying remote sensing technology aid in comprehending how a landscape changes over time, determining areas that are most likely to be affected by future movement, and discerning the factors that contribute to alteration in a mass wasting system.

NATALI KRAGH - Examining Isotope Scavenging Efficiency of Various Wet Depositional Processes in the Rocky Mountains
In the study of geomorphology, it is critical to understand how sediment is transported within a landscape. Quantifying sediment transfer of mass can speak volumes about landscape formation
and degradation over time, along with the agents of change driving that movement. Some of the most effective tracers used to record these transfers are fallout nuclides delivered to earth’s surface by precipitation. These nuclides include naturally occurring Be-7, meteoric Be-10, Pb-210, as well as Cs-137, a by-product of nuclear testing. These isotopes are all delivered to Earth’s surfaces via wet and dry deposition (i.e. rainfall/snow and dust.) However, isotope delivery rates are poorly quantified and few studies have been conducted concerning which types of precipitation are most efficient at bringing these isotopes to surface. Previous studies have also not addressed the relationship between isotope delivery and precipitation amounts. Since September 2016, precipitation samples have been collected, filtered with a cation exchange resin, and run in a germanium crystal detector for gamma spectroscopy to identify isotopic signatures. Testing the activity of Pb-210 in varying precipitation types provides key insight into the scavenging efficiency for fallout nuclides delivered by wet deposition processes in the western United States. These results will give insight to current erosion and deposition regimes, and be potentially applicable to future studies concerning paleoclimate and erosion in the Rocky Mountains.

NATALI KRAGH - A Comparison of “Bulk Composition” Determined by Energy Dispersive Spectroscopy and Surface Composition Determined by Auger Electron Spectroscopy of Naturally Occurring Sulfide Minerals

Energy Dispersive Spectroscopy (EDS) and Auger Electron Spectroscopy (AES) were used to characterize the bulk and surface compositions of seven sulfide minerals (arsenopyrite, pyrite, tennantite, bornite, enargite, cobaltite, and chalcocite). A PHI 710 Scanning Auger Nanoprobe equipped with EDS, Electron Backscatter Diffraction (EBSD), and AES detectors, housed at ICAL, was used in this study. Secondary X-rays used to determine elemental composition derive from a 3-micron excitation volume under an electron beam, whereas Auger electrons emanate from only a few atomic layers (<10nm) on material surfaces. AES is a surface sensitive spectroscopy that has long been utilized in analyzing human engineered and biologic materials. However, AES has not been extensively taken advantage of in the study of naturally occurring geologic materials. In our experiments, we collected EDS spectra to identify elements present, followed by elemental X-ray mapping to show the distribution and heterogeneity of elements present in 7 minutes. Next, AES spectra were obtained on samples “as received” (i.e., exposed to environmental contamination) and after two minutes of sputtering using an argon ion gun (2nm of surface material was removed.) In detail, bulk composition and surface compositions are different due to sorbed components on mineral surfaces (e.g., C, As, Ag). AES has great potential in the Earth and environmental sciences to characterize surface mediated reactions such as sorption, catalytic, redox, and dissolution/precipitation reactions.

SAM LEUTHOLD - A Comparison of Remote Sensing and GIS Methodologies for Predicting Soil Salinity Hazard

Soil salinization is a serious problem for agricultural producers in the semi-arid west. Salinity problems can render a field useless, and create economic hardship for producers with affected land. Currently, there is not a comprehensive, reproducible way to assess the risk of salinization without expensive aerial photography manipulation, and a large amount of field samples. This study uses a combination of map algebra and database manipulation in an attempt to create a reproducible and robust predictive model of soil salinity hazard areas in the Winifred, MT test site. Results were
then compared to a remote sensing technique for assessing salinity that has been documented by several different research teams. This study presumably lays the ground work for giving agricultural producers the tools to understand which areas of their property may need more intense attention, and will hopefully lead to better land management practices and a reduction of saline seepage across the state.

NEAL MAGUIRE - Statistical Integration of Spatial Datasets in a Predictive Model for Copper Occurrences in Western Montana

Mineral exploration is the process of data collection to assess the mineral potential of an area. Geographic Information Systems (GIS) are valuable during the early stages of any exploration campaign to evaluate existing geologic data and produce regional-scale predictions of ore body locations. Although many mineral deposits are being mined worldwide, exploration for new metal resources is vital for sustaining industry and making technological advancements. In this research, the copper mineral potential for the state of Montana will be analyzed to produce a mineral potential map. This map will identify historic and current mining operations, like Butte’s Berkeley Pit and White Sulphur Springs’ Black Butte Project, as well as areas that merit further grassroots exploration. Data for this procedure will be obtained from publicly-available sources, such as USGS, and will include bedrock lithology, faults and igneous intrusions, and aeromagnetic survey data. After converting all data layers to a single spatial reference, phenomena within each layer will be classified as either positive or negative and spatially correlated with training sites defined by deposits with past or current production, using tools within the spatial data modeler for ArcGIS (ArcSDM) to assign weights to evidential layers based on the correlation’s strength. These predictive layers will be combined into a final mineral potential map using ArcSDM’s weights-of-evidence tool. This will reveal areas with high probability of hosting a favorable copper mineral occurrence, the extraction of which could strengthen Montana’s economy moving toward the future.

NOELLA MINER - Analyzing City Transportation Variables to Compute a New City Bus Route in Bozeman, MT

GIS methods have become the epicenter of most urban and population related planning activities. Methods such as network analysis and least cost analysis allow planners to create hypothetical paths based on many different factors that can be manipulated and changed to fit the fluctuating needs of urban areas. Bozeman’s population has been rising for years. While an increasing population can benefit society in many ways, it can also be detrimental if city infrastructure, amenities, and resources are lagging behind. My project aims to consider how the Streamline bus can expand its service area to the northwest region of town. The purpose of this project is to bring attention to alternative transportation methods while considering ways to both reduce each individual’s carbon footprint as well as address population growth and traffic congestion in the city, particularly around the University’s campus. Two methods, least cost and network analyses, will be implemented to complete this project. The network analysis will help determine where a new route should be based on relevant factors, and then the least cost analysis will determine the best route to reach the desired location in the study area. Project outputs will include a map of the study area showing a new proposed route, charts and tables further explaining how the route was
synthesized, and a discussion of how the project could be improved or grow with different parameters.

**GRACE NICHOLAS - Deciphering the Preparatory and Triggering Factors Responsible for Post-glacial Slope Failures: Insights from Landslide Age and Morphology in Yellowstone National Park**

Landslides are ubiquitous to postglacial landscapes worldwide, while paraglaciation is widely considered a major predisposing factor in landslide occurrence. Withdrawal of glacier ice exposes landscapes that are unstable, and consequently susceptible to erosion. Several disparate mechanisms can act as triggers. For example, glacial debuttressing can directly destabilize slopes; however, changes in climate and subsequent degradation of permafrost may also play a role. Distinguishing between these mechanisms often relies heavily on inference, and a quantitative metric remains elusive. The fundamental question behind this study is: What are the preparatory and triggering factors responsible for slope failure in postglacial landscapes, and how can they be distinguished? I propose that quantifying the temporal and spatial patterns of landslides can provide a diagnostic understanding of the long-term influences and short-term triggers of paraglacial slope failure. This research approach is based on the theory that the timing and morphology of landslides provide clues to their preparatory and triggering factors. Using relative and absolute dating tools, and morphologic analysis of landslide morphology, we will determine the age and mechanisms of post-glacial landsliding in our system. We expect one of three conclusions based on our results; these are our multiple working hypotheses.

(H1) *Causal factors are locally and directly linked to deglaciation.* If we observe N-S differences in landslide ages that correlate with known timing of glacial retreat, then deglaciation is likely a direct trigger (e.g., via debuttressing).

(H2) *Deglaciation is preparatory for slope failure.* If ages follow N-S patterns but do not directly correlate with (follow) glacial retreat, then deglaciation is likely preparatory for slope failure, but not a direct cause.

(H3) *Slope failure is not directly linked to glaciation.* We propose 1 of 2 scenarios. If ages follow no distinguishable pattern, timing of slope failure is stochastic and probability driven. However, if landslide ages are similar, then we infer external controls such as permafrost degradation due to a warming climate. This mechanism will be further explored by comparing measured timing with abundant paleoclimate and paleoenvironmental data from the region.

**GARRETT QUIGLEY - Traffic Incident Mapping in Bozeman, MT using GPS-Based Geocoding**

My project will address the process of traffic incident mapping in Bozeman, MT. This will be used to understand the location of past traffic incidents in order to identify dangerous intersections and sections of road where traffic accidents occur frequently. This information would be useful to anyone that uses these roads on a regular basis, as it will make people more cautious when driving through these areas. The Montana Department of Transportation would find this information very valuable as they have a say in future developments of our roads. GIS analysis will be used for
determining intersections and stretches of road that have had many accidents over the years. Bozeman and the surrounding area will be the focus of this project. Geographic coordinates will be used in order to identify traffic incident locations. The final output will be two separate dot density maps of Bozeman and the surrounding area showing the location and distribution of traffic related incidents in the summer and winter months. Data used in this study was gathered from the Montana Department of Transportation.

COLIN QUINN – Rough Around the Edges: A Preliminary Spatial Analysis of Hillslope Roughness and Sediment Storage in the Bitterroot Mountains, Montana

Mountainous hillslopes are subject to multiple controls on morphology throughout space and time. Vegetation is thought to impact the rate at which soils move across the landscape, this relationship is largely conceptually understood, but poorly quantified. Quantifying the dynamic interplay between soil and vegetation can improve understanding of the timescales of sediment storage, the rate at which sediment moves downslope, and the rate sediment is transferred to streams. Our question is: To what extent do forested hillslopes impede soil mobility across landscapes into stream systems, when compared to non-forested hillslope processes? We focus our efforts on two systems in Western Montana, in the Bitterroot and Sapphire mountains. We quantify the extent of above-ground vegetation using high-resolution LiDAR data in two 20 km2 study plots. Geospatial products of geomorphic relationships with nuclides and vegetation cover will provide a comprehensive view of the study sites. Using gamma spectroscopy, we will analyze these samples for fallout radionuclides (7Be, 137Cs, 210Pb) to spatially quantify the movement of soil over the landscape on a short time scale (<100 years). Variability in nuclide activities will be used to understand the downslope connectivity of soil movement and the relative differences in soil residence times. This study will provide new insight into the continuity of soils found in forested and non-forested mountainous terrain and how soils cascade across the hillslope and stream system.

NICHOLAS ROLSTAD - Creating an Interactive Geologic Map: Wah Wah Mountains North and Tule Valley, Utah

Geologic maps have largely been confined to paper despite the rise of the interactive web. Even when geologic data is digitized it is often presented only as a static PDF-style map with little advantage over a paper map. The recent rise of JavaScript libraries such Leaflet.js and the Mapbox platform provide geologists with programming knowledge the ability to create interactive and customizable geologic maps that can be viewed by anyone with an internet connection. Providing an example of this workflow, GIS data from multiple 30’ x 60’ Utah Geologic Survey maps was compiled, edited and correlated in ArcMap. Python scripting was then used to convert shapefiles to the web-friendly geoJSON format. Basic web technologies HTML, CSS and JavaScript were used with the Leaflet and Mapbox libraries in order to create an interactive geologic map of portions of Utah's Basin & Range.

ERICH SCHREIER - Oreamnos americanus Habitat in Montana

At high elevations and high latitudes of North America, glaciers have had a tremendous impact on the landscape. These former and currently glaciated regions have created unique habitats and
niches for the organisms that inhabit them. Mountain Goats (*Oreamnos americanus*) dominate steep and rocky terrain with a native range from the Northwestern contiguous United States through the Canadian Rockies and into southern Alaska. Some introduced *O. americanus* populations in Montana are thriving while others are declining. Geographic Information Science (GIS) methods such as weighted overlay have been utilized to model the habitat suitability of various species around the world using observed parameters. This study will explore the habitat of native and introduced *O. americanus* populations in Montana, using glaciated terrain as a parameter, to explore the cause of declining introduced populations. Other parameters that will be used include land cover and land use, slope, and elevation data. A weighted overlay habitat suitability will be generated for each study area; native populations in the Bitterroot Mountains, introduced and thriving populations in the Beartooth Mountains, and introduced and declining populations in the Elkhorn Mountains. This data has implications for identifying locations of stable *O. americanus* populations and can be used for wildlife conservation efforts and the allotment of hunting tags and districts.

**ERIN SHERVEY and MERIDITH MISKA - Clay Identification using X-Ray Diffraction and Scanning Electron Microscope in “Wild Clay Project”**

In an initiative with the International Wild Clay Research Project (IWCRP), the MSU Art Department and Earth Sciences Department are collaborating to apply geochemical studies to native clays of Montana and Minnesota. Bulk geochemical analysis was done through X-ray Powder Diffraction (XRD) and scanning electron microscope (SEM) techniques. Analysis of oriented clay mounts created using USGS guidelines found that the primary clay in the samples was illite. The minerals associated with this group included muscovite, biotite, microcline, anorthite, and albite. Quartz was found throughout most of the 14 samples. In addition to spot analyses, the SEM was used to analyze fired and glazed clay disks to determine the depth of glaze penetration and compositional or structural changes to the clays after being baked. The results of this study will be applied to the ongoing research done for the IWCRP as well as being applied directly to ceramics classes at Montana State University. The IWCRP hopes to encourage the use local clay and to advance sustainable practices in ceramic arts. The data collected with this project will be used serve as a foundation for a database about wild clays. The information in this database will allow artists to find a clay that is local, sustainable, and suitable for their ceramics. Further collaboration for the project is expected in the future, with the possibility of joint field trips between art and earth science students to study the places where these clays have been harvested.

**JOHN SYKES - Using GPS Tracking to Analyze Terrain Use of Lift-Access-Backcountry Recreationists on Saddle Peak, Bridger Mountains, Montana**

Poor decision-making by educated and experienced backcountry recreationists comprise a large portion of avalanche incidents and fatalities in North America. Previous research on decision-making in avalanche terrain based on accident analysis and user surveys has identified many ‘human factors’, or behavioral patterns, that lead to high risk decision-making. GPS tracking provides a quantitative analysis of terrain selection by backcountry users and, when combined with a public avalanche forecast and current weather conditions, can estimate the level of risk taken by each user. This research focuses on the analysis of the GPS tracks and implementation of a geographic information system (GIS) model to extract terrain metrics from publicly available GIS
data. The field site used for this data collection is Saddle Peak, in the Bridger Mountains, Montana. GPS tracks are collected from users exiting the ski resort boundary along Saddle Peak ridge, and re-entering the ski resort at the base of Schlasmans chair lift. Using GIS, each GPS track can be analyzed for slope angle, aspect, elevation, slope shape, and land cover type. These terrain parameters are primary indicators of avalanche terrain severity as developed by the Avalanche Terrain Exposure Scale (ATES), a standard for mapping avalanche terrain for public communication developed by Parks Canada and the Canadian Avalanche Center. We expect to see GPS tracks with lower slope angles and less exposure to severe avalanche terrain as the avalanche hazard level increases.

DAVID WADE - Tracking Levels of Arsenic in Wells Over Time: Gallatin County, Montana
With an increasing population in Montana, water rights have become a serious issue between ranchers, tribes, and homeowners. Availability and accessibility of water is just one issue, while contamination by the heavy metal Arsenic is another. Not only present in the wells themselves but also how those levels fluctuate over time. Using Geographical Information Sciences (GIS) as well as data from the Montana Bureau of Mines and Geology (MBMG) Groundwater information Center (GWIC) I show well data from Gallatin County and surrounding areas and their measured levels of Arsenic through time. My results show the need for more persistent tracking of Arsenic coming out of wells, not just in Gallatin County, but the surrounding areas where the geology provides a suitable environment for the leaching of Arsenic into the water supply. Continuous tracking of hazardous chemicals into the water supply would allow lawmakers, ranchers and homeowners to be proactive, and well informed of issues that arise through time.

BILL WALOWITZ - FARSITE as a Historical Modeling Tool
Wildland fires are burning more acreage every year, and large fires with extreme fire behavior are becoming more common. As development extends into the wildland urban interface, more structures are being damaged or lost to wildland fires. Fire modeling software, such as FARSITE, is a valuable tool to officials because it has the ability to create predictive models before a fire happens, allowing fire professionals to predict fire growth and fire behavior. There are many studies that detail the use of FARSITE as a management and forecasting tool because it is predictive and incorporates local area data. The ability of FARSITE as a historical modeling tool has also been investigated, however there is far less literature on this use. This project will analyze the effectiveness of FARSITE for modeling the Hayden Pass Fire that occurred in 2016 near Westcliff, Colorado. To analyze the effectiveness of FARSITE, data on land cover, fuel moisture, fuel load, forest data, slope, aspect, elevation, and weather and wind data that matches conditions on the fire will be input into FARSITE to run the simulation. Results will then be exported into GIS, where maps showing the FARSITE model, the known fire perimeter, and the FARSITE model with the known perimeter will be created. For FARSITE to be considered effective in this use, attention will be paid to how accurate the model is compared to the existing fire perimeter data.