TRACKING the

14th Biennial Scientific Conference on the Greater Yellowstone Ecosystem

HUMAN FOOTPRINT

Hosted by

YELLOWSTONE FOREVER

September 11-14, 2018
Big Sky, Montana
Huntley Lodge

NPS Photo - N. Herbert
Sponsors

The 14th Biennial Scientific Conference on the Greater Yellowstone Ecosystem is hosted by Yellowstone Forever, the official education and fundraising nonprofit partner of Yellowstone National Park.

To learn more, visit www.yellowstone.org.

In addition, scholarship and in-kind donations were received from the following:

- Grand Teton Association
- Greater Yellowstone Inventory & Monitoring Network, Grand Teton National Park, Yellowstone National Park
- W.A. Franke College of Forestry & Conservation, University of Montana

Special thanks to Jamie Roberts, Sophie Runyon, Emily Gray, and the excellent team at Big Sky Resorts

14th Biennial Scientific Conference Planning Committee

- Alicia Murphy, Yellowstone National Park
- Bianca Klein, Yellowstone National Park
- Brendan Moynahan, NPS-Rocky Mountains CESU
- Charissa Reid, Yellowstone National Park
- Dan Tyers, Gallatin National Forest
- David Diamond, Greater Yellowstone Coordinating Committee*
- Erik Oberg, Yellowstone National Park
- Holly McKinney, Grand Teton National Park
- James Pritchard, Montana State University
- Jeff Augustin, Yellowstone Forever
- Jennifer Carpenter, Yellowstone National Park
- Jim Peaco, Yellowstone National Park
- Jodi Hilty, Yellowstone to Yukon
- Justin Barth, Yellowstone Forever
- Kira Cassidy, Yellowstone National Park
- Kristen Legg, Greater Yellowstone I&M Network
- Lauren Walker, Yellowstone National Park
- Libby Metcalf, University of Montana
- Lori Iverson, USFWS Elk Refuge
- Marie Gore, Yellowstone National Park Partner
- Megan Boyle, Yellowstone Forever
- Neal Herbert, Yellowstone National Park
- Sarah Haas, Yellowstone National Park
- Sue Consolo-Murphy, Grand Teton National Park
- Tami Blackford, Yellowstone National Park
- Tobin Roop, Yellowstone National Park


Suggested Citation:

Welcome

Dear Conference Participants,

Welcome to the 14th Biennial Scientific Conference on the Greater Yellowstone Ecosystem (GYE). Since 1991 this conference series has been a critical forum for sharing science between researchers, management partners, conservation groups, and other stakeholders with a common interest in understanding the natural and cultural resources of the region.

This year our theme is Tracking the Human Footprint. We are focused on the human experience and the role scientific research and communication will play in shaping future management of the GYE. As population, visitation, and development continue to grow, integrating ecosystem economics, tourism, and conservation is critical to resource protection. Examining ecosystem vital signs and stressors can offer potential conservation solutions for decision makers.

For the first time in the history of this conference series we are convening outside of Yellowstone or Grand Teton national parks. We are thrilled to be in Big Sky, Montana! Spending time in a recreation-based community that is inextricably linked to its surrounding federal lands will help to highlight our conference theme—and its state of the art conference facilities will facilitate efficient presentations and productive networking.

The conference programming is once again organized around triple concurrent sessions. For each time slot you can choose to hear science talks from the Social or Natural Sciences tracks or to participate in alternative formats in the Community and Skills Building track, including lightning rounds, workshops, and an invitation to focus on collaboration as the key to conversation success bridging state and federal agencies, affiliated tribes, conservation NGOs, researchers, journalists, science communicators, and the public.

On our final day (Thursday) we have the opportunity to participate together in two innovative plenary sessions. First, Yellowstone Superintendent Dan Wenk will moderate a panel discussion featuring County Commissioners from around the GYE. And finally, we will close the conference with an interactive panel to identify key challenges and decisions facing resource specialists and managers in the GYE, and then to identify the overarching scientific questions that need attention in the coming years to fully inform those decisions.

These are consequential questions, and we believe all attendees have a responsibility to connect with each other and to strive together for answers. **To facilitate engagement, we ask that you download the free Whova application to your smartphone. Whova will allow you to keep track of the schedule, connect with your colleagues, fill out a conference survey, and provide feedback directly to each other and the organizing committee. (See Page 6)**

The Conference Program Committee
14th Biennial Scientific Conference on the Greater Yellowstone Ecosystem

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**Nathaniel P. Reed**, an environmentalist who led conservation fights across the country and helped turn the Endangered Species Act into law while serving as an assistant secretary of the Interior in the 1970s, died last month while on a fishing trip in Canada. He was 84.

Mr. Reed was an accomplished statesman and advocate. He was instrumental in permanently protecting 80 million acres of Alaska, the Marine Mammals Protection Act, the intact and expanded Redwoods National Park, the Endangered Species Act, and the Clean Water Act.

Nat had intended to attend the conference. We extend our condolences to his friends and family and remain grateful for his life dedicated to public service and environmental protection. We dedicate this conference to his memory.
Need Assistance? 406-570-2809
Conference Information & Services Available

Conference Information Hotline: 406-570-2809

Conference Check-In & Information Desk Hours
The conference check-in desk is located in the Huntley Lodge outside the Firehole Lounge near the front entrance. The check-in desk will be open from 2-6PM on 9/11; 7:30-9:30AM on 9/12. Poster set-up will be in the Missouri Ballroom on Tuesday, 9/11, from 2-6PM. Presenters will be required to download a copy of their presentation at check-in with our support specialist. Please call the conference hotline above during the conference to arrange for alternative arrangements. Registration is required for attendance.

Presentation Practice Room Hours
The presentation practice room is available during the day. Please contact a member of the conference committee (or ask at the front desk of the Huntley Lodge) for access.

Hotel Front Desk Hours
The Huntley Lodge front desk is staffed 24 hours a day, 7 days a week.

Internet Access/Code
No code is required for Wifi in the conference facility and lodging. See BigSkyResortWifi to login. Cell coverage is available throughout the venue.

ATMs
Three ATMs are located in Huntley/Shoshone Lobby, Summit Upper Lobby, and Mountain Mall.

Local Business Information
Please see Big Sky Chamber of Commerce or Big Sky Resort's website called "While You Are Here."

Medical Clinic/Hospital
If you have an emergency, dial 9-1-1. The newly constructed Big Sky Medical Center is open 24 hours a day and can be reached at 406-995-6995.

Chet's Bar/Lounge Hours
Breakfast 6:30-10:30AM
Bar 3:00PM - CLOSE
Food 4:00-11:00 PM

Groceries & Sundries
Hungry Moose (Mountain Mall - closet, small selection)
Hungry Moose (Meadow - small selection)
Roxy's Market (Meadow - largest full service grocery)
Country Market (Meadow)

On-site Coffee Shop
Mountain Mocha (Mountain Mall)

Breakfast (this is not provided by the conference)
Chet's Bar 6:30-10:30 AM
Hungry Moose carries breakfast sandwiches, bagels, and smoothies. Mountain Mocha has pastries available. Both are in the Mountain Mall. Additional breakfast options are available in the Meadow. A free shuttle is provided.
Communicate, Organize, Participate!

Get Whova for 14th Biennial Scientific Conference on the Greater Yellowstone Ecosystem

Official Event App

- Explore the professional profiles of event speakers and attendees
- Send in-app messages and exchange contact info
- Network and find attendees with common affiliations, educations, shared networks, and social profiles
- Receive update notifications from organizers
- Access the event agenda, GPS guidance, maps, and parking directions at your fingertips

Download Whova and take your event mobile.

Our event is using the Whova app. The app can be downloaded onto all smartphone types. We are using the app behind the scenes to register participants, track agenda changes, and even print name tags. On the front end, we hope you will download the app prior to arriving at the conference and familiarize yourself with the way it can help you enjoy the conference. It is easy to use, full of great features that we think you will find useful, and a great way for us to allow you to share your information while protecting your privacy.

With the easy-to-use INTERACTIVE AGENDA, you’ll be able to check-in to sessions you want to join and create a customized agenda. Did a speaker or panelist bring up something that you’d like to start a discussion about? With the app, you will be able to leave a COMMENT on a session and share your thoughts as well.

Plenary sessions will be utilizing the app for REAL-TIME POLLS AND QUESTIONS. Have it at the ready!

Are you looking for a ride to the airport? Want to gather a group of bird biologists for a breakfast conversation? Have a lost and found item? Need to ask the conference organizers a question? The COMMUNITY BOARDS allow you to do all of the above.

We will be using the app to send participants messages (room changes, cancellations) and for the final conference evaluation as well. Please let us know if you have any concerns or questions.
Keynote Speaker: Ray Rasker, PhD

Ray is the Executive Director of Headwaters Economics, an independent, nonprofit research group. Headwaters Economics' mission is to improve community development and land management decision. This is accomplished through focusing on topics such as the economic role of federal lands, state tax policy, reducing wildfire risk to communities, expanding community trails and pathways, economic development, and free analytical tools for helping to understand the link between the economy and the environment.

Headwaters Economics partners with rural communities, state legislatures, the Forest Service and Bureau of Land Management, universities, and nonprofit organizations to accomplish its mission.

Ray has a PhD from the College of Forestry (economics) from Oregon State University, a Masters of Agriculture (agricultural marketing) from Colorado State University, and a Bachelors of Science (wildlife biology) from the University of Washington. Ray is the recipient of the Wilburforce Foundations' Conservation Leadership Award. Ray's work is also profiled in Harper's Magazine and Chronicle of Philanthropy.

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Read more:

Why Some Western Towns Live or Die
A Prominent Bozeman Economist Explains the Value of Public Land for 21st-Century America
by Todd Wilkinson
February 5, 2018
FROM: Mountain Journal

How One Group Crafts Data-Smart Solutions on Land Use
by Nicole Wallace, December 5, 2017
FROM: The Chronicle of Philanthropy

Political Climbers: Environmentalist Momentum in the West
by Richard Manning
FROM: Harper's Bazaar
Superintendent’s International Speaker: Jodi Hilty, PhD

Jodi has more than twenty years of experience in research and publication, application of science-based solutions to complex conservation challenges; community-based conservation; organizational strategic planning and implementation; leadership of large and diverse staff across multiple offices; budget development and management; and building academic, NGO, and government partnerships for greatest impact. Since 2015, Jodi has served as the president and chief scientist for the Yellowstone to Yukon Conservation Initiative. In this role, she has led large-scale conservation as a global model; developed and persuasively articulated a compelling vision; motivated and inspired staff, partners, and other leaders in the region and around the world to make the vision a reality; recruited and oversaw talented staff; worked with board and partners in translating the vision into effective programs; managed the organization and built its capacity; and provided leadership within and well beyond the conservation community.

Jodi holds a PhD (2001) from the University of California-Berkeley in Ecosystem Sciences (Division of Department of Environmental, Science, Policy, and Management). Her thesis focused on the use of riparian corridors by wildlife in the oak woodland vineyard landscape. Jodi studied geology at Middlebury College in Vermont and the American College of Switzerland in Leysin with a focus on alpine ecology.

Read more:

New Y2Y President Fits with the Organization’s Vision
FROM: Calgary Herald, Sept. 2015

Yellowstone Grizzlies May Soon Commingle with Northern Cousins

Caribou Have Almost Disappeared From the U.S.—A Warning to Canada
FROM: CBC, Apr. 2018
Joel directs a number of projects for the Wildlife Conservation Society; among these are the pronghorn migration corridor conservation project and the impact of energy development on wildlife projects in the Greater Yellowstone Area, the impacts of climate change on musk ox in the Alaskan Arctic, and the saiga antelope conservation project in Mongolia. Joel received his doctoral degree in biology from the University of Colorado, Boulder, and subsequently worked for the Smithsonian Institution for seven years. Joel is currently the Barbara Cox-Anthony Chair of Wildlife Conservation at Colorado State University and a senior scientist for the Wildlife Conservation Society. He has written six books on wild horses, rhinos, bison, and fear in prey species.

“"My work has focused on two central tenets in conservation: maintain what we have and restore what we’ve lost. Questions about evolution, mimicry, behavior, and how historic factors shape the spectrum from individuals to landscape are as thoroughly fascinating as are single species – whether extinct (e. g., mammoths) or extant (e. g., long-eared jerboas or black rhinos).

As modern humans move forth, the sheer crush of humanity and our callousness is frightening. As I search for my way forward, I am motivated by conservation and finding ways to protect our planet’s spectacular diversity. This means understanding systems and species, their challenges, and proffering solutions. At the same time, while animals often have no true voices, people in developing areas find themselves caught between two worlds. It is somewhere along this interface, that I try to work.

My interest is in targeting questions and problem solving issues in conservation biology. Actionable conservation is the goal, and science is one of many avenues in which this is achieved. I work primarily with species larger than a bread box, and thematically on population ecology, the behavior of predator-prey interactions (under a food web umbrella), migration, climate stressors, and persistence and restoration.”

Read more:
https://sites.warnercnr.colostate.edu/joelberger/
Aubrey L. Haines Speaker: Stephen J. Pyne

Steve is the author of over 30 books, mostly on fire (he’s a self-declared pyromantic), including big-screen fire histories for the U.S., Australia, Canada, Europe (including Russia), and Earth overall. Other book subjects range from Antarctica (The Ice) to How the Canyon Became Grand, the Voyager mission through the solar system, and writing.

His most recent works are a multi-volume survey of the American fire scene with a play-by-play narrative, Between Two Fires: A Fire History of Contemporary America, and a series of color-commentary regional reconnaissances under the rubric To the Last Smoke. He teaches courses on fire, the history of exploration, environmental history, and nonfiction writing.

Steve has had two National Endowment for the Humanities fellowships, two tours at the National Humanities Center, a Fulbright fellowship (Sweden), a MacArthur Fellowship, a TED talk, and the Robert Kirsch award for lifetime contribution to American letters.

He worked on North Rim Longshots for 15 summers, all at Grand Canyon National Park, and spent three summers writing fire plans, one at Yellowstone National Park in 1985.

Read more:
http://www.stephenpyne.com/
Past Lecture Series Speakers

The Biennial Scientific Conference on the Greater Yellowstone Ecosystem typically includes named lectures in honor of notable influences, Aubrey L. Haines, past Yellowstone National Park historian, and A. Starker Leopold, who greatly influenced National Park Service policy. A third lecture named for Yellowstone’s superintendent invites an international leader in conservation to speak about some global aspect of park science and management. Additionally, the conference invites an opening keynote speaker to inspire participants and set the tone for the three day meeting.

**A. Starker Leopold Lecture**
- 2016: Bob Gresswell, emeritus research biologist, USGS Northern Rocky Mountain Science Center
- 2014: Monica Turner, University of Wisconsin
- 2012: Estella Leopold, University of Washington (unable to attend)
- 2010: Mary Meagher, retired U.S. Geological Survey
- 2008: Norm Christensen, Duke University
- 2005: Jack Ward Thomas, U.S. Forest Service
- 2003: Richard Leakey
- 2001: Robert Smith, University of Utah
- 1999: Barry Noon, Colorado State University
- 1997: T.H. Watkins, Montana State University
- 1995: L.D. Mech, University of Minnesota
- 1993: Mark S. Boyce, University of Wisconsin

**Aubrey L. Haines Lecture**
- 2016: Dr. Bill Wyckoff, Montana State University
- 2014: Dr. Robert Righter, Southern Methodist University
- 2012: Paul Schullery, Montana State University
- 2010: Judith Meyer, Missouri State University
- 2008: Mark Hebblewhite, University of Montana
- 2005: Sarah E. Boehme, Whitney Gallery of Western Art (Cody, WY)
- 2003: Dan Flores, University of Montana
- 2001: John Varley, Yellowstone National Park
- 1999: Holmes Rolston III, Colorado State University
- 1997: (Not initiated until 5th Conference/1999; Haines attended in 1997 and moderated a session)

**Superintendent’s International Lecture**
- 2016: Gary M. Tabor, Executive Director, Center for Large Landscape Conservation
- 2014: Craig Groves, Senior Scientist, The Nature Conservancy
- 2012: Ian W. Dyson, Alberta Environment and Sustainable Resource Development, Canada
- 2010: Göran Ericsson, Swedish University of Agricultural Sciences
- 2005: Harvey Locke, Canadian Parks and Wilderness Society
- 2003: A.R.E. Sinclair, University of British Columbia, Canada
- 2001: Nigel Trewin, University of Aberdeen (Scotland)
- 1999: Daniel Botkin, University of California Santa Barbara
- 1997: Donald Worster, University of Kansas
- 1995: Stephen Herrero, University of Calgary, Canada
- 1993: Monte Hummel, World Wildlife Fund Canada
<table>
<thead>
<tr>
<th>DAY/DATE</th>
<th>SESSION #</th>
<th>PAGE #</th>
<th>TIME</th>
<th>SOCIAL SCIENCE TRACK</th>
<th>NATURAL SCIENCE TRACK</th>
<th>COMMUNITY BUILDING/SKILLS BUILDING TRACK</th>
<th>LOCATION</th>
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</thead>
<tbody>
<tr>
<td><strong>DAY ONE</strong> 9/11/18</td>
<td></td>
<td></td>
<td>2-6PM</td>
<td>Registration</td>
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<td>Fireside Lounge</td>
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<td>2-6PM</td>
<td>Poster Set-Up</td>
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<td>Missouri Ballroom</td>
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<td>20</td>
<td>4-6PM</td>
<td>Workshop: Utilizing geo-tagged imagery and spatially balanced sampling designs to monitor vegetation</td>
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<td>Lamar-Gibbon</td>
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<td>6-7:30PM</td>
<td>RECEPTION</td>
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<td>Grand Atrium</td>
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<td>7</td>
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<td>7:30-8PM</td>
<td>Opening Remarks</td>
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<td>Missouri Ballroom</td>
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<td>8-9PM</td>
<td>Keynote: RASKER</td>
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<td>Missouri Ballroom</td>
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<tr>
<td><strong>DAY TWO</strong> 9/12/18</td>
<td>1</td>
<td>21</td>
<td>8-9:30AM</td>
<td>Quantifying Recreational Impacts Over Space and Time</td>
<td>Ungulate, Migration, and the Green Wave</td>
<td>Collaborations to Improve Conservation</td>
<td>See session description for details</td>
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<td>2</td>
<td>37</td>
<td>9:30-9:45AM</td>
<td>BREAK</td>
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<td>Grand Atrium</td>
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<td>9:45-12PM</td>
<td>Visitor Opinion and Social Science</td>
<td>Furs, Fins, and Feathers &amp; Science Comm Workshop</td>
<td>Panels 1 &amp; 2</td>
<td>See session description for details</td>
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<td>12-1PM</td>
<td>LUNCH</td>
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<td>Huntley Dining Room</td>
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<td>3</td>
<td>53</td>
<td>1-2PM</td>
<td>Superintendent's Lecture: HILTY</td>
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<td>Missouri Ballroom</td>
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<td>2:00-2:15PM</td>
<td>BREAK</td>
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<td>Grand Atrium</td>
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<td>4</td>
<td>67</td>
<td>2:15-3:45PM</td>
<td>New Data, New Tools</td>
<td>Carnivore Ecology</td>
<td>20/20 Rounds</td>
<td>See session description for details</td>
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<td>3:45-4PM</td>
<td>BREAK</td>
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<td>Grand Atrium</td>
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<td>5</td>
<td>79</td>
<td>4-5:30PM</td>
<td>Tracking the Footprint of the Past</td>
<td>Vegetation &amp; Restoration</td>
<td>Panel 3</td>
<td>See session description for details</td>
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<td>6-7:30PM</td>
<td>DINNER</td>
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<td>Huntley Dining Room</td>
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<td>6</td>
<td>87</td>
<td>8:30AM</td>
<td>Leopold Lecture: BERGER</td>
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<td>Missouri Ballroom</td>
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<td>9:15-10AM</td>
<td>BREAK</td>
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<td>Grand Atrium</td>
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<td>7</td>
<td>99</td>
<td>10:00-11:45AM</td>
<td>PLENARY: Decision Makers</td>
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<td>Missouri Ballroom</td>
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<td>11:45AM-1PM</td>
<td>BREAK</td>
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<td>Huntley Dining Room</td>
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<td></td>
<td>8</td>
<td>101</td>
<td>1-2PM</td>
<td>Aubrey L. Haines Lecture: PYNE</td>
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<td>Missouri Ballroom</td>
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<td>2-2:15PM</td>
<td>BREAK</td>
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<td>Grand Atrium</td>
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<td>9</td>
<td>115</td>
<td>2:15-3:45PM</td>
<td>Visitor and Regional Growth, Mitigating Human Effects</td>
<td>Invertebrates &amp; Stream/River Ecology</td>
<td>Workshop: Wildlife Captures- What they entail and how they have evolved</td>
<td>See session description for details</td>
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<td>3:45-4PM</td>
<td>BREAK</td>
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<td>Grand Atrium</td>
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<td></td>
<td>4-5:30PM</td>
<td>PLENARY: Ensuring Science Serves Decision - Strategic Thinking on Yellowstone Challenges</td>
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<td>Missouri Ballroom</td>
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<td></td>
<td>10-115</td>
<td>Poster Session/Salsa Bar</td>
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<td>Missouri Ballroom</td>
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<td>5-30-7PM</td>
<td>Dinner/Entertainment (Holler 'N Pine)</td>
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<td>Huntley Dining Room, Chet's Lounge</td>
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<td></td>
<td>7-9PM</td>
<td>Student Film Showcase</td>
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<td>Auditorium</td>
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<tr>
<td><strong>DAY FOUR</strong> 9/14/18</td>
<td></td>
<td></td>
<td>8:30AM-1PM</td>
<td>The Science of National Forest Planning - Public Symposium</td>
<td></td>
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<td>Auditorium</td>
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</tbody>
</table>
# Session One

## Social Science Track: Quantifying Recreational Impacts over Space and Time

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<th>Time</th>
<th>Page #</th>
<th>Title</th>
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<tbody>
<tr>
<td>8-8:15AM</td>
<td>21</td>
<td>Hikers, Backpackers, and Climbers: Combining Geospatial and Observational Data to Analyze Visitor Use Patterns at a High-Use Trailhead in Grand Teton National Park</td>
<td>Lake/Canyon Room</td>
</tr>
<tr>
<td>8:15-8:30AM</td>
<td>21</td>
<td>What's Scale Got to Do with It?: The Importance of Scale When Measuring Experience, Impacts, and Behaviors of Users at Popular Recreation Sites</td>
<td></td>
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<tr>
<td>8:30-8:45AM</td>
<td>22</td>
<td>Quantifying the Human Footprint: Exploring the Extent and Condition of Social Trails and Impacted Areas at Parkwide and Site-Level Scales</td>
<td></td>
</tr>
<tr>
<td>8:45-9AM</td>
<td>22</td>
<td>Understanding &quot;Wildlife Jam&quot; Events in the GYE: Factors Influencing Visitor Spatial Behavior</td>
<td></td>
</tr>
<tr>
<td>9-9:15AM</td>
<td>23</td>
<td>Teton Recon: Mixed-Methods Approaches to Measuring Recreational Ecosystem Services in Grand Teton National Park</td>
<td></td>
</tr>
<tr>
<td>9:15-9:30AM</td>
<td>23</td>
<td>Visitor Attitudes and Behaviors Regarding Waste and Recycling in National Parks</td>
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</table>

## Natural Science Track: Ungulate Migration and the Green Wave

<table>
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<tr>
<th>Time</th>
<th>Page #</th>
<th>Title</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-8:15AM</td>
<td>26</td>
<td>Challenging Brucellosis: A Novel Candidate Vaccine for Use in Wild Elk</td>
<td>Lamar/Gibbon Room</td>
</tr>
<tr>
<td>8:15-8:30AM</td>
<td>27</td>
<td>Combining Datasets to Estimate Risk of Brucellosis Transmission from Elk to Livestock in Montana and Wyoming</td>
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<tr>
<td>8:30-8:45AM</td>
<td>27</td>
<td>Yellowstone Bison Manipulate the Green Wave</td>
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<tr>
<td>8:45-9AM</td>
<td>28</td>
<td>Migration Timing Plasticity in Elk Is an Effective Strategy to Account for Shifts in Environmental Cues</td>
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</tr>
<tr>
<td>9-9:15AM</td>
<td>28</td>
<td>Quality and Predictability of Native Forage Mediate Negative Influence of Irrigated Agriculture on Elk Migration</td>
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<tr>
<td>9:15-9:30AM</td>
<td>29</td>
<td>Overgrazing in Yellowstone Grasslands: A Century of Debate about How to Preserve Biological Resources</td>
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</table>

## Community & Skills Building Track: Collaborations to Improve Conservation

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<tbody>
<tr>
<td>8-8:15AM</td>
<td>31</td>
<td>Grand Teton National Park and Subaru National Park Zero Landfill Initiative: Partnerships for Success</td>
<td>Dunraven/Obsidian Room</td>
</tr>
<tr>
<td>8:15-8:30AM</td>
<td>31</td>
<td>Agency Partnerships: Collaborating for Wildlife, Safety, and Economic Opportunity on the Yellowstone Highway</td>
<td></td>
</tr>
<tr>
<td>8:30-8:45AM</td>
<td>32</td>
<td>The Lakers: A Solution for Successful Management of the Highly Utilized Muti-use String Lake Area of Grand Teton National Park</td>
<td></td>
</tr>
<tr>
<td>8:45-9AM</td>
<td>32</td>
<td>Partnering for Improved Interpretation of Crow Places in Yellowstone National Park</td>
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<tr>
<td>9-9:15AM</td>
<td>33</td>
<td>Accelerating Infrastructure and Conservation Work in Yellowstone National Park and other Public Lands – A New Approach</td>
<td></td>
</tr>
<tr>
<td>9:15-9:30AM</td>
<td>34</td>
<td>The Yellowstone-Grand Teton Biosphere Area - A Multi-Partner Expansion of the original Yellowstone Biosphere Reserve</td>
<td></td>
</tr>
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</table>

**Have a Question?**

![Whova](image)
### Session Two

#### 9:45AM-12PM

**SOCIAL SCIENCE TRACK: Visitor Opinion and Social Science**

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<thead>
<tr>
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<tbody>
<tr>
<td>9:45-10AM</td>
<td>37</td>
<td>The Social Environment of Public Wilderness</td>
<td></td>
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<tr>
<td>10-10:15AM</td>
<td>38</td>
<td>Role of Motivation in Visitor's Expectations and Perceptions of Quality</td>
<td></td>
</tr>
<tr>
<td>10:15-10:30AM</td>
<td>38</td>
<td>When Does Congestion Matter to a Park Visitor?: Translating Park Roadways' Level of Service to Impacts on the Visitor Experience</td>
<td></td>
</tr>
<tr>
<td>10:30-10:45AM</td>
<td>38</td>
<td>Assessing the Intergovernmental Use of Adaptive Management to Address the Intractable Conflict over Yellowstone-area Bison</td>
<td></td>
</tr>
<tr>
<td>10:45-11AM</td>
<td>39</td>
<td>Hitchin' a Ride: Threats and Ecological Consequences of Aquatic Invasive Species (AIS) Introduced into Yellowstone Waters</td>
<td>CANADIAN ROOM</td>
</tr>
<tr>
<td>11-11:15AM</td>
<td>39</td>
<td>Balancing Conservation and Recreation in Our Shared Place</td>
<td></td>
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<tr>
<td>11:15-11:30AM</td>
<td>40</td>
<td>Investigating a Novel Approach to Leveraging Tourism Dollars in U.S. National Parks</td>
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<tr>
<td>11:30-11:45AM</td>
<td>41</td>
<td>Building a Stakeholder-Driven, Science-Informed Assessment of Climate Change in the GYE</td>
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</tbody>
</table>

**NATURAL SCIENCE TRACK: Furs, Fins, and Feathers & How to Talk About Them**

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<tr>
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<tbody>
<tr>
<td>9:45-10AM</td>
<td>44</td>
<td>Habitat Conditions Associated with New Settlement Sites of Beavers in Southwest Montana</td>
<td>Gibbon Room</td>
</tr>
<tr>
<td>10-10:15AM</td>
<td>45</td>
<td>Sharing the Process and Product of Science among Organizations and with the General Public: Golden Eagle Reproduction in Greater Yellowstone and the American West</td>
<td></td>
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<tr>
<td>10:15-10:30AM</td>
<td>46</td>
<td>Common Loons (Gavia immer) in the Greater Yellowstone Ecosystem: Mitigating Human Disturbance</td>
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<tr>
<td>10:30-10:45AM</td>
<td>46</td>
<td>Behavioral Plasticity Buffers Temperature Constraints on Foraging Time for a Montane Mammal</td>
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<tr>
<td>10:45-11AM</td>
<td>47</td>
<td>Songbirds in Yellowstone National Park: Threats, Trends, and Management</td>
<td></td>
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<tr>
<td>11-11:15AM</td>
<td>47</td>
<td>Arctic Grayling and Westslope Cutthroat Trout Restoration in Yellowstone National Park</td>
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</tr>
<tr>
<td>11:15AM-12PM</td>
<td>48</td>
<td>Workshop: Science Communication Strategies - A Workshop for Developing Skills and Increasing Resources</td>
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**COMMUNITY & SKILLS BUILDING: Panels 1 & 2**

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<tbody>
<tr>
<td>9:45-10AM</td>
<td>51</td>
<td>PANEL ONE: &quot;From Their Mouths&quot; - The Next Generation's Perspective on Bison</td>
<td>AUDITORIUM</td>
</tr>
<tr>
<td>10-10:15AM</td>
<td>51</td>
<td>PANEL TWO: The Future of the Greater Yellowstone Ecosystem Can Be as Diverse as We Make It</td>
<td></td>
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<tr>
<td>10:15-10:30AM</td>
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### Session Three

#### 2:15-3:45PM

##### SOCIAL SCIENCE TRACK: New Data, New Tools

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<thead>
<tr>
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<tbody>
<tr>
<td>2:15-2:30PM</td>
<td>53</td>
<td>Tracks, Tires, and Grooming: A Snowroad Study to Inform Management Decisions</td>
</tr>
<tr>
<td>2:30-2:45PM</td>
<td>53</td>
<td>Chinese Tourism Growth to U.S. National Parks and Gateway Communities: A Case Study in West Yellowstone, Montana</td>
</tr>
<tr>
<td>2:45-3PM</td>
<td>53</td>
<td>Evaluating the Visitor Experience in Real-Time: Creating a New Method to Explore the Yellowstone Experience</td>
</tr>
<tr>
<td>3:3-3:15PM</td>
<td>54</td>
<td>Finding and Using Credible Information for Land Management Decision Making</td>
</tr>
<tr>
<td>3:15-3:30PM</td>
<td>55</td>
<td>The Lessons Learned in Teaching &quot;Yellowstone&quot; as an Ethical Problem</td>
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<tr>
<td>3:30-3:45PM</td>
<td>56</td>
<td>Social Media and National Parks: Understanding Virtual Visitors</td>
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##### NATURAL SCIENCE TRACK: Carnivore Ecology

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<tbody>
<tr>
<td>2:15-2:30PM</td>
<td>57</td>
<td>Measuring Hunting Impacts on Gray Wolf Population, Social Structure, and Long-Term Research in Yellowstone National Park</td>
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<tr>
<td>2:30-2:45PM</td>
<td>57</td>
<td>Wolf Population Regulation in Yellowstone: Survival, Recruitment, Dispersal, or Human Exploitation?</td>
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<tr>
<td>2:45-3PM</td>
<td>58</td>
<td>Visitor-Use and Wolf Habitat Selection in Yellowstone National Park</td>
</tr>
<tr>
<td>3:3-3:15PM</td>
<td>58</td>
<td>Wolverine Responses to Winter Recreation: Effects of Recreation Type and Intensity on Habitat Use</td>
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<tr>
<td>3:15-3:30PM</td>
<td>59</td>
<td>Unintentional Effects of Multiuse Management on Southern GYE Mountain Lions</td>
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</table>

##### COMMUNITY & SKILLS BUILDING: Lightning Rounds

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<tr>
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<tbody>
<tr>
<td></td>
<td>63</td>
<td>Climate Smart Conservation Comes to the Greater Yellowstone Ecosystem</td>
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<td>63</td>
<td>Biophysical Gradients Associated with the Performance of Whitebark Pine Seedlings in the Greater Yellowstone Area</td>
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<td>63</td>
<td>Tree Species' Responses to Changing Fire and Climate in the GYE</td>
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<td>64</td>
<td>Disease-Induced Social Disruption Is Buggered by Group Size</td>
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<td>66</td>
<td>Spatial Patterns of Winter Roadside Gray Wolf Sightedability in Yellowstone National Park</td>
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<td>66</td>
<td>Gray Wolf Ties Observed in Yellowstone National Park</td>
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**CREATE A CUSTOM AGENDA?**
## SOCIAL SCIENCE TRACK: Tracking the Footprint of the Past

<table>
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<tr>
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<tbody>
<tr>
<td>4:4:15PM</td>
<td>67</td>
<td>Where Should We Start Looking? Predictive Model for Bison Jump Sites in the Greater Yellowstone Ecosystem</td>
</tr>
<tr>
<td>4:15-4:30PM</td>
<td>68</td>
<td>The Pioneer, the Progressive, and the Preservationist: Buffalo Bill, Gifford Pinchot, and Horace Albright Collaborate in Yellowstone</td>
</tr>
<tr>
<td>4:30-4:45PM</td>
<td>69</td>
<td>11,000 Years of Native American Obsidian Use in Yellowstone: A Discussion of Issues and Ideas Regarding Public Access to Two Obsidian Source Areas</td>
</tr>
<tr>
<td>4:45-5PM</td>
<td>71</td>
<td>Highways through Wonderland</td>
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<tr>
<td>5:15-5:30PM</td>
<td>71</td>
<td>Yellowstone and the Smithsonian: Centers of Wildlife Conservation</td>
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<tr>
<td>5:15-5:30PM</td>
<td>73</td>
<td>Cross-Cultural and Transdisciplinary Research Opportunities through Greater Yellowstone Area Ice Patches with a Screening of the 2018 Short Film <em>Ice Patch Archaeology</em></td>
</tr>
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## NATURAL SCIENCE TRACK: Vegetation & Restoration

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<tr>
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<tbody>
<tr>
<td>4:15-4:30PM</td>
<td>74</td>
<td>Winter Annuals: Silent Killers</td>
</tr>
<tr>
<td>4:30-4:45PM</td>
<td>75</td>
<td>The National Whitebark Pine Restoration Plan: A Multi-Agency Collaborative Effort to Rescue a High Elevation Foundation and Keystone Forest Species</td>
</tr>
<tr>
<td>4:45-5PM</td>
<td>75</td>
<td>Fire Suppression in 21st Century Subalpine Forests of Greater Yellowstone</td>
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<tr>
<td>5:15-5:30PM</td>
<td>76</td>
<td>Multi-Decadal Succession of the Understory Plant Community Following the 1988 Yellowstone Fires</td>
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<tr>
<td>5:15-5:30PM</td>
<td>76</td>
<td>Climate Trends in Real Time?: Whitebark Pine Post-Fire Regeneration Since the 1988 Yellowstone Fires</td>
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</table>

## COMMUNITY & SKILLS BUILDING TRACK: Workshop

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<tbody>
<tr>
<td>4:5:30PM</td>
<td>78</td>
<td>Panel 3: Vital Sign Monitoring Framework for the Greater Yellowstone Ecosystem</td>
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**LOCATION**

- Lake/Canyon Room
- Lamar/Gibbon Room
- Auditorium
# Session Five

## SOCIAL SCIENCE TRACK: Regional Studies Informing Management Needs

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<tbody>
<tr>
<td>8-8:15AM</td>
<td>79</td>
<td>Yellowstone Citizen Science Initiative: Projects for the People</td>
<td>DUNRAVEN/OBSIDIAN ROOM</td>
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<tr>
<td>8:15-8:30AM</td>
<td>79</td>
<td>Bringing &quot;Home on the Range&quot; to the Next Generation</td>
<td></td>
</tr>
<tr>
<td>8:30-8:45AM</td>
<td>80</td>
<td>For Everything There Was a Season - Citizen Scientists Retrace Frank Craighead's Footsteps and Reveal Phenological Shifts in the Tetons</td>
<td></td>
</tr>
<tr>
<td>8:45-9AM</td>
<td>80</td>
<td>Utilizing Citizen Science to Monitor Visitor Use Resource Impacts at Key Locations in Yellowstone National Park</td>
<td></td>
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<tr>
<td>9-9:15AM</td>
<td>81</td>
<td>Enhancing Public Understanding of Science in the Greater Yellowstone Ecosystem</td>
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## NATURAL SCIENCE TRACK: Animal Migration, Round Two

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<tbody>
<tr>
<td>8-8:15AM</td>
<td>82</td>
<td>Mapping Elk and Mule Deer Migrations on the Wind River Indian Reservation</td>
<td>LAMAR/GIBBON ROOM</td>
</tr>
<tr>
<td>8:15-8:30AM</td>
<td>82</td>
<td>Drought Shortens Spring, Impedes Resource Tracking, and Mediates a Trade-Off Between Resource Quality and Stability for Migratory Mule Deer</td>
<td></td>
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<tr>
<td>8:30-8:45AM</td>
<td>83</td>
<td>The Wyoming Migration Initiative Migration Viewer: An Archive and Online Tool for Viewing Wyoming’s Ungulate GPS, VHF, and WGFD Habitat Data</td>
<td></td>
</tr>
<tr>
<td>8:45-9AM</td>
<td>83</td>
<td>One Herd, Many Migrations: A Test of the Fitness-Balancing Hypothesis with Mule Deer</td>
<td></td>
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<tr>
<td>9-9:15AM</td>
<td>84</td>
<td>Wild Migrations: What We Learned from Compiling the Atlas of Wyoming’s Ungulates</td>
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## COMMUNITY & SKILLS BUILDING TRACK: Citizen Science

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<tbody>
<tr>
<td>8-8:15AM</td>
<td>85</td>
<td>Workshop: Bringing Science and Collaboration Together to Steward the GYE</td>
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<td>8:15-8:30AM</td>
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<td>8:30-8:45AM</td>
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## EXCHANGE CONTACT INFORMATION

![Whova Logo]
## Session Six

### 2:15-3:45PM

#### SOCIAL SCIENCE TRACK: Visitor & Regional Growth, Mitigating Human Effects

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<tbody>
<tr>
<td>2:15-2:30PM</td>
<td>88</td>
<td>Improving Recreational Access and River Corridor Management through the Development of Sustainable Designated River Access Sites in the Gallatin Canyon</td>
</tr>
<tr>
<td>2:30-2:45PM</td>
<td>88</td>
<td>Trends and Patterns of Low-Density Residential Development in the Mountain Northwest</td>
</tr>
<tr>
<td>2:45-3PM</td>
<td>89</td>
<td>Communicating with Visitors about Bear Safety: Values, Elaboration, and Influencing Visitor Behavior</td>
</tr>
<tr>
<td>3-3:15PM</td>
<td>89</td>
<td>Reduced Speed Limit: An Effective Way to Reduce Wildlife-Vehicle Collisions?</td>
</tr>
<tr>
<td>3:15-3:30PM</td>
<td>90</td>
<td>Footprints and Hoofprints: The History of Trails in Yellowstone National Park</td>
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#### NATURAL SCIENCE TRACK: Invertebrates & Stream/River Ecology

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<tbody>
<tr>
<td>2:15-2:30PM</td>
<td>92</td>
<td>Soda Butte Creek: Clean Water Act Delisting Summary and Ongoing Monitoring Activities</td>
</tr>
<tr>
<td>2:30-2:45PM</td>
<td>94</td>
<td>A Prioritization Tool for Cross-Realm Management in the Missouri Headwaters Basin</td>
</tr>
<tr>
<td>2:45-3PM</td>
<td>96</td>
<td>An Iconic Macroinvertebrate in Peril?: Salmonfly Emergence Patterns and Climate-Driven Range Contraction</td>
</tr>
<tr>
<td>3-3:15PM</td>
<td>96</td>
<td>Arthropod Response to Reclamation Efforts in Greater Yellowstone Ecosystem's Natural Gas Fields</td>
</tr>
<tr>
<td>3:15-3:30PM</td>
<td>97</td>
<td>Piloting a Social-Ecological Framework for Improving Drought Preparedness for People and Nature in the Upper Missouri Headwaters</td>
</tr>
<tr>
<td>3:30-3:45PM</td>
<td>97</td>
<td>Drought in the Upper Missouri Headwaters: Water and Land Manager Perspectives of Vulnerability and Ecological Impacts</td>
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#### COMMUNITY & SKILLS BUILDING TRACK: Panel 5

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<tr>
<td>2:15-3:45PM</td>
<td>98</td>
<td>Workshop: Wildlife Captures - What They Entail and How They Have Evolved</td>
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**WANT FEEDBACK ABOUT YOUR PRESENTATION?**

**Whova**
Although vegetation monitoring is often considered a burden or too expensive to conduct, it is a critical component of making decisions regarding land management. Vegetation monitoring may be used to track phenological changes of plants, to identify invasive weed species, to gauge wildlife habitat quality, or for a variety of other reasons. Traditional methods to monitor vegetation often take multi-person teams a considerable amount of time conduct, resulting in high expenses or leading to monitoring outside of optimal phenological windows (potentially generating false negative reports). These methods are also highly subject to observer bias, both because observers can often subjectively choose where to monitor and because they may have different vegetation identification skills. They may also result in non-optimal spatial coverage of a site (e.g., a transect only captures a small line of vegetation over a large area).

We utilize a spatially balanced sampling design, Balanced Acceptance Sampling, along with GPS-tagged imagery and a free vegetation analysis software, SamplePoint, to optimize spatial coverage of the sampling area, to reduce time needed to spend in the field, to provide permanent records, and to reduce observer bias.

This workshop includes: 1) presentation and demonstration how this technique has been used to improve decision making and monitor reclaimed well pads and reference areas in the Pinedale Anticline and Jonah Infill gas fields, 2) a field demonstration, and 3) an image analysis and statistical demonstration concluding with questions, answers, and discussion. Our methodology is easy to use, improves statistical validity over most traditional techniques, reduces monitoring costs and observer bias, and can be used to inform decision making for multiple stakeholders. It has proven successful in restoration ecology.

NPS Photo - J. Frank
Quantifying Recreational Impacts Over Space & Time

HIKERS, BACKPACKERS, AND CLIMBERS: COMBINING GEOSPATIAL AND OBSERVATIONAL DATA TO ANALYZE VISITOR USE PATTERNS AT A HIGH-USE TRAILHEAD IN GRAND TETON NATIONAL PARK

Dr. Jennifer Newton, National Park Service
Simeon Caskey, National Park Service

With increasing visitation to parks and protected areas across the nation, the interest in understanding more about park visitors has also increased. For example, Grand Teton National Park had its fourth consecutive year of record-breaking visitation in 2017, totaling nearly 5 million. Understanding how visitors use, behave, and travel through an area are important components to visitor use management. Like many processes in ecosystems, visitor use is dynamic and patterns shift depending on a plethora of variables, including season, hour of the day, day of the week, and the behaviors of other visitors. Implementing a more quantitative, science-informed approach to understanding visitor behavior and use will provide park managers tools to manage proactively.

Past research has utilized geospatial data to better understand visitor behaviors and travel patterns, as well as recreational settings. Geospatial data give accurate and precise information on visitor movements. This presentation focuses on visitor travel patterns and behaviors along a highly used trail system, averaging approximately 270 users per day in June and July. This trail system, Lupine Meadows, offers several recreation opportunities, including hiking, backpacking, skiing, and climbing. A random sample of visitors to this trail system were asked to take a Global Positioning System (GPS) device with them on their trip. This information not only provides valuable insight to visitor movements, but also time spent on the trail system, locations where visitors may stop and spend time (i.e., hot spots), and popular destinations. Comparisons of visitor behavior among different groups of visitors headed to the same primary destination are also explored in this presentation. This information is also helpful to better understand visitor behaviors along a social, or visitor created, trail within the trail system. By better understanding visitor-use patterns, park managers are equipped to make science-informed decisions.

WHAT'S SCALE GOT TO DO WITH IT?: THE IMPORTANCE OF SCALE WHEN MEASURING EXPERIENCE, IMPACTS, AND BEHAVIORS OF USERS AT POPULAR RECREATION SITES

Jenna Baker, Oregon State University
Dr. Ashley D’Antonio, Oregon State University
Dr. Derrick Taff, The Pennsylvania State University
Dr. Peter Newman, The Pennsylvania State University
Prof. Christopher Monz, Utah State University
William Rice, The Pennsylvania State University
Dr. Zachary Miller, The Pennsylvania State University
Dr. Jennifer Newton, National Park Service

In the past decade, U.S. national parks have experienced dramatically increasing visitation rates, with 2016 setting a record of 330 million recreation visits. To make effective and informed decisions to manage for this increase, it is necessary to develop an objective understanding of the spatial and temporal extent of visitor use. The emergence and development of geospatial technology has allowed for more accurate and detailed spatio-temporal representations of topography, ecology, and organism movement within recreation systems. With these representations, scientists and managers have been able to map resource impacts, track human and wildlife movement, and ultimately monitor, understand, and even predict future events. Despite the explicitly spatial focus of these efforts, many of the results from these findings fail to consider the impact and relativity of scale.

This presentation will demonstrate the implications of considering—or failing to consider—scale in the context of measuring visitor use, experience, and impact at String and Leigh lakes (SLL) in Grand Teton National Park. In 2017 and 2018 researchers employed a variety of methods to measure visitor use, experience, and impact. Findings from this study indicated the vast majority of impact (both social and ecological) occurred at a small spatial scale relative
to the full extent of the SLL area. These smaller areas of dense visitation may influence the behavior of visitors by displacing people into the less populated reaches of the recreation site, which could change the scale of recreation resource impacts currently observed. Given that this recreation area is within a proposed wilderness site, acknowledging the impact of spatial scale when interpreting the results from social-ecological studies has direct management implications.

**QUANTIFYING THE HUMAN FOOTPRINT: EXPLORING THE EXTENT AND CONDITION OF SOCIAL TRAILS AND IMPACTED AREAS AT PARKWIDE AND SITE-LEVEL SCALES**

Susan Sidder, Oregon State University  
Dr. Ashley D’Antonio, Oregon State University  
Sue Mills, Yellowstone National Park  
Amanda Bramblett, Yellowstone National Park  
Alicia Murphy, Yellowstone National Park

Human use in wildland recreation areas leads to ecological impacts to the surrounding natural environment. With recreational use being a primary component of the Greater Yellowstone Ecosystem, it is imperative that managers understand the type, degree, and distribution of the human footprint resulting from recreational uses of the landscape. Quantifying these impacts enables management and mitigation actions to be implemented to optimize both the ecological and experiential conditions of wildland recreation areas. Since 2014, Yellowstone National Park (YNP) has developed and maintained a geospatial inventory of recreation impacts throughout the park. This presentation reports results from the summary of inventoried social trail-related impacts at the parkwide and site-level scales. Parkwide, recreation impacts exist in YNP, with the majority of impacts occurring close to designated trails and/or park roads. Overall, 1,731 social trails (90,447 meters) exist in the park. Average social trail length is approximately 52 meters and condition class ratings suggest moderate impact. YNP also has nonlinear, impacted locations in the form of patches of bare ground, impacted areas, and impacted areas near trailheads. These areas combined comprise 564 unique locations and approximately 153,713 square meters of park area. Average condition class ratings suggest that impacted areas and impacted areas near trailheads are of moderate impact, while bare ground areas are of severe impact. Site-level analyses were conducted for the following park locations, identified by YNP managers: Old Faithful, Midway, Norris, Artist Point, and Fairy Falls. These results represent one of the most complete pictures of current recreation impacts at YNP, providing managers with spatially explicit information on the type, degree, and distribution of recreation impacts that can be used for future visitor use management and restoration planning.

**UNDERSTANDING “WILDLIFE JAM” EVENTS IN THE GYE: FACTORS INFLUENCING VISITOR SPATIAL BEHAVIOR**

Dr. Abigail Sisneros-Kidd, Utah State University  
Prof. Christopher Monz, Utah State University

As recreation and tourism in parks and protected areas continues to increase, managers face rising concerns of degradation of natural resources and the visitor experience. One experience that visitors often seek is opportunities to view or photograph wildlife. As such, presence or absence of wildlife may influence visitor spatial behavior in parks and protected areas. This spatial behavior can result in impacts to park resources when visitors deviate from designated trails and roadways in search of their desired experience (i.e., viewing or photographing wildlife). Visitor behavior in areas where wildlife are present often involves visitors parking along roadways and exiting their cars to view wildlife. A phenomenon known as a “wildlife jam” can result, as visitors park informally along a roadway, often becoming pedestrians as they view wildlife, while other motorists attempt to drive through. To date, no studies have comprehensively investigated the wildlife jam phenomenon. The purpose of this research is to quantitatively characterize the nature of wildlife jams on the Moose-Wilson Road in Grand Teton National Park. Global Positioning System (GPS) technology was used to collect high-accuracy data on location and duration of the jams. Observations during jams characterize size (how many visitors and cars were involved) and visitor behaviors during jams, as well as wildlife behaviors during jams. Results suggest jam characteristics including species involved and location of jams along the road can affect
the duration, extent, and visitor behaviors that occur
during wildlife jam events. Understanding the nature
of these jams and, particularly, understanding wildlife
as factors that influence visitor spatial behavior, will
enable park managers to minimize the potential
negative effects of jams on wildlife and other park
resources (e.g., vegetation and soils impacted when
visitors leave designated trails and roadways to view
wildlife) as well as impacts to the visitor experience.

TETON RECON: MIXED-METHODS
APPROACHES TO MEASURING
RECREATIONAL ECOSYSTEM SERVICES
IN GRAND TETON NATIONAL PARK

William Rice, The Pennsylvania State University
Dr. Derrick Taff, The Pennsylvania State University
Dr. Zachary Miller, The Pennsylvania State University
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Dr. Jennifer Newton, National Park Service
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National Park Service units have seen a significant
uptick in visitation in recent years. From 2014 to
2016, Grand Teton National Park saw a 17% increase
in visitation, during that same period the String
and Leigh Lakes area of the park experienced an
even sharper increase. Managing for increased use
and new, novel uses in parks are growing issues of
concern for the agency and managers throughout
the Greater Yellowstone Ecosystem. This study uses
a mixed-methods approach, paired with recreation
ecology data collection, to examine visitor use in
the park’s increasingly popular String and Leigh
lakes area. An influx of novel uses—paddleboarding
and smartphone photography—to an area that
remains popular to more traditional uses—canoeing
and day hiking—adds a layer of complexity to
the management of the lakes. This increase in use
combined with limited parking and beach areas
proximal to the lakes has created an environment
in which crowding and displacement of visitors is
occurring.

This presentation presents methods and results of
a two-year study consisting of 62 interviews, ~1000
visitor surveys paired with GPS tracks, and a new
method for participatory mapping of recreational
ecosystem services. Using the data gathered from
the interviews, the research team crafted surveys to reach
across all revealed user groups in the area. Analyzing
this data through a recreational ecosystem services
framework, this study explores visitor motivations
and benefits-sought, the inhibiting factors associated
with these benefits, and establishes a new method
managers can utilize to understand the pushes
and pulls associated with varying recreation sites.
Most importantly, it illustrates how managers and
researchers alike can mesh social and ecological data
into a common framework for evaluation.

VISITOR ATTITUDES AND BEHAVIORS
REGARDING WASTE AND RECYCLING
IN NATIONAL PARKS

Ben Lawhon, Leave No Trace Center for Outdoor Ethics

For most park and protected area managers,
balancing resource protection with the provision of
recreational opportunities is an ongoing challenge.
A specific concern for many park and protected
area managers is waste management and/or
generation of waste by visitors, park operations,
and concessionaires, and the impact it has on both
protected areas and adjacent communities. Each
year, over 100 million pounds of waste is generated in
national parks through a variety of means including
park operations, by visitors to parks, and other
sources.

The primary goal of this study was to explore
specific visitor attitudes and behaviors towards
waste disposal and recycling in select national parks.
This was done through direct visitor observations
paired with visitor surveys at Grand Teton National
Park, Yosemite National Park, and Denali National
Park and Preserve to better understand how park
managers can achieve waste management goals
through effective educational and management
strategies. Sampling was stratified across the park
units over a three-month period in summer of 2017.
Approximately 20-25 days of sampling were allotted
for data collection in each park. A total of N=2790
surveys were administered to visitors, and N=7558
observations were obtained.

The data suggests park visitors included in this
sample are largely aligned (attitudes, norms, and
behaviors) with properly disposing of waste and
recyclable material in national parks. Results of
multiple correlation regression path analysis suggest that perceived difficulty ($b=.335$) and moral norms ($b=.459$) had a significant influence on behavioral intention. The data indicates visitors are predisposed to engage in environmentally responsible behaviors that benefit and protect national parks, which could lead to increased waste and recycling diversion rates in national parks.
CHALLENGING BRUCELLOSIS: A NOVEL CANDIDATE VACCINE FOR USE IN WILD ELK

Dr. Morgan Wehtje, USDA, APHIS, Veterinary Services, Center for Epidemiological and Animal Health
Dr. Pauline Nol, USDA, APHIS Center for Epidemiological and Animal Health
Dr. Jack Rhyman, USDA, APHIS, Veterinary Services
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Near the beginning of the last century (circa 1917) bovine brucellosis, a bacterial disease, was introduced via cattle into the Greater Yellowstone Area (GYA). Now established in GYA bison (Bison bison) and elk (Cervus elaphus nelsoni), brucellosis has left behind a trail of ecological, economic, and sociopolitical footprints. The bacterium causing brucellosis, Brucella abortus, is able to infect both elk and bison and leads to reproductive failure, such as abortion, in domestic cattle (Bos taurus), bison, and elk. It can also cause serious illness in humans. A nearly 70-year national disease eradication campaign has made cattle and ranched bison in the United States officially free of brucellosis. Yet, the numerous logistical and political obstacles encountered when attempting to manage disease in wildlife populations causes brucellosis to remain endemic in wild elk and bison in the GYA. The sporadic infections that now occur in cattle are due to exposure to infected wildlife.

Historically transmission risk between wildlife and livestock focused on the wild bison/cattle interface. However, GYA elk have been identified as the primary source for new cases of brucellosis in livestock; this has most recently been presented in a 2017 National Academy of Sciences report. The report calls for the development of a vaccine and vaccine delivery system for elk; however, an effective brucellosis vaccine in this species does not yet exist. Progress toward reducing or eliminating brucellosis transmission from wildlife to domestic species through vaccination and other management tools is possible. Here we report our work using a killed B. abortus strain originating from a GYA elk, delivered to the nasal and oral mucosa, as a candidate vaccine for elk.

Methods
Ten yearling elk were assigned to two groups: Vaccinates (n=5) and Controls (n=5). Vaccine was prepared by mixing killed B. abortus with montmorillonite clay, after which the combined material was lyophilized and pulverized to form a fine powder. Individual vaccinates received a 1.12 g intranasal/oral dose of heat-killed B. abortus equivalent to 1 x 10^12 colony forming units (cfu) on days 0, 5, 13, and 16. Control elk were administered 1g clay alone in the same manner. Fifteen weeks after primary immunization, all elk were transported to a secured Bio-Safety Level-3 facility and challenged intraconjunctivally with 9.5 X 10^6 cfu virulent B. abortus. Three weeks post-vaccination, elk were euthanized and necropsied and tissues were collected for B. abortus culture. Blood was collected for brucellosis serology from all the elk prior to vaccination, one month after vaccination, prior to challenge (three months after vaccination), and three weeks after challenge.

Results
One control elk was excluded from the study due to a positive antibody titer to B. abortus at the time of first vaccination. After vaccination, none of the elk showed any signs of deleterious effects from the treatment. All vaccinated elk produced anti-Brucella antibody within one month after vaccination, which fell below detectable levels in all but one animal at two months after vaccination. After challenge, all but one vaccinate was positive on serology. Colony counts from nine non-reproductive tissues, irrespective of tissue origin, were significantly greater in Controls than Vaccinates (One-way ANOVA, p=0.001).

Conclusion
Our results indicate that multiple mucosal doses of killed, lyophilized B. abortus offers protection in elk against B. abortus infection. This is the first report demonstrating efficacy of a killed vaccine against B. abortus infection in elk. Further research must be
done with larger sample sizes to explore efficacy of this vaccine preparation in terms of optimal dose rates, duration of immunity, protection against abortion, and application in a field setting. This vaccine, if proved effective, has the potential to allow resource managers and others to limit the extent of the brucellosis footprint in and beyond the GYE.

References


YELLOWSTONE BISON MANIPULATE THE GREEN WAVE

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Recent studies have shown that migrating large herbivores closely time their movements during
spring to extend access to forage plants at early phenomenological stages—a strategy termed “surfing the green wave.” In classic green-wave surfing, the wave of green forage progresses irrespective of the level of herbivory on the landscape. Yet, large herbivores have been known to alter productivity of forage patches where they concentrate their use (i.e., grazing lawns). Dense aggregations of large herbivores may thus be capable of altering phenology at larger scales in a manner that could alter green-wave surfing. We evaluated green-wave surfing in bison, a species that still forms large groups in Yellowstone National Park. We show that daily movements of collared bison (n = 209 animal-years) from 2005 to 2015 are generally consistent with large-scale green wave surfing at some point during spring. Yet, bison also tended to slow down their movements towards the end of spring and let the green wave pass them by. Despite this, based on fecal samples (n = 203), bison maintain remarkably high-quality diets even after the green wave recedes and broad-scale forage quality declines. An analysis of small-scale herbivore exclosures deployed across key meadows in the bison range (n = 24) indicate grazing is intense enough to suppress plant biomass and enhance forage quality in grazed versus ungrazed plots. Finally, we combined bison-use metrics from GPS collar data and plant phenology metrics from satellite imagery across 12 years, demonstrating bison grazing intensity is capable of creating landscape-scale grazing lawns that increase overall productivity and alter plant phenology. Bison appear to manipulate the green wave through the intense herbivory they create while foraging in large groups. Such behavior may have cascading effects on ecosystem properties that are reliant on plant phenology and productivity.

MIGRATION TIMING PLASTICITY IN ELK IS AN EFFECTIVE STRATEGY TO ACCOUNT FOR SHIFTS IN ENVIRONMENTAL CUES

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Migration is an effective behavioral strategy for prolonging access to seasonal resources and may be a resilient strategy for changing climatic conditions. In the Greater Yellowstone Ecosystem (GYE) elk are the primary ungulate, with approximately 20,000 individuals migrating to exploit seasonal gradients in forage quality while also avoiding energetically costly snow conditions. How climate induced changes in plant phenology and snowfall are influencing elk migration timing is unknown and critical for assessing migrant elk sub-population’s resilience to climate change. Here, we present the most complete record of elk migrations across the GYE, spanning nine herds and 414 individuals. Elk migration timing has changed at the GYE scale in spring and fall. When elk begin spring migration is a function of current and future forage conditions (R² = 0.65), while spring migration end date is governed by snowmelt timing (R² = 0.70). Fall migration start (R² = 0.41) and end (R² = 0.44) dates are influenced by snow accumulation timing and hunting. Snow accumulation and melt dates have changed since 2001, with western herds experiencing earlier melts and later snowfalls while the opposite is true for eastern herds. We posit that if these changes in snow conditions continue, the migration timings in the western herds will diverge from those in the east. This plasticity in migration timing may indicate a resilience to future climate change, however, the demographic implications are unknown. Additionally, changes in elk migration timing will affect predator-prey dynamics, disease ecology, and game management across the GYE.

QUALITY AND PREDICTABILITY OF NATIVE FORAGE MEDIATE NEGATIVE INFLUENCE OF IRRIGATED AGRICULTURE ON ELK MIGRATION

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Dr. Kelly Proffitt, Montana Fish, Wildlife and Parks

Migratory ungulates affect ecological processes ranging from nutrient cycling to predator population dynamics across disparate seasonal habitats. In
western North America, increasing numbers of ungulates reside on low-elevation winter range year-round rather than migrating, raising both conservation concerns and socioeconomic challenges. Resident ungulates can damage crops, transmit diseases to livestock, and limit effectiveness of harvest management strategies. Maintaining migration is a common management and conservation goal, but the factors that most strongly influence migratory behavior are not well-understood. We quantified and compared the effects of forage variation, human land use practices, conspecific density, and animal age on migratory behavior of 308 adult female elk in 16 herds within and adjacent to the northern Greater Yellowstone Ecosystem. We found elk were less likely to migrate if they wintered in irrigated agricultural areas, but more likely to migrate away from irrigated agriculture if better forage was available elsewhere during the summer growing season, or if they experienced high conspecific density on their winter range. When the forage available during summer varied consistently from year to year, elk were more likely to migrate regardless of whether they had access to irrigated agriculture. Thus, predictable availability of high-quality native forage during summer can encourage migration even for elk that have access to irrigated agriculture on their winter range. Our results suggest land management strategies, such as restoring degraded habitat on migratory summer ranges, or managing for ecosystem resilience to reduce unpredictable forage variation, can help mitigate the influence of irrigated agriculture on migratory behavior of elk. Because nutritional intake during late summer and fall has a strong effect on survival and reproduction of ungulates, improving the nutrition available to migrants could go beyond preserving current behaviors to effectively increase prevalence of migration where irrigated agriculture has subsidized, increasing numbers of resident ungulates.

OVERGRAZING IN YELLOWSTONE GRASSLANDS: A CENTURY OF DEBATE ABOUT HOW TO PRESERVE BIOLOGICAL RESOURCES

Dr. Chris Geremia, Yellowstone Center for Resources, Yellowstone National Park

Dr. Bill Hamilton, Washington & Lee University

The grasslands and shrublands in northern portions of Yellowstone National Park and adjacent areas in the State of Montana have been referred to as America's Serengeti. They support abundant elk, bison, deer, pronghorn, bighorn sheep, as well as their predators, including grizzly and black bears, wolves, coyotes, and mountain lions. These habitats have been a source of debate since the 1920s, when park biologists believed grazers were adversely affecting shrubland habitats through their herbivory. These beliefs led to within park reductions of elk, bison, and pronghorn through the 1960s. Thereafter, numbers were allowed to naturally fluctuate.

Dramatic increases in elk through the early 1990s led to a congressionally mandated independent investigation of the health of the range. Since the early 2000s, declines in elk concurrent with increases in bison have continued debate over whether Yellowstone is overgrazed. The debate hinges on the question of what constitutes overgrazing and comes down to personal beliefs and value systems.

We present findings from integrated field studies completed during 2012-2018 evaluating the health of the northern range. To highlight differences between value systems, we evaluate the capacity of northern Yellowstone, particularly for bison, based on landscape topography, soils, climate, and forage production. We contrast this evaluation with observed abundance and use patterns of free-ranging bison. We present findings from a six-year field study indicating how bison engineer grasslands through their grazing and movements. We also present effects of bison grazing on ecosystem services such as photosynthetic rate, soil nutrient mineralization rates, leaf tissue nutrient availability, and plant composition. We conclude by placing our findings of the state of the northern range under historically high bison abundance in the context of the "enduring grazing debate."
Collaborations to Improve Conservation

GRAND TETON NATIONAL PARK
AND SUBARU NATIONAL PARK ZERO LAN D FILL INITIATIVE: PARTNERSHIPS FOR SUCCESS

Margaret Wilson, Grand Teton National Park

In 2016, national parks sent over 42,000 tons of trash to landfills. That same year, Grand Teton National Park and its 3,270,076 recreational visitors sent over 1,400 tons (2.8 million pounds) to a landfill over 100 miles away. Waste management is a large component of national park operations and budget. In October 2014, Grand Teton National Park was invited by Subaru of America, Inc. and the National Parks Conservation Association to be a pilot park for the national parks Zero Landfill Project, along with Yosemite and Denali National Parks. The objective of the project is to leverage Subaru’s expertise to help identify, test, and promote practices to reduce the amount of trash the parks send to the landfill. Since signing Grand Teton National Park’s first Corporate Campaign Agreement, the partnership with Subaru has proven to be a successful collaboration with not just Subaru, but also park concessioners, Teton County, Jackson Hole Public Arts, and many others. In its first three years of the project, the park has analyzed its waste and waste diversion practices, more than doubled its recycling capacity, and hosted one of the largest studies on visitor attitudes and behaviors toward waste disposal and recycling in national parks. Additionally, in 2018, eight different entities collaborated to send over 73 tons of food waste from Grand Teton National Park to the West Yellowstone Compost Facility, in a composting pilot program that will help inform others on how to collect, store, and transport food waste in bear country. The Zero-Landfill Initiative continues to prove that corporate and local partnerships can assist federal agencies accomplish their mission and protect public lands for future generations.

AGENCY PARTNERSHIPS: COLLABORATING FOR WILDLIFE, SAFETY, AND ECONOMIC OPPORTUNITY ON THE YELLOWSTONE HIGHWAY

Renee Seidler, Idaho Department of Fish and Game
Tim Cramer, Idaho Transportation Department

The Idaho Department of Fish and Game (IDFG) and the Idaho Transportation Department (ITD), under the guidance of a Memorandum of Understanding and a Cooperative Agreement, are providing information and recommendations regarding how state and federal highways and concomitant traffic may be managed to reduce impacts to motorists and wildlife populations. These agencies work together to reduce wildlife-vehicle collisions (WVCs), improve safety and mobility and increase permeability of roads for wildlife. An ITD project on U.S. 20 in Island Park near Targhee Pass has provided an opportunity to address wildlife concerns while improving motorists safety and mobility. Notable long-distance ungulate migrations occur twice yearly through this four-mile stretch of highway. Grizzly bears, wolverine, and moose cross the road as part of daily movements. The project’s Purpose and Need includes goals to reduce WVCs and enhance wildlife movement across U.S. 20. Highway improvements include widening the road shoulders and adding a truck-climbing lane. Alternatives for the Environmental Assessment (EA) include three of five scenarios that describe highway design elements proven to reduce WVCs. Two alternatives will increase landscape permeability for wildlife. Through the scoping process, local government and residents have raised concerns about use of tax dollars, highway treatments to provide for wildlife movement that could lead to closure of public land, viewshed impacts, and compromised property values. Despite public meetings, website information, and regular stakeholder outreach, misrepresentations and confusion persisted about what was proposed and what the effects might be. The Idaho Transportation Department expects to announce a Preferred Alternative in June 2018. We will discuss proposed alternatives, the outcome of the project, challenges, lessons learned, and goals moving forward.
THE LAKERS – A SOLUTION FOR SUCCESSFUL MANAGEMENT OF THE HIGHLY UTILIZED MULTIUSE STRING LAKE AREA OF GRAND TETON NATIONAL PARK

Jess Erwin, Grand Teton National Park
David Vela, Grand Teton National Park
Dr. William Apel, Grand Teton National Park

String Lake (SL) is an easily accessible, 40.5-hectare lake in the front country of Grand Teton National Park (GRTE). Shallow with numerous beach areas, SL is a popular destination for swimmers, sunbathers, and non-motorized watercraft users. Situated between Leigh and Jenny lakes, and with many popular hiking trails in the Tetons, the SL area attracts backcountry, mountaineering, and horseback enthusiasts, as well as picnickers, wedding parties, and tour buses. Black bears and other wildlife frequent the SL area. Past human/black bear conflicts, primarily due to poor visitor food storage practices, have necessitated the removal of nuisance bears.

Few places in the Greater Yellowstone Ecosystem (GYE) share this unique combination of high visitor use, panoply of activities, and history of human/wildlife conflict. GRTE addressed this challenge with an equally unique solution for the successful management of this multiuse area.

In 2016, GRTE created the Lakers—a volunteer team to minimize human/wildlife conflict and provide a trained, uniformed, on-the-ground-presence at the SL area. Comprised of approximately 25 individuals, the Lakers (1) minimize human/bear conflicts, (2) promote resource conservation, (3) collect data to assess visitor habits and improve visitor experiences, (4) provide wayfaring and visitor assistance, and (5) manage traffic congestion. Lakers are trained by GRTE in many areas including bear spray use/wildlife interaction, first aid/CPR, public interface practices, and radio use and protocol. Lakers also are experienced in using mobile apps for efficient intrateam communication and daily reports.

Piloted in 2016 and 2017 and made permanent in 2018, the Laker program has been a resounding success. Since program inception, there have been no known bear food rewards in the SL area. GRTE management has used observational and scientific data collected by Lakers to increase safety, decrease congestion, and reduce resource damage. Data collected in 2016 found peak parking at SL exceeded designated capacity by 2.5 times. As a result, in 2017 when SL lots were at capacity vehicles were diverted to alternate park locations, parking on the SL main access road was eliminated, a multi-media publicity campaign was implemented throughout the intermountain region to alert visitors of crowded conditions and limited parking at SL, and an external multi-year comprehensive study of visitor-use patterns at SL was initiated by GRTE. Serving as educators and not enforcers, Laker visitor contacts exceeded 18,000 in 2017. Through this “boots-on-the-ground” interaction, Lakers informed visitors of Bear Awareness and Leave No Trace principles; increased understanding of park rules; provided wayfaring, wildlife behavior, and resource information; and significantly enhanced visitor experiences.

Piloted in 2016 with no funding, the Laker program functioned in 2017 with a $9K budget provided through philanthropic support from the Grand Teton National Park Foundation and over 3,000 hours by Laker volunteers. In 2018, GRTE has increased funding and implemented structural improvements at SL. Plans to expand the Laker program to other GRTE areas are under consideration. This paper describes development and results of the Laker program—a model for successful, low cost management of high visitation, multiuse areas in the GYE.

PARTNERING FOR IMPROVED INTERPRETATION OF CROW PLACES IN YELLOWSTONE NATIONAL PARK

Marvin Dawes, National Park Service
Staffan Peterson, National Park Service

The exclusion of Native Americans from Yellowstone at the park’s inception as a preserved wilderness has structured representations of the park that continue to impact how the park is understood and used by its stewards, the public, and traditionally associated peoples. The official acts of mapping, translating, and erasing indigenous names and meanings from the landscape limits our knowledge of the ways in which communities remember and encounter place. The emergence of archeology in the 1960s as the sole source of knowledge on
traditionally associated peoples often served to perpetuate those relationships. Recent challenges to the authority of archeology by indigenous peoples and other disenfranchised groups has resulted in an expanding dialogue with managers on how to better preserve and interpret the places in their charge, acknowledging the deep cultural needs of traditionally associated peoples.

Using a case study of Crow cultural knowledge of Yellowstone, we show how unique cultural information can be integrated into interpretive material. A collaborative and innovative program to expand the older limits of the creation of history is the Honoring Tribal Legacies project. These and other histories produced using multiple perspectives are far richer than those that may rely on science data and selective memory. Inclusively produced history is a space for multiple conversations and engagements, resulting in distinctive cultural understandings, centered on the complex and evolving relationship with time and place. Crow knowledge and practices based on ancient connections have significantly expanded notions of a park archeological “site” from a local and delimited area, to a dispersed, socially evolving and culturally meaningful engagement with place. Inclusively produced histories that engage in a critical way with maps, names, and legacies, reclaim indigenous connections to physical geography and cultural values, while offering managers, interpreters, and the public much richer understanding of Yellowstone.

ACCELERATING INFRASTRUCTURE AND CONSERVATION WORK IN YELLOWSTONE NATIONAL PARK AND OTHER PUBLIC LANDS – A NEW APPROACH

Larry Rogers, The Conservancy Project Study Group
J.D. Davis, Yellowstone Forever
Eric Curby, The Conservancy Project Study Group

The Problem

“I contribute to my favorite national park non-profit to the best of my financial ability. Unfortunately, that means I will not have the impact I want to have.”

Does that sound familiar? That was me. I wondered, “How can I have an impact beyond my financial contribution? I have skills, I have experience, and I have some time. Clients have paid big money for my skills and experience for many years.” And, the idea was born.

My Personal “Why”

“By leveraging my most valuable assets to improve our national parks, and by encouraging others to do the same, we can get more done than through money alone.”

How You Can Help

What are your most valuable personal assets? Your passion, education, and experience are needed right now. You can help us solve problems, like:

- traffic congestion in parks
- affordable housing for park employees, in parks and gateway communities
- project execution

The Scale Challenge in Park Projects

The Conservancy Project Study Group is researching best practices for accelerating projects to reduce the $11 billion maintenance backlog at our national parks, including $516 million in backlogged projects at Yellowstone. It is often challenging to execute large programs both timely and with excellence. Having the right talent available at the right time, to do just the work needed, can be daunting. Anything less is inefficient, costly, and a risk to quality.

A Pew-commissioned analysis concluded in March 2018 that as many as 100,000 additional jobs may be needed to execute the current backlog of work. Yellowstone’s share could require as many as 200-300 new people. Where will these people come from? Will it be possible to find the critical skills and experience needed, in just the right measure, at just the right time?

The Execution Challenge

We have learned the key to having just the right talent at just the right time is to assign those tasks requiring the most specialized skills to the most highly qualified people on an “as-needed on-call” basis. These roles can have the highest impact on project quality and execution time, while costing the project less than full-time resources.

Projects often fail due to incomplete scope development, which may lead to:

- additional risk
- excessive changes
- cost and schedule overruns
- project cancellation and failure
How is it that failure factors like those listed above occur?

- start spending as soon as possible after funding
- award to the lowest bidder
- without a complete scope
- without adequate contractor vetting
- allow planned completion date to dictate (bad) decisions

The Opportunity Before Us

What if it were possible to overlay a new era of scientific and technical volunteerism onto the burgeoning backlog of infrastructure and conservation projects at Yellowstone National Park? What if there are hundreds, perhaps thousands, of well-qualified, experienced men and women who will jump at the opportunity to make a difference for our national parks? Can we communicate the problem to them, and create an easy way to match them with real, challenging, and rewarding projects? Yes! Many have reached a point in life where they can volunteer a few hours or more each month. We can realize this concept by mapping skills, experience, technology and proximity as key measures to match a candidate to a project.

The opportunity before us is to attract, pre-qualify, and retain a broad talent pool of experienced experts by engaging them in interesting, challenging, and rewarding work.

The “How”

1. Align strategic non-government organizations (NGO’s) like Yellowstone Forever (YF) with the concept and value proposition of scientific/technical volunteerism. These organizations are the trusted partners of our national parks.
2. Partner with YF and the National Park Service (NPS) on best practices to implement the talent pool process within current contract award and management practices.
3. Communicate the concept broadly, reaching a large population of people who are candidates to join the talent pool.
4. Conduct a vetting process, leading to a pre-qualified database of candidates matched to skills, experience, and proximity to project locations.
5. Execute one or more “sample” projects to validate the concept or make adjustments.

A “day-in-the-life” of a Candidate

“Jennifer Doe” has worked as a senior ranger at Yellowstone and is nearing retirement. With a degree in wildlife biology and many years of experience in park operations, she wants to remain engaged in the work she loves after retirement.

Jennifer learns about volunteering to help with the execution of work at our national parks. She enrolls in the program and is quickly pre-qualified to work on assignments involving wildlife health, wildlife migration and mitigation, park management, and traffic. Based upon her home address, Jennifer is matched to roles in Yellowstone National Park, Grand Teton National Park, and all of the public lands in the area.

Soon, Jennifer is offered an opportunity to assist with scope development and on-boarding a new contractor that will be working in Lamar Valley at Yellowstone. She is asked to be available up to four hours each week, as a volunteer. Her work involves occasional meetings in the park, but mostly working online, reading and evaluating detailed scope documents and construction work orders. She suggests possible revisions to correct and clarify the desired project scope.

She performs her work with exceptional results. After the project, both the NPS project manager and the contractor superintendent praise her contribution to the project, which experienced far fewer changes and delays than a typical project at Yellowstone.

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THE YELLOWSTONE-GRAND TETON BIOSPHERE AREA; A MULTI-PARTNER EXPANSION OF THE ORIGINAL YELLOWSTONE BIOSPHERE RESERVE

Christie Hendrix, Yellowstone National Park
Sarah Haas, Yellowstone National Park
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The United Nation’s Man and the Biosphere (MAB) Program designates conservation areas as “biospheres,” and promotes the rational and sustainable use and conservation of natural and
cultural resources. The program also upholds the need for a positive, mutually-beneficial relationship between people and their environment. In 2016, the United Nation's MAB Program informed the National Park Service of new policies related to their Biosphere Reserve Program. Throughout the United States, several national parks participating in the program, including Yellowstone National Park, had to reevaluate if they could reconfigure their biosphere boundaries to adhere to the new program standards. They were forced to ask the question, "What is the value of this program and do we fit the new paradigm?" The new program standards were designed to put people at the center of biospheres, recognizing that human actions worked in unison with the conservation of these unique areas. They also set forth a system where each biosphere should offer multiple uses and varying restrictions of resource protection. Yellowstone reached out to several local communities immediately bordering the park, as well as Grand Teton National Park, John D. Rockefeller, Jr. Memorial Parkway, and the National Elk Refuge, to see if they would be interested in joining the newly proposed Yellowstone-Grand Teton Biosphere Area. The park worked successfully with these groups to propose a newly expanded biosphere boundary, with conservation areas that represent no human occupation (wilderness areas), areas where hunting, research, and temporary visitation occur, and communities where humans reside and play an integral part in the conservation of the GYE. Here, we describe the actions we took to expand the biosphere, to network with agency and community partners, the status of our application, and potential future steps for the Yellowstone-Grand Teton Biosphere Area.
THE SOCIAL ENVIRONMENT OF PUBLIC WILDERNESS

Justin Menke, University of Oregon

Research on visitor use in parks and protected areas informs planning and management efforts to minimize impacts to resources and provide for visitors’ quality of experience. The National Park Service (NPS), for example, is mandated “to conserve the scenery and the natural and historic [resources] and to provide for the enjoyment of the same in such manner...as will leave them unimpaired for the enjoyment of future generations.” Balancing the dual mandate—for public use and “unimpaired”—is a growing challenge for managers as visitation to parks increases. To meet this challenge successfully, managers must be equipped with information about visitors and their behavior. This research is an approach to examining how visitors’ behavior is influenced by social variables of park environments.

Recent studies have utilized GPS technology to track visitors’ spatial movement and identify behavioral patterns. However, the variables that influence visitors’ spatial behavior (why those patterns occur) are not well understood. The natural environment (inherently associated with parks) attracts visitors and influences their behavior. Parks tend to evoke a romantic notion of nature free from human interference; yet, they have been altered with infrastructure (the built environment) to support visitors’ interaction with the natural environment. Roads, trails, and signage guide navigation patterns; visitor centers and parking lots produce navigational confluences; and lodges, concessions, and other nodes of conveniences attract. The built environment, by design, influences visitor behavior. A third environment of influence, less physically apparent yet significant, also arises as consequence of public interaction with parks—the **social environment**. Visitors’ behavior is influenced by interaction with other visitors, not by overt design but circumstance. Visitors, by sharing physical space and their experiences in that space, become a part of the environment they occupy.

Research has long examined the influence of other people on the quality of visitors’ experience, but less attention has been given to the influence on their spatial behavior. Where it has been examined, the framing is often of displacement—avoiding others, especially crowds. Visitor use, however, is not spatially uniform, rather a universal finding is that visitor use is concentrated (and, evidence indicates, increasingly so). Beyond the inherent qualities of natural resources, and the access and conveniences provided by built infrastructure, how does the social environment influence visitors’ decision-making and spatial behavior? This research examines that question in two contexts—in situ (in the park) and ex ante (before arrival)—and illustrates the social environment as potential benefit and attractant, in addition to potential detriment and repellant. This research expands recent work in the “how” and “when” of visitor behavior to further understand the “why” of visitor behavior.

Yellowstone National Park (YNP) will serve as a primary case study. YNP is an ideal case study for several reasons: it offers visitors exceptional autonomy—they have freedom of choice, with nearly all visitors navigating in personal vehicles; the large size and diversity of available experiences offers visitors a variety of choices; its iconic attractions draw disproportionate visitation relative to other developed areas of the park; and it attracts a range of visitor experience levels, many visiting for the first time. Additionally, the park is grappling with rapid visitation increases, especially in the past several years. To inform planning efforts, YNP is conducting a visitor-use management study over the peak visitation season this year (2018). Location specific surveys, via GPS-enabled tablets, will collect visitor responses across a range of social environments and crowding conditions. I plan to analyze these data to understand in situ behavioral responses to the social environment, while my own data from a behavioral intention instrument will inform variables of ex ante influence. Cartographic visualizations of these data will also contribute to the forthcoming *Atlas of Yellowstone, 2nd Edition.*

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1Social environment refers to the real, perceived, or anticipated presence of other people and their behavior in a physical environment. It is not used to refer to societal-level institutions, social structure, or culture.
ROLE OF MOTIVATION IN VISITOR’S EXPECTATIONS AND PERCEPTIONS OF QUALITY

Dr. Jennifer Newton, Grand Teton National Park

Visitors travel to parks and protected areas, and specific destinations within them, for different reasons. Some may want to have a quiet picnic by a lake while admiring beautiful vistas, while others may want to get their heart rate up by going for a trail run around that same lake. Many visitors have multiple motivations for visiting one area, for example those enjoying a quiet picnic mentioned in the previous sentence may also be looking for quality family time and listening to the sounds of nature, whilst taking in scenic beauty and eating lunch. By understanding visitor’s motivations managers can better recognize the types of recreation experiences visitors are seeking, and best offer opportunities for them while preserving resources.

While many studies have investigated the role of visitor’s motivations in regards to their chosen activity or setting preference, few have examined if there is a relationship between visitor motivations and their expectations and perceptions of the quality of their experience. This study examines the motivations of visitors to the Jenny Lake area in Grand Teton National Park and if visitors differ significantly in regards to their motivations. By using the importance-performance method as a model for analysis, this study expands the understanding of visitor’s motivations by grouping visitors by motivation and then exploring if they differ in their expectations and perceptions of quality. This presentation offers insight to the heterogeneity of park visitors, as well as how managers more effectively communicate to visitors to set expectations of their experience, which can aid in better overall perceptions of experience.

WHEN DOES CONGESTION MATTER TO A PARK VISITOR?: TRANSLATING PARK ROADWAYS’ LEVEL OF SERVICE TO IMPACTS ON THE VISITOR EXPERIENCE

Dr. Jeremy Sage, The University of Montana - Institute for Tourism and Recreation Research
Dr. Jake Jorgenson, RRC Associates
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Annual Yellowstone National Park visitation has increased more than 40% over the past 10 years, including a 21% increase from 2014 to 2016 to a historic level of use of 4.2 million visitors. Based on historic visitation trends, demand for visitation is expected to continue to increase. A 2016 traffic mobility study found the level of service on most Yellowstone roads rated a D, indicating serious platooning and delays. Substantial evidence indicates negative externalities are generated by congestion in urban settings as a result of frustrated drivers and lost productivity by commuters and commercial traffic. However, much less is known about the externalities associated with congestion in a national park. Do visitors experience the same frustration, and thus reduced visitation quality, with slow traffic due to bison in the road as they would due to urban congestion? Currently, a gap exists in the knowledge of how visitor experiences are impacted by conditions in real-time and across time and space.

This presentation reports on preliminary findings from a 2018 study utilizing GPS tracking on roughly 1,000 visitors to Yellowstone. Results provide valuable insight to the movement patterns of visitors across the park in variable levels of visitor density. Key attributes of assessment include the relationship between the visitors’ travel speed in relation to free-flow speed, length of time to find parking, and ability to stop at desired locations. Each of these indicators are then correlated with user responses to visitor experience questionnaires to assess the degree to which congestion and visitor density impact experience. Further, results provide additional decision support to management by nuancing level of service indicators provided from an engineering and planning perspective.

ASSESSING THE INTERGOVERNMENTAL USE OF ADAPTIVE MANAGEMENT TO ADDRESS THE INTRACTABLE CONFLICT OVER YELLOWSTONE-AREA BISON

Peter Metcalf, The University of Montana

Adaptive management is a learning-by-doing approach to managing environmental resources under conditions of uncertainty or complexity that has been widely embraced due to its theoretical potential to facilitate learning and improve
management outcomes over time. Despite its popularity, examples of successful implementation by government agencies remain scarce. To better understand why, we examined how an intergovernmental arrangement of federal, state, and tribal entities use adaptive management to implement a joint management plan for northern Yellowstone-area bison. We sought to understand how they operationalized adaptive management, to evaluate its effects on management learning and outcomes, and to identify barriers to its use in a multi-party context. Using a qualitative case study design, we conducted in-depth interviews with 50 federal, state, and tribal officials, as well as key informants; observed six manager meetings; and analyzed the administrative record. We found that despite the creation of a detailed, theoretically-informed adaptive management plan, its implementation only nominally followed the theoretical cycle. In particular there was a general failure to evaluate management actions against objectives and then close the adaptive loop by documenting what had been learned. Numerous barriers contributed to its sub-optimal implementation including institutional inflexibility, leadership, distrust between partners, risk aversion, scientific disagreement, and limited resources. Despite these shortcomings, adaptive management functioned as a conceptual orientation that facilitated improved management practices, accumulation of extensive monitoring data used to inform management decisions, and allowed plan adjustments to further bison conservation objectives. While our results illustrate the difficulty of conducting adaptive management in a multi-party context, they also suggest an underappreciated benefit: an adaptive orientation as the grease for continued commitment to work at long-standing resource management conflicts. The implications of these findings for both practitioners and scholars are discussed as well as recommendations offered to improve the use of adaptive management in cooperative settings.

HITCHIN’ A RIDE: THREATS AND ECOLOGICAL CONSEQUENCES OF AQUATIC INVASIVE SPECIES (AIS) INTRODUCED INTO YELLOWSTONE WATERS

Roy Renkin, Yellowstone National Park

This presentation will explore the ecological consequences of known aquatic invasive species currently inhabiting Yellowstone waters, and identify current threats facilitated by human use and recreation for a suite of AIS of national concern. The presentation will emphasize the importance of protecting headwater lakes and drainages from invasion and recognize the potential impacts downstream to the Gulf of Mexico and Pacific Ocean.

BALANCING CONSERVATION AND RECREATION IN OUR SHARED PLACE

Brooke Regan, Greater Yellowstone Coalition
Kathy Rinaldi, Greater Yellowstone Coalition
Dr. Mark Fiege, Montana State University

As the Greater Yellowstone Ecosystem (GYE) becomes a more popular place to visit and live, there is growing concern about the environmental and social impacts of more people recreating in more places. Meanwhile, federal agency budgets for managing recreation are declining. As a first step toward building coordinated solutions for recreation, Greater Yellowstone Coalition conducted an inventory of recreational use and hosted a symposium with Montana State University on balancing conservation priorities with growing recreation pressures.

Our objectives were to understand where and to what extent people are recreating in the GYE, potential challenges and opportunities, and next steps for crafting solutions to balance growing demand with conservation goals. We conducted interviews with land managers and recreational users, hosted roundtable discussions, compiled existing data, and convened diverse interests to share knowledge and provide feedback about what should be done next.

We found hotspots of recreation infrastructure and demand in the urban interface areas of the GYE. These hotspots intersect with sensitive wildlife habitat, including migration corridors, winter range, and occupied grizzly bear habitat (figure 1). We identified a need for data to describe the spatial patterns of recreation intensity. Information on the implications of recreation impacts to wildlife behavior and physiology for populations or ecological patterns and processes at broad spatial scales is lacking. We also identified places where current science may not adequately inform the visitor use management frameworks increasingly used within federal agencies for recreation related projects. We found shared concern about the challenges of growth and common value for wildlife among a diversity of interests.
This common ground poses an opportunity to build a shared ethic across the region for responsible recreation in light of growing demand.

Lessons learned from convening a variety of interests highlighted the need for more inclusive conservation planning that creates space and growth for communities of color. We found substantial interest in exploring an ecosystem level approach to building collaborative solutions, using socially generated data from digital applications to fill information gaps, and identifying creative mechanisms for securing new funding to conserve and manage GYE public lands.

References

INVESTIGATING A NOVEL APPROACH TO LEVERAGING TOURISM DOLLARS IN U.S. NATIONAL PARKS

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Background
During the 2018 Budget Session, the Legislature of Wyoming passed a Joint Resolution proposing a "wildlife conservation fee" for visitors to Yellowstone National Park and Grand Teton National Park. This fee would be transferred to the states of Wyoming, Montana, and Idaho for managing the impacts of wildlife moving outside the parks' boundaries.

While state agencies have traditionally addressed these needs through consumptive use of wildlife, increasing costs and the significant recent funding cuts that many state agencies have faced in recent years have resulted in a situation where insufficient resources restrict these agencies' ability to implement preventive and management solutions for mitigating the issue. The proposed fee would ensure revenue would also accrue from non-consumptive users.

Most national parks in the U.S. lie within mosaic landscapes with diverse ownership and land-use patterns, including agriculture and ranching operations that epitomize rural America. The movement of large mammalian fauna across and outside the boundaries of these parks can result in acute economic losses to communities living in these landscapes, in addition to the costs incurred for preventive actions by federal and state agencies and private landowners. Despite these challenges, this connectivity with the larger landscape is critical for system resilience. While these large protected wild areas undoubtedly have significant positive impacts on the larger landscape, local communities often end up bearing the costs, in a way subsidizing the presence of many of these iconic species. In many areas with significant large mammal populations that move outside protected areaboundaries, there is a
need to ensure that wildlife conservation pays for at least a part of the externalities associated with it.

Objectives
This extended abstract touches upon the three core objectives of the analysis. First, it briefly reviews international precedents where tourist entry fees and revenues from related sources have been channeled to ensure financial support for local issues and needs. Second, it discusses the opportunities for establishing similar mechanisms in the U.S., given the limitations imposed by existing legislation and regulations. Lastly, it discusses specific ideas that have the potential to create impact at the local level and on communities in working lands in these landscapes that can be funded through such initiatives.

Selected Global Case Studies
Across the world, tourist entry fees for national parks and other areas that support wildlife are often used for local initiatives. Apart from the specific interventions resulting from these funds, these systems have a greater impact—that of achieving buy-in and support for wildlife conservation from local communities.

Africa leads the way in this effort, with several well-established examples from across the continent, with site-specific or across-country initiatives. For example, in Amboseli NP in Kenya, 12.5% of entry fees are used for local community development projects. Wildlife legislation in Madagascar and Uganda mandate that 50% and 20% of park entry fees, respectively, are used locally. In Asia, a similar mechanism has been formalized for all 50 Tiger Reserves in India—100% of tourist entry fees are routed to a foundation that works on local issues. These foundations have representatives from the Forest Department, local NGOs, and local governments. In the Royal Chitwan National Park in Nepal, 50% of tourist entry fees are routed to a Buffer Zone Management Committee and used locally for a variety of initiatives.

Replication in the U.S.: Regulatory Limitations
Significant regulatory challenges prevent the use of tourist and other recreational fees for addressing issues outside park boundaries. Of the $400 million the National Park Service (NPS) generates annually from a combination of entry fees and concession agreements, 80% can be used locally in the parks that generate the revenue, with the balance going towards a pool used for non-revenue-generating parks. For this 80%, the Federal Lands Recreation Enhancement Act limits recreation fee use to a narrow list of activities related to recreational and maintenance purposes and limits the powers of individual parks in increasing recreation fees.

Potential Implementation Mechanisms
America’s parks are incredibly diverse—not just ecologically, but also from administration and management perspectives. This diversity calls for site-specific solutions that address critical issues unique to some of these parks while leaving the larger majority accessible to the masses. Potential implementation mechanisms include:

a. voluntary donations for wildlife management
b. revenues from concessionaire agreements
c. differential pricing

The funds generated through these mechanisms may be routed to a non-profit organization established specifically for this purpose, managed by representatives from the NPS, state wildlife agencies, local non-profits, and members from the ranching community, and may be used for a variety of initiatives with the broad objective of preventing or managing economic losses due to wildlife around the protected area.

The governance aspects are equally critical. Protected areas are often viewed by communities as top-down impositions by distant provincial or national governments that ignore legitimate local issues caused by setting aside these lands. It is important that local community representatives have the legal authority to participate in the decision-making process for using funds routed through such initiatives and that the money is used for addressing their priorities. These studies and pilots have the potential of offering solutions that ensure these wild landscapes become truly sustainable and garner broader support from the communities that live in these lands and play an often underappreciated role in conserving wild America.

BUILDING A STAKEHOLDER-DRIVEN, SCIENCE-INFORMED ASSESSMENT OF CLIMATE CHANGE IN THE GYE

Dr. Cathy Whitlock, Montana State University
Dr. Steve Hostetler, USGS Northern Rocky Mountain Science Center

The Montana Climate Assessment (MCA), released September 2017, was the culmination of a two-year effort that synthesized climate-change information in
a manner that addressed the concerns of stakeholder groups (http://montanaclimate.org). The MCA compiled observed climate trends and future climate projections and considered their potential impacts on water, agriculture and forest resources for the state. The project was a partnership of the Montana universities, state and federal agencies, nongovernmental organizations, tribal colleges, and local businesses. Involving stakeholders early in the MCA process was instrumental in ensuring a receptive audience for the findings of the report. Over the last year, the MCA has inspired productive discussions among stakeholder groups and communities across the state as they plan for the future. The MCA framework provides a model for stakeholder engagement that is needed in the GYE. A GYE climate-change assessment would synthesize the current state of scientific knowledge and explore the consequences for relevant stakeholder-identified sectors.

Climate model projections indicate that, by the end of the century, annual GYE temperatures could warm by 13°F with more days above 90°F. As a result, annual snowpack would be reduced by 20-80% and the timing of related stream flow would shift earlier in the year leading to longer periods of low flows. The region is thus likely to face (1) shortened winter seasons for recreation; (2) increased visitation pressures in summer, as people flee hotter regions; (3) late-summer water shortages and higher stream temperatures that would challenge agriculture, ranching, and recreational activities; and (4) increased fire, smoke, and health-related effects. The goal of an ecosystem-wide assessment is to foster grassroots conversations about climate change and elevate the topic in resource-relevant decisions. While clearly needed, the success of a GYE assessment would hinge on the participation and interactions of researchers and stakeholders similar to the MCA.
HABITAT CONDITIONS ASSOCIATED WITH NEW SETTLEMENT SITES OF BEAVERS IN SOUTHWEST MONTANA

Torrey Ritter, Montana State University
Lance McNew, Montana State University

Beavers (Castor spp.) are increasingly used as a tool for stream and riparian habitat restoration. Managers generally want to use beavers in semi-degraded streams that are relatively unmodified by beaver activity and represent suboptimal habitat. However, the identification of restoration sites is typically based on an understanding of beaver habitat suitability that may not accurately reflect the habitat selection process in suboptimal and unmodified habitats. Most beaver habitat suitability studies compare habitat at established colonies to unoccupied or abandoned stream sections. Because beavers drastically change their surroundings, many metrics used to assess suitable habitat may be altered by the time researchers collect data, and therefore may not adequately portray the state of the habitat when the colony was first established.

We conducted beaver-use surveys on streams in the upper Gallatin and Madison river drainages in southwest Montana to investigate habitat selection by beavers when they are colonizing habitats similar to those targeted for beaver restoration projects. Our objectives were to: 1) map stream sections that were relatively unmodified by beavers, 2) identify new settlement sites in unmodified habitats, 3) compare habitat conditions at new settlement sites to unsettled sites to identify factors associated with colonization, and 4) provide baseline information on beaver habitat suitability to help identify restoration sites with the highest probability of colony establishment.

We walked along streams in the study area during July-November, 2015-2017, and marked all active and inactive beaver sign. We then used the spatial distribution and relative age of sign to classify 400-m stream segments as active, abandoned, relic, or unoccupied. Active stream segments were part of established beaver colonies. Abandoned stream segments had lodges and dams in place but the structures were not being maintained by beavers. Relic stream segments had sign of past beaver occupancy, but dams and lodges would need to be rebuilt for beavers to occupy the area. Unoccupied stream segments had no sign of previous beaver occupancy. We defined new settlement sites as any beaver colony that was established within two years of the survey and was located in a stream segment previously classified as relic or unoccupied.

We measured habitat conditions representing three categories hypothesized to influence beaver habitat selection: stream geomorphology, woody riparian vegetation, and wetland types. We evaluated habitat at two spatial scales. First, we measured habitat conditions using a GIS to assess broad-scale habitat suitability. Second, we measured more fine-scale habitat conditions in the field. We used logistic regression to compare newly settled stream segments to unsettled stream segments. We only considered stream segments that were classified as relic or unoccupied as available to be newly settled. Therefore, abandoned and active segments were not included in the analysis. We evaluated models consisting of combinations of habitat variables we hypothesized would have the greatest impact on the probability that a stream segment would be newly settled by beavers.

We surveyed 244 km of 27 streams in the study area over three years. Within these streams, we surveyed 613 segments that were 400 m in length, 370 of which were classified relic or unoccupied. Over the study period we identified 27 new settlement sites which accounted for 48 of the 370 available stream segments (13%). Thirty (63%) of the settled segments were classified as relic and 18 (37%) were classified as unoccupied. Thus, beavers apparently selected for settlement sites with previous beaver modifications even if those modifications were old and no longer directly influencing the stream channel.

Our broad-scale habitat selection analysis indicated beavers selected stream segments with low gradients, dense woody riparian vegetation, narrow stream channels, and low-lying areas next to the stream. Our fine-scale habitat selection analysis suggested settled segments had greater variation in channel width and depth, and greater channel complexity in the form of side channels, backwaters, and tributaries. Our results suggest beavers selected new settlement sites
that facilitated stable and efficient dam construction. Low gradient streams reduce stream power acting on the front of the dam, and narrower streams may be easier to dam. Low-lying areas next to the stream may provide a larger flooded area behind the dams and may relieve pressure on the dam during high water events. Greater channel complexity and variation in channel form likely provide a variety of microsites to fulfill the requirements of colony establishment.

When evaluating potential locations for beaver restoration projects, we suggest managers evaluate habitat suitability at multiple spatial scales. An initial screening of the project area using a GIS and aerial imagery can give managers an overview of suitable habitat, which can then be refined using field-based habitat assessments. Stream segments that have been modified by past beaver occupancy may be especially attractive to beavers. Therefore, pre-engineering of the habitat at the restoration site using beaver dam analogues or rudimentary lodges may be a necessary step to encourage beaver occupancy. Whenever possible, such structures should be built in stream segments with characteristics similar to those described by our habitat selection models, with greater channel complexity, more variation in stream channel form, and conditions that facilitate efficient dam construction.

SHARING THE PROCESS AND PRODUCT OF SCIENCE AMONG ORGANIZATIONS AND WITH THE GENERAL PUBLIC: GOLDEN EAGLE REPRODUCTION IN GREATER YELLOWSTONE AND THE AMERICAN WEST

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The golden eagle (Aquila chrysaetos) has emerged as a species of growing conservation concern in recent years, as its habitats in western North America undergo dramatic changes. It is a wide-ranging, apex predator, capable of capturing a variety of species across diverse landscapes. Local breeding populations have been monitored and studied for many years by various agencies and organizations across Greater Yellowstone and other areas of the western U.S. A comparison of data collected in these sites reveals a wide variation in reproductive parameters both spatially and temporally. Annual reproductive rates, for example, were lowest in Yellowstone National Park, averaging 0.35 fledglings per occupied territory (range 0-0.80), and highest in western Utah, averaging 0.97 fledglings per occupied territory (range 0.53-1.44). Collaboration among the agencies and organizations conducting these studies improves our understanding of common demographic measures and provides opportunities for more comprehensive studies on the effects of climate, human activities, diseases, and other factors on population dynamics at biologically meaningful scales. It is critical to standardize monitoring/research methods to facilitate realistic comparisons, and that process has begun with efforts to establish a network of long-term golden eagle reproduction monitoring sites. The golden eagle is a charismatic icon of the American West and provides a powerful vehicle to engage the general public with the process and product of science. The Draper Natural History Museum, at the Center of the West, has installed a new exhibition entitled Monarch of the Skies: The Golden Eagle in Greater Yellowstone and the American West that showcases long-term monitoring and research conducted by several agencies and organizations. The exhibition is expected to be viewed annually by more than 200,000 people, who will learn about the importance of science-based conservation and collaboration among diverse research organizations and other stakeholders.
COMMON LOONS (GAVIA IMMER)
IN THE GREATER YELLOWSTONE ECOSYSTEM: MITIGATING HUMAN DISTURBANCE

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With an observed population of 20 territorial pairs in 2017, the common loon (Gavia immer) is Wyoming’s rarest breeding bird. Centered in northwest Wyoming, this small and geographically isolated population faces unique conservation challenges that require targeted management action. As a highly territorial, lakeshore-nesting species, loons are susceptible to nest failures caused by human disturbance, such as shoreline development or recreational activity. Studies and observations of loons in other regions (New England and the Midwest) suggest loons can successfully breed in areas with high human disturbance. Wyoming loons primarily occupy remote areas with historically low human population densities and, thus, may not have acclimated to human activity as well as loons in other populations. Despite formerly low human presence, Yellowstone National Park and the surrounding area now draw in nearly four million visitors annually, and human disturbance appears to be a primary factor limiting loon population growth in this area. In 2013, following a recent population decline, Biodiversity Research Institute working in collaboration with the Wyoming Game and Fish Department, Yellowstone National Park, Caribou-Targhee National Forest, Bridger-Teton National Forest, and Grand Teton National Park, began to assess the effects of human disturbance and other threats to loon survival and reproduction, and develop an array of management strategies to mitigate the effects of these stressors. Such strategies include creating and posting informational signage highlighting the sensitivity of nesting loons at lakes and trailheads; establishing temporary closures of campsites, shorelines, and other areas surrounding nest sites; and deploying artificial nest platforms in areas of high human-use. Some loon territories have also benefitted from lake or shoreline closures enacted for other species, including trumpeter swans (Cygnus buccinator) and grizzly bears (Ursus arctos). In 2017, 10 loon territories (50%) benefitted from one or more management actions. Following the initiation of these strategies, the Wyoming loon population has experienced increased productivity (measured as the number of chicks surviving per territorial pair), and data predict an increase in the number of adult loons continuing into 2019 unless countered by increased adult mortality or habitat loss. By advancing our understanding of this population, ongoing surveillance and banding efforts have helped to enhance existing management and are critical to developing future management strategies.

BEHAVIORAL PLASTICITY BUFFERS TEMPERATURE CONSTRAINTS ON FORAGING TIME FOR A MONTANE MAMMAL

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Contemporary climate change is altering temperature profiles across the globe, including within the Greater Yellowstone Ecosystem (GYE). Increasing temperatures can reduce the amount of time during which conditions are suitable for animals to engage in essential activities, such as securing food. Behavioral plasticity, the ability to alter behavior in response to the environment, may provide animals with a tool to adjust to changes in the availability of suitable thermal conditions. The extent to which individuals can alter fitness-enhancing behaviors, such as food collection, to proximately buffer temperature variation, however, remains unclear. Even less well understood are the potential performance advantages of flexible strategies among endotherms. We examined the degree to which individuals altered rates of food collection in response to temperature, and the corresponding nutritional benefits, using the American pika (Ochotona princeps), a temperature-sensitive, food-hoarding mammal, as model. From July–Sept., 2013-2015, we used motion-activated cameras and in situ temperature loggers to examine pika food-caching activity for 72 individuals across 10 sites in the GYE. We quantified percent nitrogen by cache volume as a metric of cache quality. We found a strong negative effect of temperature on the rate at which pikas cached food. Individual responses
to temperature varied substantially in both the level of food-collecting activity and in the degree to which individuals shifted activity with warming temperature. After accounting for available foraging time, individuals that exhibited greater plasticity collected a significantly higher amount of nitrogen by cache volume. By varying food-collection norms of reaction, individuals were able to plastically respond to temperature-driven reductions in foraging time and, through this increased flexibility, simultaneously amass a higher-quality overwinter food resource. Our results show given sufficient resource availability, plasticity in foraging activity may help temperature-limited endotherms to adjust to climate-related constraints on foraging time.

SONGBIRDS IN YELLOWSTONE NATIONAL PARK: THREATS, TRENDS, AND MANAGEMENT

Dr. Lauren Walker, Yellowstone National Park
Dr. Douglas Smith, Yellowstone National Park

Songbirds are a large and diverse avian group, widely threatened by the human footprint. Within the Greater Yellowstone Ecosystem, songbird populations suffer from habitat loss largely due to climate change, a shifting fire regime, and over-browsing by ungulates. To track songbird population trends, the Yellowstone Bird Program has participated in the nationwide Breeding Bird Survey every summer since the mid-1980s. However, to better evaluate how the human footprint impacts songbirds in locally vulnerable habitats, the Bird Program has more recently added surveys to track the timing of spring migration as well as monitor songbird abundance and diversity in the breeding and fall migration seasons within riparian corridors, grasslands, old-growth forests, and recent burns. Additionally, in 2018, the park established a banding station to collect demographic data vital to assessing songbird population stability.

In the spring, several migrant songbird species now arrive earlier compared with a decade ago. During summer and fall migration, willows host the greatest songbird abundance and diversity across monitored habitats. In contrast to the generalist songbird community found in over-browsed willows, tall willow stands provide habitat for riparian/willow specialists during the breeding season. Other avian specialists require intact grasslands or old-growth forests, habitats threatened by predicted climate and fire patterns. Recently burned forest supports numerous cavity-nesting species, depending on fire size, intensity, and years since burn. Woodpeckers, for example, are most abundant and diverse in forests two years post-fire.

By documenting baseline measures of songbird abundance, diversity, and demography, as well as how those measures change through time, the Yellowstone Bird Program provides valuable insight into the drivers of local songbird population trends. Ultimately, this insight may help establish clear links between park management and songbird conservation (e.g., the role of fire policy in preserving old-growth forest) and encourage the development of more comprehensive conservation strategies.

ARCTIC GRAYLING AND WESTSLOPE CUTTHROAT TROUT RESTORATION IN YELLOWSTONE NATIONAL PARK

Dr. Todd Koel, Yellowstone National Park
Jeffrey Arnold, Yellowstone National Park
Colleen Detjens, Yellowstone National Park
Brian Ertel, Yellowstone National Park

Fish native to the Gallatin and Madison watersheds within Yellowstone National Park include stream-dwelling (fluvial) arctic grayling and westslope cutthroat trout. Native fish are important because they evolved as an important component of a food web within Yellowstone National Park, with several resident and migratory animals relying on them as a source of energy during critical periods of the year. However, the historical stocking of non-native brook and brown trout and construction of the Hebgen Lake dam resulted in complete loss of the fluvial grayling. Westslope cutthroat trout, where they persisted, were mostly hybridized with introduced rainbow and/or Yellowstone cutthroat trout. As continued losses of native fish and altered ecology were realized over the past two decades, Yellowstone's approach to native fish conservation has greatly evolved. There is great potential to reconstruct native aquatic communities in some headwaters areas to conditions more closely resembling their historic state. Management
now focuses on the implementation of large-scale, innovative actions to preserve and restore native fish faced with non-native threats. For example, activities within the Gallatin and Madison river drainages include creating barriers and isolating headwater refuges; removing non-native and hybrid fish using piscicides (fish toxins); and reintroducing native species as eggs, juveniles, and/or adults from genetically-unaltered or other pure sources from within and outside Yellowstone National Park. The success of these activities requires a broad approach, includes a wide range of partners and stakeholders, and utilizes scientific oversight and assessment to ensure conservation goals are being met.

WORKSHOP: SCIENCE COMMUNICATION STRATEGIES: A WORKSHOP FOR DEVELOPING SKILLS AND INCREASING RESOURCES

Kira Cassidy, Yellowstone Forever

Science communication is increasingly recognized as an important part of scientific research yet scientists are rarely provided the guidance and opportunity to develop skills to effectively present their work to public audiences. Communicating this information is of great importance to promoting fact-based attitudes and decision-making and requires skills in a variety of communication strategies to engage audiences from many different backgrounds and disciplines. Communication of scientific research and results helps disseminate information in a way that is understandable and enjoyable with the ultimate goal of fostering appreciation for ecosystems, conservation, and science.

This workshop will consist of a lecture by the presenter followed by guidance and discussion using previous presentations as examples. The main focus of the workshop will be on presenting scientific information to public audiences in a powerpoint or classroom style. Some time will be spent discussing field presentations for public audiences. Participants attending this workshop will leave with a workbook and/or pdf document with links to online resources along with a list of tips and additional guidance for presenting scientific information. Participants will also be provided access to GYE-specific, custom-made presentation templates and media such as vector graphics (please bring a thumbdrive), and will leave with enhanced skills and an increased appreciation for communicating their research to public audiences.

NPS Photo - N. Herbert
SESSION TWO: Community/Skills Building

Panel Discussions

PANEL DISCUSSION: FROM THEIR MOUTHS: THE NEXT GENERATION’S PERSPECTIVE ON BISON

Facilitators: Ecology Project International – Erin Clark, program director; Daniel Fleming, program assistant
Panelists: Dr. Chris Geremia, Yellowstone National Park; Students from Gardiner School and Park High School - Zander Opperman, Elizabeth Leafty, Cole Nashan, and Sonia Bornemann

Each year, Ecology Project International (EPI) provides Montana, Idaho, and Wyoming middle and high school students with the opportunity to contribute directly to GYE research and service projects. The students collect field data, restore habitat, and explore human elements that influence public land and wildlife management.

Students graduate from their EPI field-learning experience with new perspectives, heightened self-efficacy, and a desire to be active participants in future decision-making around land use and wildlife management. EPI and Yellowstone’s bison management team have brought four Gardiner and Livingston students to this conference to share their next generation perspectives. These students, growing up in a county that is challenged to live with free roaming bison, are uniquely positioned to discuss the future of bison management in the GYE. These students also have the potential to become the next GYE natural resource managers and scientists.

EPI, in conjunction with Gardiner and Livingston science teachers, have selected and prepared four high school students to participate in this panel. The students will be joined by Dr. Chris Geremia, who interacted with them during their EPI field experience.

Attend this panel to learn directly from these local students about their hands-on learning and research experience in Yellowstone National Park and their hopes for future GYE wildlife and land management.

THE FUTURE OF THE GREATER YELLOWSTONE ECOSYSTEM CAN BE AS DIVERSE AS WE MAKE IT

Facilitator: Kristin Legg, Greater Yellowstone Inventory & Monitoring Network, National Park Service

Maintaining biodiversity and cultural heritage are critical to the conservation of the resources in the Greater Yellowstone Ecosystem (GYE) for the benefit and enjoyment of future generations. But who are these people? Studies show that diverse and inclusive workforces and communities are stronger, more creative, and innovative. As stated in the call for abstracts for this conference, “diversity in public land management is an important component to ensuring that all voices and perspectives are represented in decisions.” More than ever we need to create a welcoming environment for all to ensure the long-term stewardship of the natural and cultural resources of the GYE. This panel will explore the need for human diversity, obstacles to, and the steps we can take to make the Greater Yellowstone an inclusive environment for all visitors and for all who want to live and work here.
SESSION THREE: Social Science

New Data, New Tools

TRACKS, TIRES, AND GROOMING: A SNOWROAD STUDY TO INFORM MANAGEMENT DECISIONS

Molly Ohlen, Montana State University
Ry Phipps, Montana State University
Dr. Ed Adams, Montana State University
Dr. Dan Miller, Montana State University
Prof. Robb Larson, Montana State University

In winter, the National Park Service (NPS) at Yellowstone creates “snowroads” by grooming snow that builds up on the park’s roads. Visitors access the park via snowmobiles and snowcoaches. Modes of visitor access have long been controversial. Within the last few years, however, they have been successfully managed through a plan resulting from years of NPS collaboration with stakeholders.

The adaptive management plan central to this includes collaboration between NPS employees, oversnow vehicle operators, gateway communities, and others. This stakeholder team identified snowroad degradation as a priority issue due to its negative impacts on visitor experience and safety. The NPS reached out to snow scientists at Montana State University (MSU) to design and implement a scientific investigation of this problem and provide recommendations to park management. The NPS was especially interested in comparing road impacts of traditional, tracked snowcoaches with those of experimental, low-pressure-tire (LPT) snowcoaches as they consider future policy for LPTs.

This two-year field study investigated factors influencing snowroad quality in Yellowstone. Parkwide road quality analysis considered grooming activity, weather, snowroad depth, traffic quantity, and the resultant road hardness. Vehicle-by-vehicle impacts were studied using both road surface and subsurface measurements. Load cells, accelerometers, a high-speed camera, a penetrometer, and a “profilometer” provided data. Results indicated individual vehicles’ impacts are driven by surface rather than subsurface interactions with the road. On hard, groomed snowroads, both tracked and LPT snowcoaches can form ruts, but tracked vehicles continue to dig ruts deeper whereas LPT coaches’ ruts level out and stop deepening with successive passes. LPTs appear to form ruts primarily through compaction and tracked vehicles through snow displacement. Reduced tire pressures reduce rut formation and can harden the road. Results from this study will help inform NPS policies and operations at Yellowstone in the winter.

CHINESE TOURISM GROWTH TO U.S. NATIONAL PARKS AND GATEWAY COMMUNITIES: A CASE STUDY IN WEST YELLOWSTONE, MONTANA

Dr. Jennifer Thomsen, University of Montana

Chinese outbound tourism is one of the fastest growing industries worldwide including to many national parks. Despite positive economic aspects of increased tourism, parks and communities are faced with challenges that can impact management and the tourists’ experience. There is extremely limited research on Chinese tourism to U.S. national parks and this study addresses these gaps through a case study in a gateway community of Yellowstone National Park. Through interviews with Chinese tourists, tour operators, and local business owners, our findings offer insight to Chinese tourists’ travel patterns and perceptions, communication, and adapting to cultural changes in a gateway community.

EVALUATING THE VISITOR EXPERIENCE IN REAL-TIME: CREATING A NEW METHOD TO EXPLORE THE YELLOWSTONE EXPERIENCE

Dr. Jake Jorgenson, RRC Associates
Dr. Norma Nickerson, The University of Montana, Institute for Tourism and Recreation Research
Dr. Jeremy Sage, The University of Montana, Institute for Tourism and Recreation Research
Mandi Roberts, Otak, Inc.

As visitation numbers reach record levels in Yellowstone National Park, the visitor experience and movement patterns have become increasingly important topics of interest for park managers. Traditionally, park visitors have been surveyed either
as they enter or leave the park, or after they return home to gauge the perception of their experience. Additionally, travel flow monitoring has occurred in Yellowstone, but generally without the ability to ask questions about the experience at the same time. Unlike fields like wildlife biology, who have a plethora of movement information to correlate with on the ground conditions, social science has had limited ability to both monitor location of visitors in real-time while also delivering surveys about their experience. The ability to capture the real-time experience of visitors is vital, as they may be very different than results with post-experience surveys. Differences arise as visitors have the time to rationalize negative experiences and cope with the situation at hand. The purpose of this study was to use a new method to capture visitor experiences in real-time, as close to the start/end of the experience as possible, in order to guide Yellowstone managers to better understand specific visitor experience issues in the park.

During the summer of 2018, participating Yellowstone visitors were asked to travel a day in the park carrying a tablet with pre-programmed geofences. A mobile data collection application was custom designed to trigger surveys at key attractions and focal congestion areas. The tablet also recorded key GPS based attributes like speed and direction. Survey responses and GPS information can then be correlated to provide a deeper picture of the conditions present at the time of the experience. The results of this study are novel and provide park managers with in-the-moment perceptions at the site-specific level to make strategic management decisions.

FINDING AND USING CREDIBLE INFORMATION FOR LAND MANAGEMENT DECISION MAKING

Stephen E. Williams, University of Wyoming & S.E. Williams & Associates, LLC

Stanley E. Bellgard, Manaaka Whenua Landcare Research, Auckland, New Zealand

Public land overseers are confronted with a myriad of disparate elements to evaluate, audit, or judge in making land management decisions. These include scientific studies, economic imperatives, aesthetic, ethical, and cultural considerations. Recently added elements of importance include extracting knowledge from “big data” sets and integrating information based on traditional knowledge and cultural outlooks. Mechanisms have been developed to handle and integrate these various elements into the decision-making process. Bayesian networks have been developed to model systems that involve uncertainty (e.g., natural variation, imperfect understanding of the system, incomplete data, or a combination of these). There is effort to utilize such tools such as Bayesian networks to aid in decision making. This is laudable, but contended here is that other factors are more crucial to decision-making success.

Various policies (often codified as rules and laws) and end-users frequently demand that specific elements be used to make decisions sometimes in attenuated time frames. Circumstances aside, land-management decision making should be supported by the best available information and analysis. But what constitutes best available? Further, legitimate stakeholders (those with economic, aesthetic, ethical, and/or cultural ties to a decision) often demand to have their voices heard even when having conflicts of interest compromising their credibility. Ultimately success of the decision-making cycle (see examples in Bunnefeld et al. 2017) relies exclusively on trust between decision makers and trust in the process (including trust in Bayesian networks). Trust encompasses a vast range of factors. These collapse into a set of five fundamentals: propensity to trust and perceived ability, integrity, reliability, and benevolence of not only the decision makers but also the decision process (Chee et al. 2017). Injecting individual or group beliefs and dogmas in an attempt to direct decisions can foster mistrust especially where such beliefs and dogmas are counter to principles well founded on analysis and showing consensus (i.e., a lack of transparency).

A decision-making committee often is composed of a wide range of individuals with a wide range of talents and backgrounds (e.g., the Committee on Rangeland Classification was composed of 14 members including four university science professors, one university law professor, two USDA Forest Service science administrators, two private consultants, a USDA Science advisor, a representative from the Soil Conservation Service, a natural resources lawyer, a private rancher, and the committee chair from an institute for agriculture development.) Decision-rendering committees often find themselves in the position of being advisory to a
political entity that makes final decisions. If findings of a committee are not in keeping with the desires of one extreme side or another that is a constituency of the final decision-making entity, that committee may be fiercely attacked on their credibility, intelligence, motivations, and objectivity. "Standing in the arena with gladiators circling is neither an experience sought or relished" by most committees. Such a scenario as painted here erodes if not destroys trust. Mistrust engenders conflict. Once mistrust arises, the decision making cycle is broken and chances for a successful decision-making are diminished.

One of the first steps, therefore, in decision making is building trust. A crucial component of trust is credibility of input to the decision making process. This presentation evaluates criteria for determining input credibility pertaining to land management decision making. It includes validity measures of science and economic studies (e.g., statistical validity, degree of professional peer-review); public input on aesthetic and ethical characteristics (e.g., level and volume); ecosystem characteristics and services (e.g., data cleaning and transformation, information extraction and interpretation); traditional historical information pertaining to the decision (from persons usually having long-term observations and perspective in a given ecosystem); and cultural considerations (usually by indigenous individuals or groups and may have spiritual, sense of place, and esoteric ecosystem connections). This presentation highlights several case studies of land management decisions and the information and analysis used (e.g., The Hetch-Hetchy controversy, CA, USA; Medicine Wheel preservation, WY, USA; Development by Design land use planning, Mongolia; Jabiluka Uranium Mine in Kakadu N.P., Australia; and the Cascade Regional Park cultural imposition, NZ).

**The Lessons Learned in Teaching “Yellowstone” as an Ethical Problem**

Dr. Stephen Friesen, University of San Francisco

I teach environmental ethics, environmental justice, and philosophy of science at the University of San Francisco. In each of these courses, I teach Yellowstone: the principles and ideas that led to its creation and changes to management philosophy throughout its history. My presentation is a reflection on the way students respond to learning about Yellowstone and in the process, what I have learned Yellowstone can teach about the intersection of science and the humanities.

Yellowstone has long been a battleground of competing ideals concerning nature and natural resources, management priorities, and cultural values. As a consequence, teaching Yellowstone to undergraduate students requires a unique communication and learning strategy. It forces students to think holistically about three difficulties. I briefly articulate each of them and provide an instance of the learning objective at stake.

First, students have to consider competing general ethical principles concerning Yellowstone: do we have a moral duty to Yellowstone, as a biogeographical region, or is our ethical relation one which must only consider the consequences of our management interventions or non-interventions?

Second, students must grasp the relation between general ecological principles and particular management strategies: what should our management/intervention goals be when the science is profoundly indecisive, uncertain or even contentious (e.g., as in historical controversies over the carrying capacity of elk)?

Third, students must ponder the difficult distinction between the natural and the artificial: does regarding Yellowstone as part of a “natural” system have

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**References**


implications about our stewardship? And what if the concept of “natural” is deeply problematic in the Yellowstone context?

Many of us are led to visit Yellowstone, and to study its natural and human history, because we believe it to be a special place. In the preface to a recent edited volume concerning Yellowstone’s wildlife, E. O. Wilson declared Yellowstone to be “the real thing.” In the course of study, students have difficulty adopting uncritically this loftier ideal for Yellowstone’s significance. While searching for the “real” nature or meaning of Yellowstone, they invariably confront the deep and murky footprint that Americans have impressed on the Rocky Mountain ecology of North America.

**SOCIAL MEDIA & NATIONAL PARKS: UNDERSTANDING VIRTUAL VISITORS**

Dr. Zachary Miller, *The Pennsylvania State University*

Dr. Wayne Freimund, *Clemson University*

Social media platforms, like Facebook, Twitter, and Instagram, have fundamentally changed the way people communicate. This includes communication with agencies like the National Park Service. Although many organizations are trying to benefit from the huge numbers of people that can be accessed by social media, we know next to nothing about these “virtual visitors.” This presentation shows some of the first empirical research on social media and national parks from a project in Yellowstone National Park. In the presentation, we discuss virtual visitor characteristics, motivations, and preferences for engaging with the official Yellowstone National Park Facebook page. Additionally, it is often assumed that social media can be an excellent tool for engaging younger populations that may not find national parks as relevant as previous generations. To further explore how to better engage younger populations, we examine differences between millennials and non-millennial virtual visitors related to motivations and preferences for engaging Yellowstone on Facebook. Results indicate that virtual visitor demographics are nearly identical to the demographics of in-park visitors. Virtual visitors were mainly motivated to “like” the page for social, affective, and education/entertainment reasons. Analysis also suggest that millennial virtual visitor motivations and interactions with the page were significantly different compared to non-millennials. Managers, scientists, and other attendees of this presentation will gain insight into how to improve visitor experience on social media, as well as ways to improve their use of social media to communicate with the public.

NPS Photo - N. Herbert
MEASURING HUNTING IMPACTS ON GRAY WOLF POPULATION, SOCIAL STRUCTURE, AND LONG-TERM RESEARCH IN YELLOWSTONE NATIONAL PARK

Kira A. Cassidy, Yellowstone Forever

Dr. Douglas Smith, Yellowstone National Park

Trophy hunting of large mammals, especially carnivores, across the globe is increasingly a controversial issue involving many different stakeholders with a wide range of beliefs and values. Since gray wolves were removed from the Endangered Species List in 2009, with the latest delisting in Wyoming in March 2017, part of the management strategy for each state bordering Yellowstone National Park (MT, WY, and ID) is to limit wolf population growth and provide recreational opportunity through wolf hunting seasons. In order to quantify the impacts of hunting on wolf social structure, behavior, and population changes, the Yellowstone Wolf Project monitored wolf packs that used areas under the jurisdiction of the National Park Service >95% of the time. Ground and aerial observations were used to determine pre-hunt pack counts and compositions and to document when a wolf was harvested from one of the study packs. During eight hunting seasons, YNP recorded 36 harvests (13 radio-collared wolves) and were often able to determine the sex, age, coat color, social status, and breeding status of the harvested wolf. For comparison, all packs in YNP were monitored (both those that experienced a harvest and those that did not), recording changes in future pack size, territory size, dispersals, mortalities, and reproduction. Our results aim to inform conservation and National Park Service decision making for the future of large mammals moving across boundaries established by humans and through areas managed by several different agencies.

WOLF POPULATION REGULATION IN YELLOWSTONE: SURVIVAL, RECRUITMENT, DISPERAL, OR HUMAN EXPLOITATION?

Dr. Douglas Smith, Yellowstone National Park

Ben Balmford, University of Exeter

Dr. Daniel R. Stahler, Yellowstone National Park

Kira A. Cassidy, Yellowstone Forever

Dr. Daniel MacNulty, Utah State University

Dr. Tim Coulson, Oxford University

What drives wolf population fluctuations—or more precisely what leads to a change in wolf population growth rate? This is an age old question, but rarely has it been quantitatively addressed for wolves. Perhaps this is due to the overwhelming influence of human exploitation on wolves so looking for the natural cause proved elusive or impractical. Human killing leads to short lifespans, usually less than five years, with high turnover and male biased dispersal at least in Yellowstone. Human mortality may be a substitute for high natural mortality. How do wolves cope with so much death? The objective of our study was in the absence of high human-caused mortality (<3% per year) to determine which vital rate—survival, recruitment, or dispersal—was most important to determining wolf population growth rate. We used deterministic and stochastic models. In the deterministic model, vital rates were held constant at their mean value; in the stochastic model, we allowed vital rates to vary randomly within bounds observed in our Yellowstone wolf data. Using 294 radio-collared wolves from 1996 to 2016 (773 wolf years), we found adult survival had the strongest effect on mean population growth rate. Survival of yearling wolves was most important in both models, followed by two-year-olds, and then old wolves (six years old or more), which is an unexpected finding. Recruitment impacted variance in population growth as there was significant year-to-year variability in pup production. Dispersal depended on scale (did they leave the population or not).
WHO’S WATCHING WHO? VISITOR-USE AND WOLF HABITAT SELECTION IN YELLOWSTONE NATIONAL PARK

Colby Anton, Center for Integrated Spatial Research, University of California, Santa Cruz
Prof. Timothy Duane, University of California, Santa Cruz
Dr. Douglas Smith, Yellowstone National Park
Dr. Daniel R. Stahler, Yellowstone National Park
Prof. Christopher Wilmers, Center for Integrated Spatial Research, University of California, Santa Cruz

Tourism, specifically “visitor enjoyment,” is one of the foundational objectives of the National Park Service; and over the last century, U.S. national parks have become international travel destinations. Yellowstone National Park (YNP) data indicates that from 1979 to 2015 annual visitation increased by nearly 250% from 1.8 to 4.1 million annual visitors. Most of the roads in YNP bisect prime wildlife habitat, increasing the likelihood of human-wildlife interactions. This access to excellent wildlife viewing areas, along with hosting large, charismatic, and rare fauna, makes YNP an ideal stop for nature enthusiasts. Further, the wolf (Canis lupus) reintroduction in the mid-1990s unexpectedly created a growing demand for opportunities to watch wild wolves, increasing road use. Animal response to human activity is context dependent and can vary spatially and temporally. However, the potential effect of seasonal vehicle travel on wildlife habitat selection has not been sufficiently studied in the park. Research shows road presence in YNP significantly affects wolf habitat selection; however, this analysis did not account for varying road use intensity or wolf diel activity budgets. Here we use a resource selection framework to explicitly relate spatial and temporal visitor road use to wolf habitat selection from GPS collar data and ongoing visitor use trends. We will discuss how topographic, social, and ecological covariates influence wolf habitat selection in YNP. As visitation to protected areas like YNP increases, this methodology will allow us better to manage current and potential human-wildlife interactions, furthering our ability to understand human impacts in protected areas.

WOLVERINE RESPONSES TO WINTER RECREATION: EFFECTS OF RECREATION TYPE AND INTENSITY ON HABITAT USE

Dr. Kimberly Heinemeyer, Round River Conservation Studies
Dr. John Squires, U.S. Forest Service, Rocky Mountain Research Station
Dr. Mark Hebblewhite, Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, College of Forestry and Conservation, University of Montana
Julia Smith, Round River Conservation Studies
Dr. Joseph Holbrook, U.S. Forest Service, Rocky Mountain Research Station
Jeffrey Copeland, U.S. Forest Service, Rocky Mountain Research Station

Outdoor recreation provides opportunities for people to connect to nature, and is both a critical economic driver and part of the cultural fabric of some rural communities. Outdoor recreation is also increasingly recognized to have potentially important impacts on nature and wildlife, and we need to understand these potential effects. Technological advancements in over-snow equipment including “powder snowmobiles” and lightweight backcountry ski gear provide opportunity for backcountry enthusiasts to access previously remote landscapes for winter recreation activities. Wolverines may be vulnerable to direct and indirect impacts of backcountry winter recreation, as they remain active through the winter, naturally occur at low densities, have low reproductive rates, and enter reproductive dens within deep snowpack during the winter recreation season. Over six winters (2010-2015), in four study areas including the Teton, Centennial, and Henry mountains of the Greater Yellowstone Ecosystem, we GPS collared 24 individual wolverines exposed to a diversity of winter recreation activities within their home ranges. We simultaneously monitored and sampled winter recreation, collecting nearly 6,000 GPS tracks from backcountry winter recreationists, with additional information collected through trail-use counts and aerial-based recreation surveys. This combination of data allowed us to create maps of backcountry winter recreation portraying the extent and relative intensity of motorized recreation and non-motorized recreation...
within wolverine home ranges, and we found that winter recreation extent and relative intensity varies widely across individual home ranges. Using data for 18 animals (25 animal-years, >53,000 locations), we modelled habitat selection using resource selection functions. We measured habitat selection responses of wolverines to road-based and off-road motorized and non-motorized winter recreation. Wolverines exhibit functional responses to winter recreation, with avoidance increasing as relative intensity increases across home ranges. We provide the results from these analyses, and discuss them within the context of the large landscapes used and required by wolverines.

UNINTENTIONAL EFFECTS OF MULTI-USE MANAGEMENT ON SOUTHERN GYE MOUNTAIN LIONS

Dr. Mark Elbroch, Panthera
Dr. Lucile Marescot, CEFE
Dr. Howard Quigley, Panthera
Dr. Heiko Wittmer, Victoria University

Multiuse management is the hallmark of the American West, where landscapes are mosaics of lands managed by the National Park Service, U.S. Forest Service, U.S. Fish and Wildlife, Bureau of Land Management, state jurisdictions, and diverse private holdings. Western landscapes are influenced by diverse management objectives and stakeholder values. Migratory species and wide-ranging apex predators cross these jurisdictional boundaries, and are influenced by multiple management strategies simultaneously. Using multistate capture-mark-recapture models and an integrated population model (IPM), we explored age-specific survival and cause-specific mortality rates for 156 mountain lions (Puma concolor) monitored in the Greater Yellowstone Ecosystem in an area where multiuse management objectives included the restoration of gray wolf (Canis lupus) populations, decreasing and redistributing the local elk population through “liberal” hunting seasons, mechanized recreation, limited resource extraction, and controlling mountain lion numbers through managed hunting. Our results suggested three management interventions (unsustainable mountain lion hunting, reduction of a primary prey, reintroduction of a dominant competitor) have unintentionally impacted mountain lion survival. Mountain lion survival across age classes was lower in the six-month hunting season than the six-month non-hunting season. Predation on mountain lion kittens and starvation rates for all mountain lions also increased as managers reduced elk (Cervus elaphus) abundance in the system, highlighting direct and indirect effects of competition between re-established wolves and mountain lions over prey. The results of our IPM further suggested that the best strategy to stabilize the local mountain lion population was through increasing elk numbers on native range, an objective managers recently abandoned as an unachievable goal given their current toolbox. Our research highlights the synergistic effects of multiuse management strategies with those brought about by reintroduced, dominant carnivores (wolves). More importantly, our research emphasizes their combined effects on subordinate, hunted carnivores in human-dominated landscapes.

RISE OF THE BLACK WOLF: EVOLUTIONARY HISTORY AND SELECTION FOR THE BLACK COAT COLOR GENE IN NORTH AMERICAN WOLVES

Dr. Daniel R. Stahler, Yellowstone National Park
Dr. Douglas Smith, Yellowstone National Park
Dr. Daniel MacNulty, Utah State University
Dr. Rena Schweizer, University of Montana

The discovery of genetic variants that affect phenotypes and the mechanisms that maintain their prevalence is a rarity when studying natural populations. Yellowstone wolf research has revealed one such fascinating case. Specifically, black coat color has been investigated and found to be due to a beta-defensin gene (CBD103, or the K-locus), with all black individuals carrying a 3-nucleotide deletion linked to this color phenotype, a mutation believed to have originated in domestic dogs of the Old World. Black wolves’ presence in North America results from an adaptive introgression from human-transported dogs in northern Canada in the last 7,300 years. Using Yellowstone pedigree data, the black allele was discovered to be dominant over the gray resulting in its presence in black-colored homozygous and heterozygous individuals, but absent in homozygous grays. Interestingly, the frequency of black and gray wolves has remained approximately equal over 20 years. These unexpected results set the stage for studies exploring the link between genetics, fitness,
selection, and maintenance of color polymorphisms. Remarkably, it has been found that coat color genotypes are significantly linked to several fitness-related traits (survival, reproduction) and behavioral-related traits (mate choice, aggression) with population-level effects. Yellowstone wolves show strong selection for the black allele compared to other populations possibly due to immunological advantages. Integrating longitudinal data on reproduction, survival, mate choice, aggression, and disease, with molecular techniques, a surprising story linking coat color genes to wolf ecology is emerging. The modern presence and biology of black wolves in the Greater Yellowstone tracks the “footprints” of ancient humans and their dogs.
NATURE’S WEALTH: THE ECOLOGICAL AND ECONOMIC ROLE OF ECOTOURISM AND CHARISMATIC FAUNA IN THE GREATER YELLOWSTONE ECOSYSTEM

Dr. Barbara Jones, Brookdale Community College

Human social, economic, and ecological goals have typically been satisfied by relying on the more apparent economic measurability of development or resource extraction at the expense of what society has tended to see as “free” nature. This failure to assign nature a measurable value so that it is recognized as an asset has resulted in decisions regarding resource and land use to be made as if there was no cost to their loss. When decisions occur that lead to an increase in the scarcity of wolf habitat or a decline in the number of moose, the “freeness” of nature fails to trigger an increase in costs for resource users that would ultimately lead to a change in their behavior. Today that cost, though, is more frequently mitigated by blending the goals of biodiversity with the pragmatic valuation tools of the ecosystem services model. This model relies on human well-being as its metric. With this approach, the costs associated with the loss of nature and the benefits of maintaining intact ecosystems can more fairly be balanced against development or resource extraction in the decision-making process.

Measuring the value of nature is not necessarily about generating a cash flow, but rather about making nature competitive in any policy decisions that have typically relied on development or extractive practices as the social or economic default. Ecotourism as one of the measurement tools offered through the recreational amenity of the ecosystem services model gives decision-makers the opportunity to measure the value of tourist spending on ecotourism like wildlife viewing and the revenue that spending contributes to local economies. For the Greater Yellowstone Ecosystem (GYE), the accessible presence of iconic charismatic megafauna like wolves, bears, moose, and bighorn sheep that through their size and emotional appeal attract large numbers of people to the region offers significant economic benefits to the GYE. The number of visitors and the revenue generated from wildlife viewing opportunities have been significant enough that for Yellowstone National Park, wildlife viewing rather than hunting and fishing has become the biggest draw to the region in the fall shoulder season. A survey conducted for Yellowstone Park Foundation (now Yellowstone Forever) between 2004 and 2006 determined that more than 150,000 park visitors came to see wolves specifically and as a result of those visits generated for the GYE $35.5 million worth of economic activity annually. For the moose, according to a park ranger at Grand Teton National Park, it is the number one animal people come to the park to see. Accessible wildlife viewing opportunities like these not only encourage a greater public awareness of wild nature’s needs, but through tourist expenditures can incentivize local communities to maintain the integrity of these resources. By identifying the pantheon of species that live within the GYE as natural assets, the intrinsic and extrinsic values of protecting these animals and their habitats become a logical conclusion in both ecological and economic terms.

For the GYE specifically, when considering other competing land or resource use options, by measuring the value the presence of its iconic wildlife and their associated habitats provides, better decisions can be made that more accurately reflect the role intact ecosystems make to human well-being and the overall health of the planet. To make this connection, this presentation, through a reliance on interviews, archival work, and field observations, will investigate how the ecosystem services model, more specifically ecotourism and wildlife viewing, can by assigning value to the resources of the GYE more effectively balance natural resource consumption with its conservation.

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CLIMATE SMART CONSERVATION COMES TO THE GREATER YELLOWSTONE ECOSYSTEM

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Tom Olliff, National Park Service
Dr. Molly Cross, Wildlife Conservation Society

Understanding climate change is hard, but managing natural resources through this change will be much harder. The difficulty is accentuated by large areas, which are managed for different purposes and protect a diversity of affected resources. In an effort to demystify climate science and provide a road map for navigating this new management challenge, the Greater Yellowstone Coordinating Committee recently hosted a climate adaptation workshop for subcommittee members to promote practical and coordinated adaptation strategies. The workshop introduced a common language, provided information resources, and reinforced existing coalitions through focused, locally relevant case studies that dealt with changes to fire regimes, hydrology, and terrestrial invasive plants. This talk will discuss the benefits of the workshop and next steps towards refining management objectives and linking them to implementable actions that lead to specific, well-defined outcomes.

BIOPHYSICAL GRADIENTS ASSOCIATED WITH THE PERFORMANCE OF WHITEBARK PINE SEEDLINGS IN THE GREATER YELLOWSTONE AREA

David Laufenberg, Montana State University
Dr. Andrew Hansen, Montana State University
Dr. David Thoma, National Park Service
Dr. Jia Hu, University of Arizona

The efficacy of planting efforts for species of interest is important for ecosystem managers. Planting efforts represent an opportunity to conserve and manage species during a population crisis. Although federal agencies have been planting whitebark pine (WBP) in the Greater Yellowstone Area (GYA) for over two decades, these efforts have been met with varying success. In this study, we use a combination of field sampling and remote sensing approaches in order to investigate local biophysical gradients as explanatory variables for WBP performance in GYA planting units. Present-day field sampling affords an opportunity to evaluate WBP performance relative to earlier planting and monitoring records. Along with expected environmental drivers such as temperature, precipitation, evapotranspiration, elevation, aspect, slope, and competition, we also use MODIS and Sentinel-2 imagery to monitor snowpack longevity as a potential indicator of climate change microrefugia for this cold-adapted species. Ecosystem managers will continue to plant WBP in the GYA for years to come. This research aims to inform future planting efforts, and help identify potential microrefugia during a period of changing climate and high GYA WBP mortality rates.

TREE SPECIES RESPONSES TO CHANGING FIRE AND CLIMATE IN THE GYE

Kristen Emmett, Montana State University
Dr. Ben Poulter, Biospheric Sciences Laboratory (Code 618), NASA Goddard Space Flight

Climate-driven changes in fire disturbance could potentially alter tree species regeneration catalyzing abrupt changes in forest composition, structure, and function in the Greater Yellowstone Ecosystem. Our ability to predict species’ responses under novel conditions is dependent on the development of ecosystem models that can represent complex interactions between disturbance, climate, species competition, forest demography, and increasing atmospheric carbon dioxide. Dynamic Global Vegetation Models (DGVMs) are process-based models that represent these interactions and are therefore widely used to predict climate change impacts on terrestrial vegetation, frequently at the continental to global scale. DGVMs require input parameters including physiology, biochemistry, structure, and allocation to characterize generalized plant functional types. The potential for modeling vegetation at the landscape scale with DGVMs is promising, but presents a challenge for parameterizing individual species with limited data. Yet when accomplished, the species-level approach is exciting because it enables investigation of interactions between species composition, forest demography, and fire dynamics. Here we present results from parameterization of the dominant tree species in the Greater Yellowstone Ecosystem for the DGVM LPJ-GUESS to explore the causes of
recent changes in plant productivity detected from satellite-derived vegetation indices. Results from fractional factorial model simulations indicate a strong carbon dioxide fertilization effect on post-fire forest regeneration, while climate change is reducing post-fire productivity. These results suggest that the ability of plants to benefit from increasing atmospheric carbon dioxide depends on the bioclimatic context and the physiology of individual species, and demonstrates the utility of process-based DGVMs for modeling species responses to future novel climate and disturbance conditions.

DISEASE-INDUCED SOCIAL DISRUPTION IS BUFFERED BY GROUP SIZE

Ellen Brandell, The Pennsylvania State University
Dr. Emily Almberg, Montana Fish, Wildlife and Parks
Dr. Paul Cross, USGS
Dr. Andrew Dobson, Princeton University
Dr. Douglas Smith, Yellowstone National Park
Dr. Peter Hudson, The Pennsylvania State University

Infectious diseases play a large role in wildlife population dynamics, particularly in socially structured populations. The relationship between sociality and infectious disease is somewhat antagonistic whereby individuals in larger groups have higher contact rates and therefore a higher probability of becoming infected, yet smaller groups are more likely to suffer during infections from lack of functional redundancy (i.e., every individual is needed to cooperatively perform tasks). We address this issue using the Yellowstone National Park wolf-mange system. Mange is a disease caused by the introduced mite *Sarcoptes scabiei*, which induces scratching; scratching leads to hair loss and increased susceptibility to secondary infections. Although mange is a non-native infection, it is now endemic in Yellowstone’s wolf population. We have monitored mange invasion into the naive wolf population using the observed disease dynamics of uniquely identifiable wolves through space and time; this research has only been possible with citizen science. Specifically, GYE visitors share wolf sightings, disease status information, and photos on our site www.yellowstonewolf.org. Using these data, our modeling shows that solitary infected wolves benefit more from an increase in pack size than solitary healthy wolves. This suggests that sociality buffers disease-induced mortality and enhances recovery, probably because healthy pack-members are able to perform tasks that benefit infected individuals. Our models also demonstrate that recently infected packs have higher dispersal rates than healthy packs below an optimal pack size. Together, these results suggest that smaller packs are likely to suffer increased consequences of infectious diseases in a positive feedback loop—we refer to this as the social disruption hypothesis. The social disruption hypothesis provides insight into the relationship between sociality and infectious diseases by demonstrating the non-linearities that arise from differences in group size, and that smaller groups are more likely to be driven to extinction.

Literature Cited

Panel plot of mange spread from 2007 to 2016 in Yellowstone National Park. Color denotes maximum mange prevalence in each pack that year; no fill = no detected infection, light gray = 1-25%, medium gray = 26-50%, dark gray = >50% of wolves in the pack were infected at the same time during the year. Skull-and-crossbones symbols represent packs dissolved in that year (Brandell et al., in press).
Predicted weekly hazard, or probability, of mortality given pack size and infection status with sarcoptic mange based on 81 wolves studied in Yellowstone from 2007 to 2014. The figure on the left illustrates how infected individuals suffer much higher probabilities of mortality if they are alone or in small packs; however, as pack size increases, they survive as well as uninfected individuals. The panel on the right depicts predicted weekly hazards of mortality for uninfected individuals versus infected individuals for different pack sizes (N) and numbers of infected packmates. In this case, as the proportion of infected packmates increases, so too does the hazard of mortality for infected individuals. Tick marks on the top and bottom axes reflect observed data used in the analysis (Almberg et al. 2015).

SPATIAL PATTERNS OF WINTER ROAD-SIDE GRAY WOLF SIGHTABILITY IN YELLOWSTONE NATIONAL PARK

Jeremy SunderRaj, University of Montana
Matthew Metz, Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, College of Forestry and Conservation, University of Montana
Dr. Mark Hebblewhite, Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, College of Forestry and Conservation, University of Montana
Dr. Douglas Smith, Yellowstone National Park
Dr. Daniel R. Stahler, Yellowstone National Park

Imperfect detection is ubiquitous among wildlife research and can affect research conclusions and management. Accordingly, detection probability is often included in observation-based models. We leveraged research of gray wolves (Canis lupus) in Yellowstone National Park (YNP) to evaluate how the probability of sighting wolf packs from ground-based locations was affected by the characteristics of each spatial location (i.e., distance from the road, visibility from the road, habitat openness, carcass presence, and wolf group size). We used two approaches focusing on sightings during winter study periods in YNP between 1995 and 2017. We used 2,681 unique observations of 17 wolf packs collected during 44 unique 30-day monitoring periods. We compared these observations to the same number of random locations within wolf home ranges, and then used matched-case control logistic regression between observed and random locations to estimate the probability of observing a wolf. Second, we used information on visibility for wolves collared with Global Positioning System (GPS) collars and developed a probability of observing a wolf using logistic regression, but only compared telemetry locations where wolves were observed to locations where wolves were known to not be observed. We termed the first analysis a used-available model, and the second a used-unused model in accordance with the field of resource selection functions. Using both models, we found that the probability of wolf sightings declined as wolves were farther from the road and increased when wolves were in open areas and visible areas. We also found a higher detection probability when wolves were in larger groups. Ultimately, we used our results to build spatial predictions for seeing wolves in YNP. These predictions are useful to managers for identifying “hot-spots” of wolf observations and can also be incorporated into research related to wolf ecology and predator-prey dynamics that relies on ground-based observations of wolves.

GRAY WOLF TIES OBSERVED IN YELLOWSTONE NATIONAL PARK

Lizzie Cato, Yellowstone National Park
Rick McIntyre, Yellowstone National Park
Dr. Douglas Smith, Yellowstone National Park
Dr. Daniel R. Stahler, Yellowstone National Park
Erin Stahler, Yellowstone National Park
Kira Cassidy, Yellowstone Forever

Gray wolves (Canis lupus) were successfully reintroduced to Yellowstone National Park in 1995 to 1996. Since then, the population has been self-reproducing and highly visible in some park locations. This unique opportunity has allowed us to collect detailed data on wolf behavior in a wild free ranging population. Wolf Project biological technician Rick McIntyre worked on the project from 1997 to 2018. From 2000 to 2017, he recorded or complied from other Wolf Project staff and wolf watchers
detailed observation notes on 214 wolf ties during the annual winter breeding season. This is the largest known data set of observed ties in a wild free ranging gray wolf population. For each tie, the wolves involved were identified, along with their social status, coat color, and pack. Historically it has been thought that only the alphas or dominant breeding pair from each pack would mate each year. We found that less than half of the ties involved both of the alphas and over half of the ties involved at least one of the alphas. This suggests subordinate wolves are breeding more often than we had originally thought. We found more than half of the ties involved wolves of different coat colors. Previous research has shown that gray and black coat colors each have different biological advantages. More than 70% of the ties involved wolves from the same pack. Wolves are strongly territorial so this is expected. This is an ongoing study and we hope to analyze the data more in future studies.
WHERE SHOULD WE START LOOKING?
PREDICTIVE MODEL FOR HIGH ELEVATION BISON JUMP SITES IN THE WIND RIVER MOUNTAINS AND YELLOWSTONE NATIONAL PARK, WYOMING

Mara Gans, Central Wyoming/Middlebury Colleges

Is the Dinwoody Bison Jump a fluke? Located at 3,353 meters (11,000 ft) above sea level in the Northern Wind River Mountains, it is 732 m (2,400 ft) higher than the next highest documented jump site. Bison jumps are typically regarded as a plains phenomenon, which makes this site an archeological anomaly. If it is unique, it is merely interesting; however, if other similar sites are found, it becomes an indicator of a regional hunting strategy. Perhaps the Sheep Eater Indians used high-elevation communal hunting practices to kill bison on a wider scale than currently known. The discovery of additional high elevation bison jumps would change the way we understand the Native American human footprint within mountainous regions of the Greater Yellowstone Ecosystem. Yet, searching for new jump sites is an arduous task. This project aids that process by identifying the environmental characteristics necessary for a productive bison jump and then uses them to build a predictive model for where other jump sites could be located. This model has been applied across the Wind River Mountain Range and Yellowstone National Park to guide researchers as they search for additional alpine bison procurement sites. This talk discusses the process of building this model and the preliminary testing of the model in the northern Wind River Range.

The Dinwoody Bison Jump in the northern Wind River Mountains presents an intriguing anomaly. Located at 11,000 ft above sea level, it is the highest elevation documented bison jump in North America. Are there other similar sites out there? And if so, how does that change our understanding of how Native Americans used the Greater Yellowstone Ecosystem?
THE PIONEER, THE PROGRESSIVE,
AND THE PRESERVATIONIST FIND
COMMON GROUND IN YELLOWSTONE

Dr. Jeremy Johnston, Buffalo Bill Center of the West

On July 4, 1927, various dignitaries met at Cody, Wyoming, to join Buffalo Bill's niece and curator Mary Jester Allen in the dedication of the Buffalo Bill Museum. Within this group were old friends and business partners of Buffalo Bill, Senators John B. Kendrick and E. V. Robertson, representatives of the Burlington and Quincy Railroad, and members of the International Cody Family Association. Also attending were Margaret Hayden, clerk of the Shoshone National Forest Service, and Horace Albright, superintendent of Yellowstone National Park, whose presence reflected the critical role of federal land agencies in the region and their alliances with Buffalo Bill and the community of Cody.

Two years later, Superintendent Horace Albright sent the Buffalo Bill Museum a portrait with the following handwritten inscription, "For the Buffalo Bill Museum at Cody, one of our most cherished institutions." In addition to Albright's portrait, the Buffalo Bill Museum received a portrait of Gifford Pinchot, who inscribed the following, "For the Buffalo Bill Museum with admiring remembrance of Col. Cody." For many years, American Western historiography has categorized Buffalo Bill Cody, Gifford Pinchot, and Horace Albright in the respective camps of pioneer, progressive, and preservationist, often portraying these three groups and their representatives as being consistently at odds with one another. In the realm of popular literature, sometimes these individuals represent "the Good, the Bad, and the Ugly" of the tumultuous past regarding the use, conservation, and preservation of the natural resources and scenic wonders found within the American West. Yet these three photographs should cause us to pause and reconsider the relationship between the pioneer Buffalo Bill, Gifford Pinchot the progressive, and Horace Albright the preservationist.

Much has been critically written about these three men and their environmental legacies. Buffalo Bill is often portrayed as the pioneer scout and Indian fighter who advocated and practiced the slogan, "first in time, first in rights" for white settlers who ironically settled on American Indian land. Gifford Pinchot emerged from the Theodore Roosevelt administration as the leading progressive in the conservation movement, advocating the "greatest good for the greatest number for the greatest time." Using scientific principles, professional government bureaucrats would ensure the proper use of America's natural resources, as modeled by Pinchot's United States Forest Service created in 1905. Horace Albright advocated the "preservation unimpaired" for the nation's national parks through the National Park Service, created in 1916 and modeled after the Forest Service. This approach would ensure the continuation of national parks "for the benefit and enjoyment of the people" for generations to come. Seemingly the battle lines had been drawn between these three groups by 1916 with the creation of the National Park Service. Past conflicts, such as the damming of Hetch Hetchy in Yosemite National Park also stressed the different factions within the early conservation movement that emerged in response from the vast destructive forces of American expansion, such as the near extinction of the bison through market hunters like Buffalo Bill Cody. Simple events, such as Gifford Pinchot threatening to kill a spider in front of John Muir, which earned him a stern lecture regarding the rights of nature, also stressed the differences between the three groups.

Despite their differing perspectives and conflicting goals regarding the economic development, conservation, and preservation of public lands, Buffalo
Bill, Gifford Pinchot, and Horace Albright collaborated with one another to develop and promote visitor use patterns throughout the Greater Yellowstone Ecosystem. Regardless of their apparent differences, these three men found common ground and worked with one another to advance both their individual and collective tasks. Buffalo Bill, a renowned bison hunter and frontiersman, became an early advocate for Yellowstone National Park and the first national forests by promoting the opportunity these lands afforded to both protect wildlife habitat and advance tourism. Both Gifford Pinchot and Horace Albright viewed Buffalo Bill as a forceful, vocal advocate whose strong marketing appeal would reach vast international audiences and promote their emerging government agencies and endorse their differing government policies. The three men shared common interests in recreational tourism, human movement patterns, and ecosystem economics that generated greater federal oversight of the vast natural resources within the Yellowstone Ecosystem. Together their collaboration reflected modern interagency land-management practices through their collective goal to promote tourism and protect the natural wonders of the Greater Yellowstone Ecosystem, a partnership that for more than the first half of the 20th century united the disparate factions of the pioneers, the progressives, and the preservationists.

Horace Albright. Albright's handwritten inscription reads, "For the Buffalo Bill Museum at Cody, one of our most cherished institutions – Horace M. Albright, Yellowstone National Park." Photo courtesy of the McCracken Research Library, Buffalo Bill Center of the West, Cody, Wyoming, #p.69.663.

11,000 YEARS OF NATIVE AMERICAN OBSIDIAN USE IN YELLOWSTONE: A DISCUSSION OF ISSUES AND IDEAS REGARDING PUBLIC ACCESS TO TWO ACCESSIBLE OBSIDIAN SOURCE AREAS

Dr. Douglas MacDonald, University of Montana

Yellowstone National Park (YNP) is home to numerous sources of obsidian, a type of volcanic glass collected by Native Americans to make stone tools for more than 11,000 years. This paper discusses Native American use of two of Yellowstone’s obsidian sources, Obsidian Cliff and Cougar Creek. Both Obsidian Cliff and Cougar Creek are easily accessible to the public by road and trail, respectively. As such, this paper also discusses the implications of increasing public awareness regarding the two obsidian sources.

The earliest evidence of obsidian use by Native Americans in the region is two Clovis projectile points found at Yellowstone Lake by the University of Montana (figure 1). One of the Clovis points (figure 1a) was produced from Teton Pass obsidian found near Jackson, Wyoming, while the other Clovis point (figure 1b) was produced from the famous Yellowstone obsidian found at Obsidian Cliff. Another projectile point (figure 1c) was found near Lewis Falls and dates to more than 10,000 years old; it also was produced from Teton Pass obsidian.

Since that time, Native Americans have collected obsidian across greater Yellowstone to make stone tools. With warming climatic conditions, human use of YNP increased during the Late Paleoindian period after 10,000 BP. Over 50 sites in YNP have evidence of Cody complex Late Paleoindians, as attested by the famous Osprey Beach site in the West Thumb of Yellowstone Lake excavated by former Park Archaeologist Ann Johnson. Human use of the park area increased steadily during the Early Archaic (8,000 to 5,000 BP) and Middle Archaic (5,000 to 3,000 BP) to a peak during the Late Archaic period (3,000 to 1,500 BP). During the Late Archaic, Native Americans actively collected Yellowstone obsidian to use in communal bison hunts, as well as to trade within the Hopewell Interaction Sphere. One mound of the 2,000-year-old Ohio Scioto Hopewell culture contained more than 300 pounds of obsidian from the Obsidian Cliff and Bear Gulch sources in the Yellowstone region. Native American tribes, including the Shoshone, Crow, Nez Perce, Blackfeet, among
others, continued to live in Yellowstone until the late nineteenth century, even after Yellowstone was established as the world’s first national park in 1872.

Over the past 2.1 million years, active volcanism has played a pivotal role in shaping the Yellowstone region. The most recent volcogenic cycle began more than 640,000 years ago with the pyroclastic eruption of the Lava Creek Tuff and was later frequented with massive rhyolitic and basaltic magma flows. Of particular importance to this study were isolated rhyolitic magma extrusions of the Roaring Mountain member of the Yellowstone Plateau volcanic field, including those at Cougar Creek and Obsidian Cliff which both contain significant amounts of obsidian useful for Native Americans in stone tool manufacture.

In west-central Yellowstone, approximately 10 km northeast of the town of West Yellowstone, Montana, the 2.14 km$^2$ Cougar Creek rhyolite dome (figure 2) erupted 399,000 years ago, while 25 km further to the northeast, the 14.49 km$^2$ Obsidian Cliff rhyolitic magma flow occurred 180,000 years ago (figure 3). Both of these magma extrusions occurred north of the limits of the Yellowstone caldera boundary, but are linked to the system via subterranean magma chambers.

In the late 1980s, YNP completely documented the Obsidian Cliff obsidian source area with its listing as a National Historic Landmark. At the time, the park also initiated the recording of Cougar Creek. Both sources were sampled for x-ray fluorescence analysis to determine their chemical composition, thus making it possible to link artifacts from archaeological sites with their geologic sources. Of 2,259 sourced obsidian artifacts from YNP examined for this study, more than 60% come from Obsidian Cliff. Other important sources include Bear Gulch (Idaho; 13%), Cougar Creek (6%), and Teton Pass (5%). Based on an analysis of various attributes of the obsidians and the locations of the quarry areas, it appears Obsidian Cliff was the preferred obsidian due to its large source area, the high quality of obsidian, and its enhanced aesthetic qualities. The Cougar Creek source area is much smaller, the obsidian is of an inferior quality, and is not available in color varieties, making it less valuable to Native American stone tool producers. Another major difference of the source areas is the amount of quarry activity. Obsidian Cliff has more than 60 documented pits and trenches (evidence of Native American excavation to obtain obsidian), compared to only three at Cougar Creek. Clearly, Obsidian Cliff was the preferred material for Native Americans.

Yellowstone cultural resource staff have long sought to make information regarding Native American use of the park more available to the public. Today, both the Obsidian Cliff and Cougar Creek obsidian quarries are in close proximity to tourist areas. Obsidian Cliff is located along the Grand Loop Road a few miles north of Norris Junction. Cougar Creek is only a few miles northeast of West Yellowstone, Montana, and is easily accessible off of a popular hiking trail. Today, access to Obsidian Cliff is restricted due to its status as a National Historic Landmark, while the Cougar Creek source location is not widely known and does not...
The landscape and the principle roads undergoing improvement and expansion on a yearly basis. But most importantly, they have transformed the area from true wilderness to a park where matchless wonders are readily accessible for the benefit and enjoyment of the people.

The archaeological work associated with the road system leads us to a conundrum; the Historic Properties that we know the most about are also the ones most at risk. Expanded roads bring increased visitor use around them, and infrastructure development as we accommodate ever-increasing visitation and make travelling in the park safer is an inherently destructive force. In addition to the historic developments in the park and prehistoric cultural resources that have been documented by researchers as a result of the road improvement plan, in many cases the roads themselves are also culturally significant resources and worthy of protection on the National Register of Historic Places. The balance of protecting nature, preserving cultural resources, maintaining a parklike atmosphere, and increasing safety is complex, rewarding, and a very visible aspect of the human footprint in Yellowstone.

YELLOWSTONE AND THE SMITHSONIAN: CENTERS OF WILDLIFE CONSERVATION

Dr. Diane Smith

In 1872, the U.S. Congress established Yellowstone National Park, "dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people." The new park was also designated to "provide against the wanton destruction of the fish and game found within said park, and against their capture or destruction for the purposes of merchandise or profit."

While many scholars have looked at the history of Yellowstone and its wildlife management, particularly after the establishment of the National Park Service in 1916, few have explored how the U.S. Cavalry administered and transformed the park into a centralized source of animals (both living and dead) for museums and zoos.

This presentation shows how the Smithsonian Institution looked to Yellowstone National Park as a source of natural history specimens generally and, after the establishment of the National Zoological
Park, how it requested multiple specimens of living animals for protection and display in Washington, D.C. Initially envisioned as "a home and city of refuge for the vanishing races of the continent," the National Zoo was often referred to as an adjunct of Yellowstone, or even the nation's second national park. Thus, Secretary of the Interior John Noble agreed that such a request for animal shipments from Yellowstone was "altogether legal and one of the valuable purposes for which the park has been established."

Relying on extensive primary documents from both the Smithsonian and Yellowstone archives, this presentation shows how Yellowstone developed a system of trapping, displaying, and shipping iconic American wildlife around the country and even around the world, and created a captive breeding program for at-risk animals. Indeed, during the formative years prior to 1916, Yellowstone became in essence a vast zoological park and living museum, where visitors expected to see wildlife displays from the moment they passed through the great stone arch and often complained when they didn't.

Based on the book *Yellowstone and the Smithsonian: Centers of Wildlife Conservation* (University Press of Kansas, 2017), this presentation introduces the unique relationship the Smithsonian Institution established with Yellowstone National Park for scientific specimens. By the early 20th century, the park evolved into its own "center of conservation," where science, tourism, and wildlife conservation became inextricable linked, with tableaus of megafauna as carefully constructed as in any zoo or natural history museum display. This is a legacy that lives on in Yellowstone National Park, one that park managers struggle with to this day.

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Fig 1: One of the first illustrations of the area that would become Yellowstone National Park, showing a scientist collecting a specimen. Illustration by Thomas Moran, Scribner's Illustrated Weekly, 1871. NPS Photo.
CROSS-CULTURAL AND TRANSDISCIPLINARY RESEARCH OPPORTUNITIES THROUGH GREATER YELLOWSTONE AREA ICE PATCHES WITH A SCREENING OF THE 2018 SHORT FILM ICE PATCH ARCHAEOLOGY

Dr. Craig Lee, Institute of Arctic and Alpine Research and Montana State University
Halcyon LaPoint, Custer Gallatin National Forest
Dr. Shane Doyle, Native Nexus
Dr. Lawrence Todd, Greybull River Sustainable Landscape Ecology (GRSLE) program
Dr. Beth Horton, Yellowstone National Park
Ben Skudlarek, Montana PBS

Melting ice patches offer a tiny silver lining to the dark cloud of climate change in that the paleobiological material and archaeological material being exposed provides an unprecedented window into the past. Archaeological resources emerging from retreating ice patches capture public interest and offer an opportunity to integrate education about archaeology and Native American cultures with ancient and modern climate change and conceptions of land use. This presentation will begin with a short, nine minute video on Ice Patch Archaeology in the Greater Yellowstone Area (GYA), made by Montana PBS and INSTAAR with support from the U.S. Forest Service’s Custer-Gallatin National Forest and Region 1 Heritage Stewardship Enhancement Program. What we tend to think of as “empty” wilderness served as “home” for many people throughout millennia. Much of the GYA is currently managed as a place devoid of humans (except for tourists), and yet these places were indeed a “peopled-landscape” and contain clear evidence of sustained human interaction and involvement year-over-year, century over century, and millennia over millennia. It is patently wrong to think of these places as “intact” ecosystems without humans as an integral participant. What can we learn from Native people’s interactions with these spaces over time? The opportunities afforded by the ice patch record are finite and fragile—the decisions we make to engage (or not) with this opportunity to know more about the past will affect all future generations. The paper will end with a summary of the proactive steps being taken by Yellowstone National Park and other land managing agencies in the GYA to learn from ice patches in the coming years.
SESSION FOUR: Natural Science

Vegetation & Restoration

APPLIED WETLAND RESTORATION: USING HISTORY TO INFORM FUTURE RESTORATION WORK IN YELLOWSTONE NATIONAL PARK

Heidi Anderson, Yellowstone National Park
Christine Taliga, Denver Service Center

By the late 1800s, Yellowstone National Park (YNP) had already seen the introduction and planting of many Eurasian agricultural species including timothy (Phleum pratense), redtop (Agrostis stolonifera), and alsike clover (Trifolium hybridum), species now considered ecological weeds. YNP and others have documented their wide ecological amplitudes, often far surpassing their anticipated ecological niches and displacing native vegetation. Due to their widespread pervasiveness and the historic assumption that non-native species prevalence was related to groundwater depth, treatment and eradication have been considered unrealistic and a low threat to new restoration projects. YNP wetland restoration efforts have historically focused on treating existing visible non-native species and preventing introduction of new species by implementing protocols to prevent their spread and introduction. Native flora in sites restored with passive or aggressive revegetation efforts still faced Eurasian weed issues once hydrology was restored. An analysis of 17 years of YNP wetland monitoring data indicates non-native species prevention and passive or active native flora restoration is not sufficient to achieve desired restoration goals. Disturbance activities associated with the wetland restoration tend to release agricultural weed species from a seemingly inexhaustible seedbank, species often not expressed as high cover values in the reference communities. Once released these species are adept at reproducing vegetatively, freely colonizing wetland restoration sites without the competition of native species and forming monocultures. YNP monitoring data further indicates the floristic makeup of the existing seedbank is more important than groundwater depth for restoration of native wetland species. An examination wetland restoration data (>45 sites, 5 reference sites) indicates the use of a combination of restoration techniques including ongoing weed treatment and native species plantings are necessary to yield the desired restoration goals. Wetland monitoring in YNP has resulted in informing our direction for future vegetation restoration projects.

WINTER ANNUALS: SILENT KILLERS

Stefanie Wacker, Yellowstone National Park
Heidi Anderson, Yellowstone National Park

Vegetation is an important resource often taken for granted. Native plant communities are more than the pretty backdrop for wildlife photos; intact, native flora is a critical part of providing ecosystem services. Disturbances facilitate the degradation of our native communities, particularly by invasive species. Invasive species displace natives, alter community function, can create monocultures, and alter fire regimes. Human and environmental disturbances both contribute to the spread of invasive species. In Yellowstone National Park, human contributions include ground disturbance construction projects, increased social trails, expanding parking lots, roadside degradation, and shifting allocation of personnel resources. Exacerbating the human impacts are the local effects of climate change: decreased snowpack, earlier runoff, and warmer temperatures. Combined with other disturbances, conditions are increasingly suitable for the invasion of non-native species that operate as winter annuals. Winter annuals are problematic because they are prolific seed producers which germinate in the fall, overwinter with an active root system, and green-up in the spring before any of the native species. Early green-up allows species such as cheat grass and desert alyssum to exploit the water and nutrient resources. Disturbances intensify the proliferation of cheat grass, desert alyssum, and other species at alarming rates. Concomitantly, resources to chemically and mechanically treat these species have decreasing applicability on large scales and in the backcountry. We need to develop new tools for detection, prioritization, treatment, and rehabilitation of disturbed lands to lessen the spread of invasive plants. We have begun fall treatment of winter annuals and will present first year data.
THE NATIONAL WHITEBARK PINE RESTORATION PLAN: A MULTI-AGENCY COLLABORATIVE EFFORT TO RESCUE A HIGH ELEVATION FOUNDATION AND KEYSTONE FOREST SPECIES

Dr. Diana Tomback, Whitebark Pine Ecosystem Foundation and University of Colorado Denver
Eric Sprague, American Forests
Dr. Robert Keane, U.S. Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory
Dr. David Gwaze, U.S. Forest Service, Washington, D.C.

Whitebark pine (Pinus albicaulis) is a widely-distributed subalpine and treeline conifer in the western U.S. and Canada that functions as a foundation and keystone species important to community development and watershed protection. Its large, nutritious seeds are used by many wildlife species. Whitebark pine ecosystems are declining rangewide from exotic disease (white pine blister rust), west-wide mountain pine beetle outbreaks, advancing succession, and climate change. The species is listed as endangered in Canada under the Species at Risk Act and undergoing status review in the U.S. under the Endangered Species Act. Agencies with oversight for managing whitebark pine in the U.S. include the U.S. Forest Service, National Park Service, Bureau of Land Management, U.S. Fish and Wildlife Service, tribal governments, and private and state lands. In 2017, the U.S. Forest Service in partnership with American Forests and the Whitebark Pine Ecosystem Foundation began an ambitious, multi-step outreach process to organize a cross-jurisdiction restoration plan. The restoration plan, which is geo-spatial, identifies core areas (20-30% of the U.S. distribution) that will serve as "dispersal centers" for whitebark pine to adjacent regions. The core areas are being selected within agency units primarily based on biological criteria, including health status and ecosystem values, with proposed restoration actions for nominated areas. The national plan was announced and discussed at the National Whitebark Pine Summit, held in Missoula, MT, November 2017. Collaboration and active involvement by managers, scientists, and resource professionals are proving to be critical to the success of this plan, with multiple opportunities for feedback, especially by way of a steering committee comprised of agency liaisons. Plan deliverables will include a management/restoration strategy linked to the spatial data, field data on health status and restoration actions, implementation costs, and a compilation of best management actions.

FIRE SUPPRESSION IN 21ST-CENTURY SUBALPINE FORESTS OF GREATER YELLOWSTONE

Dr. Winslow Hansen, Columbia University
Prof. Rupert Seidl, University of Natural Resources and Life Sciences (BOKU)
Dr. Werner Rammer, University of Natural Resources and Life Sciences (BOKU)
Prof. Monica Turner, University of Wisconsin-Madison

Warming and drying in subalpine forests of Greater Yellowstone have caused large upticks in the number of wildfires and area burned. Increased burning will likely continue in the 21st century. Whether and how suppression of subalpine fires might mediate 21st-century climate-fire trends has not been evaluated, however. Twentieth-century observations suggest that past suppression has not influenced the frequency, size, or severity of subsequent subalpine fires and has not altered subalpine forests—unlike suppression in dry conifer forests. We used a process-based model, iLand, to assess whether past observations hold under 21st-century conditions by characterizing how a contemporary subalpine landscape would be different if fires had not been suppressed over the last three decades and how letting fires burn affects 21st-century fire and forests. We simulated a 60,000 ha subalpine landscape (46,000 ha of forest) in Grand Teton National Park from 1989 to 2099 with one scenario in which all fires were suppressed when weather conditions were average and another scenario where all fires burned without suppression. On average, 200 more ha yr-1 burned when fires were not suppressed between 1989 and 2017. Forest structure and composition changed little by 2017, irrespective of fire suppression. In the 21st century, cumulative area burned grew faster when fires were not suppressed. By 2099, almost twice as much area had burned. However, climate change had a much stronger effect on forest age and composition than fire suppression. Stand ages declined. By 2099, young stands (<40 years old) made up ~85% of
forested area, whether fires were suppressed or not. Lodgepole-pine dominance also declined markedly and was replaced by Douglas-fir. It appears fire suppression could reduce 21st-century burned areas but may only have a small to moderate effect on forests. Instead, climate change will likely be a more important determinant of forest age and tree-species composition.

MULTI-DECADAL SUCCESSION OF THE UNDERSTORY PLANT COMMUNITY FOLLOWING THE 1988 YELLOWSTONE FIRES

Andrew Andrade, University of Colorado Denver
Dr. Diana Tomback, University of Colorado Denver
Dr. Sabinne Mellmann-Brown, U.S. Forest Service, Northern Region
Dr. Tim Seastedt, University of Colorado

The 1988 Yellowstone fires represent the most significant fire event of the 20th century within the Greater Yellowstone Ecosystem (GYE). The understory plant community (forbs, graminoids, shrubs) responds rapidly after fire, with species composition influenced by abiotic gradients. Assessing the relative importance of competing gradients during succession is vital as understory vegetation will occupy an increasing proportion of the landscape through predicted changes in fire regimes within the GYE. In 1990, DFT initiated a long-term study at Henderson Mountain, Montana, and Mt. Washburn, Wyoming, each with two crossed factors: burn status (burned, unburned) and moisture regime (mesic, xeric). We asked the following questions: 1) How have richness and cover changed during the study, and how do values compare nearly 30 years after fire; 2) Have burned and unburned communities converged in community composition?

At both study areas, preliminary results indicate low richness in burned treatments in 1990, with yearly increases until 2001. By 2016 at Henderson, mean richness was greater within burned than unburned treatments, as well as mesic than xeric treatments (17.18 ± 0.72 xeric-burned, 7.64 ± 0.85 xeric-unburned, 26.36 ± 0.82 mesic-burned, 18.32 ± 1.46 mesic-unburned); similar trends were observed at Washburn in 2017 (14.06 ± 0.39 xeric-burned, 13.32 ± 0.46 mesic-burned, 8.24 ± 0.80 mesic-unburned). Bootstrapped 95% high density intervals (HDIs) of mean cover ranged from 41% to 63% at Henderson but suggested no difference among treatments. HDIs at Washburn ranged from 51% to 68%, also suggesting no differences among treatments. Regressions revealed significant treatment effects on plant functional group abundances at Henderson, with greatest graminoid and forb abundance in xeric-burned and mesic-burned, respectively. However, no significant treatment effects were detected at Washburn, except for forb abundance. Seral communities on Washburn appear to be converging in community composition with unburned communities, whereas communities on Henderson remain distinct.

CLIMATE TRENDS IN REAL TIME? WHITEBARK PINE POST-FIRE REGENERATION SINCE THE 1988 YELLOWSTONE FIRES

Dr. Diana Tomback, University of Colorado Denver
Elizabeth Pansing, University of Colorado Denver
Dr. Tony Chang, Conservation Science Partners

Whitebark pine (Pinus albicaulis) is an ecologically important species of upper subalpine and treeline communities in the Greater Yellowstone Area (GYA). Climate change studies in the GYA concur that whitebark pine will decline at its lower elevational boundary and eventually throughout most of the GYA. We monitored subalpine forest recovery since the 1988 fires at the lower elevational boundary (~2600 m) of whitebark pine in two study areas, tracking mapped whitebark pine through seven remeasurements of 200 plots. Because the regeneration niche for whitebark pine should be more restrictive than the niche for mature trees, are the effects of climate change apparent in whitebark pine regeneration patterns?

PRISM data from 1989 to 2017 for the Henderson Mountain (HM), Custer Gallatin National Forest, study area indicated average annual air temperature increased 0.100°C yr-1 (95%CI: 0.070, 0.129), but average annual precipitation did not change. PRISM data for the same period for xeric burned and mesic burned treatments on Mt. Washburn (MW), Yellowstone National Park, indicated increasing average annual temperature by 0.090°C yr-1 (95% CI: 0.059, 0.116) and 0.095°C yr-1 (95% CI: 0.066, 0.124), respectively, but no change in average precipitation. As of 2016/2017, median whitebark pine regeneration
density across three burned treatments in the two study areas reached 0.1 sites/m$^2$ but was four times greater (0.450 sites/m$^2$) on the northwest-facing MW mesic burned treatment. Based on AR5 RCP 4.5 and 8.5 global climate models, the HM study treatments have a higher probability (~0.115-0.162) of retaining whitebark pine through 2099 than MW (0.006-0.016). Higher regeneration density on the MW mesic burned treatment suggests interactions on a local scale may influence regeneration density dynamics. These factors, which may include soil moisture or shading by faster-growing conifers, could expand the regeneration niche and lead to higher germination rates and greater seedling survival.
In medicine, vital signs like blood pressure and pulse rate are simple routine measurements used to assess human health. When tracked over time, vital sign measurements contribute to diagnoses and track a patient's response to medical treatments. Slight abnormalities in vital signs may warrant a more careful diagnosis, whereas extremely abnormal vital signs may indicate a life-threatening condition and an immediate medical response. Vital sign monitoring has strong parallels in ecology for understanding the health of plant and animal populations, ecosystems, and public land units. Ecological vital signs include both physical and biological indicators that are sensitive to environmental change. Monitoring of vital signs may reveal when ecosystems reach critical thresholds. The most valuable vital sign indicators can be used to support decisions that promote ecological health and characterize the success of past management actions. Today, ecological vital sign surveillance programs employ reliable and standardized measurements to assess whether indicators are functioning within a natural or historical range of variation or nearing ecological tipping points. The National Park Service's Vital Sign Monitoring Program formalized the use of ecological vital signs to help track the health of national parks. The Greater Yellowstone Network and its partners currently collect data on several vital signs (e.g., amphibians, climate, river flows, and whitebark pine) in Grand Teton and Yellowstone national parks and across neighboring public lands. This program serves as a model to expand the monitoring program to generate information on selected vital signs that are important measures of ecosystem health at local, regional, and even global scales. A discussion panel will be available to review strategies for and current challenges associated with using vital signs to characterize annual and long-term vital sign trends that are likely to shape the future of the GYE.
YELLOWSTONE CITIZEN SCIENCE INITIATIVE: PROJECTS FOR THE PEOPLE

Joshua Theurer, Yellowstone Forever

“I love this place, but why would I bring a student group or my family here if they only contribute to the problems it faces? Many educators and visitors ask themselves this question after exploring places like Yellowstone, and seeing its management challenges firsthand. Yellowstone, and other parts of the Greater Yellowstone Ecosystem (GYE), are experiencing a human footprint conundrum—we are loving this place to death.

We need to connect people with public lands in meaningful ways. The challenge is to innovate new opportunities for engagement without compounding the impacts. In 1953, Bernard DeVoto wrote a letter entitled “Let’s Close the National Parks”, where he suggested just that, closing the park’s gates in response to increased visitation in the face of diminishing infrastructure.

While I disagree with this suggestion, some action is needed to help land managers meet their conservation mission and provide quality visitor experiences. That’s where The Yellowstone Citizen Science Initiative can help.

When applied carefully, citizen science projects allow us to engage park visitors in unique ways, generate scientific literacy, and contribute data that can help inform resource management decisions. It’s a win win.

In collaboration with National Park Service biologists and Ecology Project International, Yellowstone Forever launched six citizen science projects proposed by NPS and designed to involve visitors in the scientific process, Yellowstone resource issues, and ultimately civic engagement. This processes has been complex, and we continue to work through the nuances of our partnership, but together we have built a citizen science initiative we should all be proud of.

BRINGING “HOME ON THE RANGE” TO THE NEXT GENERATION

Rachel Garwin, Ecology Project International

Management of wildlife in Yellowstone National Park has both ecological and human dimensions. Effective ecological management requires both sound scientific research and an engaged, scientifically literate public. While some management issues may feel intractable, fostering relationships between scientists and the public at large can help bridge gaps and correct misunderstandings.

Since 2017, Ecology Project International (EPI), in partnership with the Yellowstone Bison Management team, has engaged over 400 middle and high school students in contributing to the bison team’s “Home on the Range” study. While the primary purpose of this work is to increase data collection efforts, a secondary result has been to create interest among the next generation in topical scientific and management questions surrounding the historically high bison population and its interactions with other ungulate species in the park and humans outside of the park.

By engaging in the scientific process—from discussing the study rationale to forming questions to collecting and interpreting data to making arguments based on evidence—students genuinely connect with the Greater Yellowstone Ecosystem and begin to understand their abilities to make positive change in both the present and the future.

Senior Bison Biologist Rick Wallen leads a 2017 group of EPI students from all over Montana looking for a collared animal as part of the Bison Ecology and Management Office’s “Home on the Range” study. Photo Credit: Brett French.
A student from Corvallis High School (Corvallis, MT) uses a radio antenna to locate an ungulate that’s part of the “Home on the Range” study during a February 2018 winter ecology course.

Students from Park High School (Livingston, MT) show off the fecal samples they collected from a collared mule deer as part of the “Home on the Range” study in March 2018.

FOR EVERYTHING THERE WAS A SEASON—CITIZEN SCIENTISTS RETRACE FRANK CRAIGHEAD’S FOOTSTEPS AND REVEAL PHENOLOGICAL SHIFTS IN THE TETONS

Trevor Bloom, The Nature Conservancy in Wyoming and Northern Rockies Conservation Cooperative

Dr. Corinna Riginos, The Nature Conservancy in Wyoming

Around the world, phenology—the timing of ecological events—is shifting as the climate warms. This can lead to a variety of consequences for individual species and entire ecological communities, most notably when asynchronies develop between plants and animals that depend upon each other (e.g., nectar-consuming pollinators). Grand Teton National Park biologists have identified this topic (“effect of earlier plant flowering on pollinators and wildlife”) as one of their priority research needs. We have gathered, digitized, and quality-controlled phenological observations of first flowering dates collected by Frank Craighead, Jr. in the 1970s, before significant warming occurred. First flowering date for 87% of a 72-species data set correlates significantly with spring temperatures in the 1970s, suggesting that these plants should now be flowering earlier and will continue to flower earlier in the future. In 2017, we began standardized phenological observations of these 72 species in the same location and initiated a citizen science program. Our proposed next steps are to: (1) gather and analyze further historical records of plant phenology in the region, (2) conduct 3-5 additional years of contemporary observations, (3) link plant phenological changes with potential cascading impacts on pollinators and foragers, (4) model phenology under future climate change scenarios, and (5) implement a sustainable long-term citizen science program in the Tetons, Wildflower Watch, engaging hundreds of visitors and the local community in research while simultaneously building a robust phenological dataset.

UTILIZING CITIZEN SCIENCE TO MONITOR VISITOR USE RESOURCE IMPACTS AT KEY LOCATIONS IN YELLOWSTONE NATIONAL PARK

Dr. Ashley D’Antonio, Oregon State University
Susan Sidder, Oregon State University
Alicia Murphy, Yellowstone National Park

In the face of rapidly increasing visitation rates to national parks across the United States, monitoring visitor use over time is becoming even more important. Visitor use monitoring allows park and protected area managers to better understand changes in visitation levels, visitor-use patterns, and recreation-related resource impacts over space and time. However, monitoring programs can often be time and resource intensive. During the summer of 2017, Yellowstone National Park embarked on an effort to use citizen science to monitor visitor use at five popular recreation destinations. Monitoring protocols were developed and then employed in the field by Youth Conservation Corp (YCC) crews. These protocols included data collection techniques to estimate visitor-use levels, understand visitor use patterns, document behaviors related to resource impacts, and record capacity-related measures such as counts of people at one time and visitor encounters.
This presentation will focus on 1) the methods and sampling approach used by the YCC Crews and 2) the opportunities and limitations of using citizen science approaches in visitor use and resource impact monitoring. Overall the YCC Crews were able to collect good quality data in a short amount of time with careful attention to detail. A key limitation of this approach is the small sample size collected per recreation destination. Despite this limitation, the data collected by the YCC Crews is of a high enough quality for beginning to understand visitor use at each site and for monitoring visitor use and associated resource impacts over time. The methods and approaches used in Yellowstone National Park can be applied to other recreation destinations in the Greater Yellowstone Ecosystem to help inform management decisions related to visitor use and resource protection.

ENHANCING PUBLIC UNDERSTANDING OF SCIENCE IN THE GREATER YELLOWSTONE ECOSYSTEM
Prof. Diane Debinski, Montana State University

Every year hundreds of scientists receive permits to conduct research in Yellowstone and Grand Teton national parks and the surrounding national forests. Afterwards, they diligently fill out annual reports and publish scientific papers. But how many of the park visitors understand or value the breadth of research that is going on in the Greater Yellowstone Ecosystem? There are some venues for public presentations, notably the University of Wyoming National Park Research Center’s Harlow Summer Seminar Series. However, most research is invisible to the visiting public. In fact, neither scientists nor managers would want to encourage visitors to think that they can take plant samples home or whip out a butterfly net. However, we may be missing an opportunity here. There may be some ways to encourage more interchange among scientists, managers, and visitors through 1) displays, 2) web sites, 3) phone apps, 4) signs, 5) field site visits, or 6) campfire talks. Although space is often at a premium, temporary displays in visitor centers could serve to feature a current scientist in residence and the research they are conducting. Communication could also be enhanced by providing links to web sites or apps related to featured research in the park or forest service newsletters. Digital linkages could allow visitors to learn about species either in real time as they hike or in the evening when they are relaxing in a hotel room. Signage is expensive and requires approval at multiple levels; but for longer-term research that involves instrumentation, this could be helpful. For example, a sign could explain what a phenocam is and why scientists are collecting phenology data. Finally, there may be other innovative ways that scientists could partner with agency interpreters to engage with the public, either in the field or at visitor centers.
MAPPING ELK AND MULE DEER MIGRATIONS ON THE WIND RIVER INDIAN RESERVATION

Gregory Nickerson, Wyoming Migration Initiative
Dr. Matthew Kauffman, University of Wyoming
Art Lawson, Shoshone & Arapaho Tribes Fish and Game
Pat Hnilicka, U.S. Fish and Wildlife Service
Holly Copeland, The Nature Conservancy in Wyoming

During the last decade, biologists have used GPS collars to document elk and mule deer migration corridors in the Greater Yellowstone Ecosystem, but the Wind River Indian Reservation has been left out of these studies. Even entities like National Geographic have represented migration corridors as ending near the border of this 2.2 million-acre reservation, which is jointly managed under the sovereignty of the Eastern Shoshone and Northern Arapaho. In fact, Tribal hunters and non-Indian residents of Fremont County have long recognized that migration corridors traverse the reservation boundary—and management jurisdictions—as documented by USFWS biologist Bruce Smith in the late 1970s. To remedy this lack of corridor data and provide better information to Tribal Fish and Game managers, a collaborative group launched a migration mapping study in March 2018. The project is creating the first detailed maps of elk and mule deer corridors along the reservation portion of the Wind River Range and the Owl Creek Mountains. The project complements the Wyoming Migration Initiative’s historical research into American Indian place names and travel routes that relate to wildlife migrations, to be published Oct. 2018 in Wild Migrations: Atlas of Wyoming’s Ungulates. The mapping project further dovetails with a National Endowment for the Humanities-funded project to document the cultural role of elk on the reservation. Together these projects recognize that effective scientific research with tribal groups in the GYE requires a foundation of cultural and historical literacy, and a respect for tribal sovereignty and protocols for conducting research. As part of this work, the co-authors held meetings in Ethete and Fort Washakie to introduce the project, share a meal, and receive blessings from Northern Arapaho and Eastern Shoshone elders. Our experience suggests that the study of ungulate migrations can be a uniting force across cultural and jurisdictional boundaries.

DROUGHT SHORTENS SPRING, IMPEDES RESOURCE TRACKING, AND MEDIATES A TRADE-OFF BETWEEN RESOURCE QUALITY AND STABILITY FOR MIGRATORY MULE DEER

Ellen Aikens, Wyoming Cooperative Fish & Wildlife Research Unit, University of Wyoming
Dr. Kevin Monteith, Wyoming Cooperative Fish & Wildlife Research Unit, University of Wyoming
Dr. Jerod Merkle, University of Wyoming
Samantha Dwinnell, Wyoming Cooperative Fish & Wildlife Research Unit, University of Wyoming
Gary Fralick, Wyoming Game and Fish Department
Dr. Geneva Chong, USGS
Dr. Matthew Kauffman, University of Wyoming

In spring, many migrating ungulates pace their movements with the progression of “the green wave” or the flush of nutritious plant green-up that sweeps across the landscape. The act of tracking or “surfing” the green wave plays a key role in the foraging benefit of migration. Despite concern surrounding the effects of climate change on migratory species and the critical role of plant phenology in mediating the ability of an ungulate to surf, little is known about how drought shapes the green wave itself and how drought influences the benefits and persistence of migration. To address this, we paired a 14-year drought dataset with remotely sensed data on plant phenology. Drought shortened spring green-up (p=0.022, r²=0.34) resulted in less sequential green-up (p=0.018, r²=0.36) along migration routes of mule deer in the Wyoming Range in the southern Greater Yellowstone Ecosystem (GYE). We used GPS tracking data to quantify green-wave surfing in a drought year (2013), an average year (2014), and a year with a wet spring (2015). Although individuals still surfed...
drought-altered green waves, albeit not as well as in more typical years, the most notable impact of drought was the overall shortening of spring. Even with perfect tracking of altered green-waves, migrants cannot behaviorally compensate for the reduction in the amount of time that key forage resources are available during springs shortened by drought. Lastly, we investigated the impact of drought on the duration of green-up at the level of individual routes, with an eye towards identifying routes that are buffered from drought. We did not find any routes to be drought buffered. Instead, our analysis revealed that high-quality routes with the longest green-up were the most affected during drought years. Increased drought is likely to decrease the foraging benefit of migration for ungulates in the GYE and beyond.

THE WYOMING MIGRATION INITIATIVE
MIGRATION VIEWER: AN ARCHIVE AND ONLINE TOOL FOR VIEWING WYOMING’S UNGULATE GPS, VHF, AND WGFD HABITAT DATA

William Rudd, Wyoming Cooperative Fish and Wildlife Research Unit
Dr. Shannon Albeke, Wyoming Geographic Information Science Center
Teal Wyckoff, Wyoming Geographic Information Science Center
Dr. Matthew Kauffman, University of Wyoming

The Wyoming Migration Initiative’s (WMI) mission includes the sharing of scientific information through public outreach. WMI has developed an archive for ungulate radio-collar data and an online viewer of ungulate migrations, which were built and are housed by the Wyoming Geographic Information Science Center at the University of Wyoming. In addition, the development of a second data archive and viewer for WGFD habitat data is underway. These projects provide a secure and consistent infrastructure to store and protect VHF, GPS, and habitat data. To date, five GPS datasets have been contributed by a variety of researchers, agencies, and organizations that have conducted migration research in Wyoming and will be the repository of future datasets. In addition, historical VHF data and related study information has been added and a project to view WGFD habitat data is under development. These applications are being developed in a flexible, hierarchical manner, aiming to accommodate researchers who wish to share their data with others, yet maintain a level of control for how raw data is accessed and shared.

The web-based migration viewer (migrationinitiative.org) allows users to access geospatial datasets and associated metadata, including study location, date, species, number of animals monitored, researcher name, and available reports or publications. Users can view study locations and animate animal movements through time. The habitat project viewer will also allow users to access geospatial associated metadata for WGFD habitat projects in Wyoming.

ONE HERD, MANY MIGRATIONS: A TEST OF THE FITNESS-BALANCING HYPOTHESIS WITH MULE DEER

Anna Ortega, University of Wyoming
Dr. Hall Sawyer, West Inc.
Patrick Burke, Wyoming Game and Fish Department
Mark Zornes, Wyoming Game and Fish Department
Dr. Jerod Merkle, University of Wyoming
Dr. Kevin Monteith, Wyoming Cooperative Fish & Wildlife Research Unit, University of Wyoming
Dr. Matthew Kauffman, University of Wyoming

The fitness-balancing hypothesis (FBH) posits that partial migration (multiple migration strategies within a single population) is maintained when tradeoffs in life-history characteristics and annual variation in environmental conditions result in equivalent fitness among migratory strategies. Although variation in the timing and extent of migration exists across ungulate taxa, mechanisms driving partial migration remain understudied. We are testing the FBH in a partially migratory herd of mule deer (Odocoileus hemionus) sharing a common winter range in the Red Desert of south-central Wyoming. This herd exhibits three distinct migratory strategies, including long-distance migration (~150 miles), medium-distance migration (~70 miles), and short-distance migration (~30 miles). On average, long-distance migrants spend less time on winter range and begin spring migration earlier (112 +/- 2 d; mean Julian day +/- SE) than medium-distance (129 +/- 2 d) and short-distance migrants (127 +/- 7 d). To evaluate whether the three migratory
strategies differed in their foraging benefit, we evaluated how well they surf spring green-up along their respective corridors. Based on spring movement data from 2014-2017, long-distance migrants are migrating significantly closer to peak green-up (14.3 +/- 0.2 d; mean days from peak +/- SE) than medium-distance migrants (21.1 +/- 0.2 d; ANOVA, F1,21970 = 392.2, P < 0.001), which we presume to carry a foraging benefit. In line with the greater spring foraging benefit, long-distance migrants exhibited higher percent body fat (9.0 +/- 0.5%; mean +/- SE) compared to medium-distance (7.0 +/- 0.4%) and short-distance migrants (5.5 +/- 0.5%) immediately following the fall migration (ANOVA, F2,320 = 4.53, P = 0.01). However, migration distance does not influence odds of pregnancy (P = 0.7). These results provide insights into the benefits of long-distance migration as well as the value of maintaining multiple migration strategies within a single herd.

WILD MIGRATIONS: WHAT WE LEARNED FROM COMPILING THE ATLAS OF WYOMING’S UNGULATES

Dr. Matthew Kauffman, University of Wyoming
James E. Meacham, University of Oregon
Dr. Hall Sawyer, West Inc.
Alethea Steingisser, University of Oregon
William Rudd, Wyoming Migration Initiative
Emilene Ostlind, University of Wyoming

Wild Migrations: Atlas of Wyoming’s Ungulates tells the story of the long-distance migrations that elk, mule deer, moose, pronghorn, bighorn sheep, and bison make each spring and fall across the landscapes of Wyoming. This book is the culmination of a six-year effort, and is the first synthesis of these epic journeys as seen through the eyes of the biologists and wildlife managers who have studied these herds. This broad effort to document the history, science, threats, and conservation efforts surrounding ungulate migration corridors has yielded many new discoveries. And our effort to tell the complete story of Wyoming’s ungulate migrations brings a historical and cultural perspective that is unique to the ways that we typically frame migration ecology and conservation. The migrations of the Greater Yellowstone Ecosystem feature prominently in the atlas. For example, the story of Yellowstone’s bison illustrates how a nearly extirpated population can build back its numbers and rediscover new ways to migrate across the park landscape over a century of learning. The bighorn sheep of Grand Teton National Park show the ways in which a formerly migratory herd can behaviorally adapt to living year-round on one, high elevation range. And the Red Desert to Hoback mule deer migration makes clear that long-distance corridors connect the multiple-use landscapes of the GYE’s periphery with its more protected core. A clear finding of the atlas is that although protecting migration corridors was not the initial rationale for creating the parks and other public lands that tie Wyoming, Montana, and Idaho together, today the vast, intact system of parks and forests that make up the GYE is one of our last remaining migratory landscapes.
SESSION FIVE: Community/Skills Building

Science & Collaboration

WORKSHOP/PANEL DISCUSSION: BRINGING SCIENCE AND COLLABORATION TOGETHER TO STEWARD THE GYE

This interactive workshop session will feature:

Mark Haroldson, US Geological Survey
Kris Inman, Wildlife Conservation Society
Chris Johns, National Geographic Society
Yvonne Martinell, Centennial Valley Association
Mark Deleray, Region 3 Supervisor, Montana Fish, Wildlife & Parks

Moderators: Gary Burnett, Heart of the Rockies Initiative
David Diamond, Greater Yellowstone Coordinating Committee

This interactive session will begin with a 25-minute panel of leaders in science and collaborative partnerships describing a case study of a private/public partnership to reduce conflict between grizzly bears and people in the High Divide corridor between the Northern Continental Divide and Greater Yellowstone Ecosystems. In 2016, landowner-led groups initiated a partnership across this larger landscape in order to continue or build funding for individual efforts. The partnership completed an assessment of existing conflicts and existing conflict reduction programs, developed possible future programs, and submitted a successful application to the National Fish and Wildlife Foundation’s Northern Rockies: Great Migrations and Crucial Corridors Program. The panel will be telling their perspective on this case study of how science can support, rather than direct, collaboration.

The panel will be followed by 35-minute breakout groups where participants will discuss barriers to success, and methods to bridge the gap between science and collaboration to support and enhance partnerships. The session will close with a 15-minute report-out session to summarize next steps for collaboration supported by science to inform stewardship within the GYE.

Panelists include:

- Mark Haroldson, US Geological Survey, Supervisory Wildlife Biologist for the Interagency Grizzly Bears Study Team, to represent the Interagency Grizzly Bear Study Team as a trusted source of science, and describe the challenges of drawing connectivity lines on maps;
- Kris Inman, Community Partnerships Representative for the Wildlife Conservation Society, will describe efforts to assist local communities in delivering wildlife conflict reduction tools and provide education awareness;
- Chris Johns, National Geographic Society, will describe the funding community’s perspective on supporting delivery of conflict reduction tools across a large landscape;
- Yvonne Martinell, a rancher from Southwest Montana and Chairwomen of the Centennial Valley Association, will provide a private landowner perspective on efforts to reduce conflict by removing attractants and supporting range rider programs;
- Randy Arnold, Region 2 Supervisor, Montana Fish, Wildlife, and Parks, will provide state wildlife management agency perspectives for reducing conflicts in the GYE, and for building long-term social trust.
Connectivity and Reduced Conflict between the Northern Continental Divide and Greater Yellowstone Ecosystems

Partner Organizations
- Swan Valley Connections
- Confederated Salish and Kootenai Tribes
- Blackfoot Challenge
- Granite Headwaters
- Watershed Restoration Coalition
- Big Hole Watershed Committee
- Ruby Watershed Council
- Madison Valley Ranchlands Group
- Centennial Valley Association
- Missouri Headwaters Partnership
This panel discussion will address three topics relevant to the Greater Yellowstone Ecosystem: Ecosystem Economics; Sharing Science Across Agencies and with the Public; and Partnerships, Collaborations, and Decision Making. The session will begin with short presentations from each commissioner on a current issue. Following the presentations, we will hold a facilitated discussion regarding what information decision makers need most from scientists and how the scientific community can effectively engage their constituencies.

Wildlife, water, visitors, residents, and commerce cross federal, state, and local government boundaries in ways that create opportunities for collaboration as well as conflict. Increasing visitation, a growing regional population, and growth in residential and commercial development are complex trends that demand reactive and proactive decision making. The best results will come from decision makers collaborating across boundaries and disciplines with scientists, sharing the growing body of scientific research around the region’s wildlife, landscape, water, climate, and people.

The infrastructure that supports 165,000 residents and millions of visitors in the GYE’s surrounding counties is substantial and provides critical support for the visitor experience in and the operation of the protected areas. Visitors provide a living for many, enriching our communities even as providing services and infrastructure for those visitors presents challenges to local taxpayers and officials.

A County Commissioner from each of five GYE counties will participate in a panel to present current projects and to engage in a moderated discussion. These elected officials are part of the network of GYE decision makers who guide the present and shape our future.

**Cindy Riegel**, Teton County Idaho Commissioner, will speak about Buxton River Park, a collaborative effort resulting from Teton County’s Recreation and Public Access Master Plan (2014). The county purchased 80 acres on the Teton River in partnership with the Trust for Public Land, the Idaho Department of Parks and Recreation, Idaho Fish and Game, and local non-profits. The project will protect and improve access to the river while providing an ideal site for river user and visitor education.

**Lee Livingston**, Park County Wyoming Commissioner, Outfitter, and governor-appointed member of Wyoming’s Outdoor Recreation Task Force, will speak to the importance of recreation. Recreation is a major player in the local economy and community of Park County. He will discuss the Outdoor Recreation Task Force’s final report and policy recommendations, tying those to their impact on the GYE.

**Mark Newcomb**, Teton County Wyoming Commissioner, will focus on vehicle-wildlife collisions that result in the deaths of around 200 animals every year and cost citizens and visitors over $1.2 million. This number could reach 500 animals per year as soon as 2020. Keeping the number of wildlife-vehicle collisions from growing requires a comprehensive suite of public and private efforts. Public efforts include funding the construction of wildlife crossings on county, state, and federal roads. Private efforts include working with landowners to allow wildlife movement in key areas and efforts to make drivers aware of wildlife, encouraging slower speeds through wildlife crossing zones.

**Don Seifert**, Gallatin County Montana Commissioner, will discuss the relationship between the Forest Service, Friends of Hyalite, and Gallatin County in the Hyalite drainage. Hyalite presents challenges of multi-seasonal use and planning for additional recreation on public lands with a rapidly growing population.

**Bill Berg**, Park County Montana Commissioner, will discuss a Federal Lands Access Program grant that focuses on the Old Yellowstone Trail from the Roosevelt Arch through Yankee Jim Canyon into Paradise Valley. This is a county road that travels through a section of Yellowstone National Park, crosses U.S. Forest Service land, and connects to a BLM river access. This historic route, key for secondary access, currently has an impassable section. The route also holds recreational value and provides a critical wildlife corridor.
IMPROVING RECREATIONAL ACCESS AND RIVER CORRIDOR MANAGEMENT THROUGH THE DEVELOPMENT OF SUSTAINABLE DESIGNATED RIVER ACCESS SITES IN THE GALLATIN CANYON

Jeff Dunn, RESPEC
Kristin Gardner, Gallatin River Task Force
Wendi Urie, Custer Gallatin National Forest

To address increased recreational use and associated impacts to streambanks and riparian vegetation along the Gallatin River, an assessment of river access sites was conducted between the Yellowstone National Park boundary and Spanish Creek. Within the project area, floating access and fishing access sites were mapped along 40 miles using color aerial imagery and on-the-ground observations. Additionally, local fishing outfitters and rafting companies, along with individuals from the rafting and kayaking communities, provided input on river access site usage. For each of the 111 identified river access points, the usage type, access type, and potential restoration treatments to improve the site for long-term sustainability were identified, with an emphasis on reducing streambank erosion and riparian degradation by focusing river access to designated locations. Based on this assessment, the Moose Creek Flat Campground was identified as the first site for river access improvements, which included installation of designated river access points for launching rafts and kayaks at hardened features, including a boat ramp, rock terrace, and rock kayak launch. Streambank bioengineering techniques were applied to restore degraded streambanks between the hardened features and riparian plantings were conducted on the floodplain within the campground to enhance the riparian buffer. A total of 3,500 native willow cuttings were collected by volunteers for use in the bioengineered streambank, and native trees and shrubs were planted on the floodplain. A trail system was developed to connect designated river access points and fencing was installed to protect riparian plantings and restored streambanks. Implementation of this project will provide for sustainable river access by reducing streambank erosion and the loss of riparian vegetation, which will result in reduced sediment loads to the river, increased shading along the channel margin, and reduced stream water temperatures.

TRENDS AND PATTERNS OF LOW-DENSITY RESIDENTIAL DEVELOPMENT IN THE MOUNTAIN NORTHWEST

Dr. Scott Powell, Montana State University
Rachel Ulrich, Montana State University
Dr. Andrew Hansen, Montana State University
Dr. Katrina Mullan, University of Montana
Dr. Dave Theobald, Conservation Science Partners

This paper presents an analysis of the spatial and temporal patterns and trends of land use and land use change in the mountain northwest region of the U.S. between 1990 and 2010. We focus specifically on trends in rural residential development for two primary reasons: first, because of the potentially oversized role that low-density residential development plays in conservation and maintenance of wildlands in the mountain northwest region; and second, due to poor quantification and mapping of this under-studied land use type and a limited understanding of its socio-economic and biophysical drivers. To address these knowledge gaps, we sampled 618 locations across Washington, Oregon, Idaho, and portions of Montana, Colorado, Wyoming, and Utah, according to a stratified random sampling design across gradients in distance to urban areas, economic drivers, climate, and proximity to natural amenities. At each sampling location, we used aerial photo interpretation at multiple scales to record land use and change over the 20-year time period. The results indicated that rural residential development increased by nearly 50% between 1990 and 2010, from 5.1% of the private land portion of the study area to 7.5%. Across all land use types, home number increases were observed in 11% of plots, including in 41% of plots already classified as rural residential development in 1990, and nearly 9% of plots previously classified as cropland in 1990. Relative to our sampling strata, home number increases were
more commonly observed in transitional areas near, but not including urban areas and, in particular, in high natural amenity locations. These results suggest that while rural residential development comprises a relatively small proportion of land use types across the mountain northwest region of the U.S., it is rapidly increasing, particularly in locations with high conservation value, such as those in close proximity to public land.

COMMUNICATING WITH VISITORS ABOUT BEAR SAFETY: VALUES, ELABORATION, AND INFLUENCING VISITOR BEHAVIOR

Dr. Zachary Miller, The Pennsylvania State University
Dr. Wayne Friemund, Clemson University
Dr. Elizabeth Metcalf, The University of Montana
Dr. Norma Nickerson, The University of Montana - Institute for Tourism and Recreation Research
Dr. Robert Powell, Clemson University

Human-wildlife conflict is a serious issue in the Greater Yellowstone Ecosystem. Although managers have many tools available to address human-wildlife challenges, communication is frequently used because it is appropriate in wilderness settings, is preferred by visitors and managers, and can be highly effective when designed correctly. In this presentation, we provide a conceptual framework from survey research conducted in Yellowstone National Park that is designed to influence the bear safety behaviors of day hikers. First, we look at the role values play in capturing visitor attention through messaging. Results show most visitors have more "ecocentric" values related to wildlife and that "ecocentric" messages about bear safety may be more effective at capturing visitor attention. Next, we look at ways to impact visitor behavior through communication strategies through the concept of elaboration, or thoughtful processing. We show that increasing visitors' interest, awareness, and cognitive engagement has a positive relationship with bear safety behaviors. Lastly, leverage points are identified using the theory of planned behavior for creating communications that are both efficient and effective. The structural equation model suggests attitudes and subjective norms have the largest effects on visitor behaviors, with perceived behavioral control playing a smaller role. When viewed collectively, the results from the research provide a science-based framework for improving communications with day hikers about bear safety.

REduced SPEED LIMIT: AN EFFECTIVE WAY TO REDUCE WILDLIFE-VEHICLE COLLISIONS?

Elizabeth Fairbank, Northern Rockies Conservation Cooperative
Erica Hansen, Northern Rockies Conservation Cooperative
Jaron Kolek, Northern Rockies Conservation Cooperative
Dr. Marcel Huijser, Western Transportation Institute - Montana State University
Dr. Corinna Riginos, The Nature Conservancy in Wyoming

Every year wild ungulates in the Greater Yellowstone Ecosystem make migrations spanning tens to hundreds of miles. This behavior is essential to maintaining the abundance and health of the GYE's deer, pronghorn, elk, and moose. Migratory ungulates must cross a matrix of highways to reach the resources they need. Wildlife-vehicle collisions (WVCs) on these roads are a significant source of wildlife mortalities, and traffic on roads creates a partial to complete barrier to wildlife movements. Wildlife crossing structures can reduce WVCs by ~90% and greatly improve habitat connectivity. However, these structures are expensive and, in some cases, impractical—prompting transportation managers to seek alternatives. Among the general public, there is support for reducing speed limits in WVC hotspots. However, almost no research exists on the effectiveness of reducing speed limits as a way to reduce WVCs, and studies of driver behavior suggest that reducing the posted speed limit may not slow drivers down. In order to inform this debate and future management practices, we are working with the Wyoming Department of Transportation (WYDOT) to assess the effectiveness of reduced nighttime speed limits in six WVC hotspots in the southern GYE. In each location, WYDOT reduced the posted speed limit from 70 mph to 55 mph at night during peak WVC seasons. Using a BACI design, we measured the effects of these speed limit reductions on vehicle speeds and traffic dynamics using radar.
recorders, deer road-crossing behavior using infrared video cameras, and deer-vehicle collision rates using carcass counts. Our preliminary results indicate drivers reduce their speed by 3-5 mph in response to the 15 mph reduction in speed limit, which may not be sufficient to alter WVC rates. This study is unique in scope and will be important in determining whether reduced speed limits are adopted more widely in the GYE.

**FOOTPRINTS AND HOOFPRINTS: THE HISTORY OF TRAILS IN YELLOWSTONE NATIONAL PARK**

Dr. Judith Meyer, Missouri State University

Hiking and bridle trails have left enduring footprints—and hoofprints—on the Yellowstone landscape and provide evidence of Yellowstone’s long history as a tourist destination, as well as administrators’ attempts to meet changing demands of what a national park experience should be. Serving as corridors for both transportation and recreation, trails are an important component of park management today. This poster investigates and illustrates the history of Yellowstone trails between 1881 and 1970 using historical documents, maps, and photographs; re-photography pairs; and Historical Geographic Information Systems. A series of maps is used to reveal the appearance, disappearance, and changing location of established trails to show that today’s numerous and well-maintained trails are (a) the modern manifestation of a long history of traveling on foot or horseback through the park, and (b) evidence of the changing role of trails as part of park management and visitor use.

Yellowstone’s trails pre-date the establishment of the park itself. The first Euro-American explorers reported seeing heavily-used Indian trails in the 1860s, and United States Geological Survey (USGS) topographic maps from the 1880s show almost a dozen different bridle trails, many of them named. Most of the park’s oldest trails seem to have been entrance and exit routes for visitors traveling to and through the park on horseback and not trails used by sightseers arriving by rail, “dudes,” or even “sagebrushers” (those traveling on their own with wagons, food, and other camping supplies). Most sightseeing was done via the Grand Loop Road, and early trails were most likely used by those who sought a different sort of park experience. Between 1900 and 1950, the number of named, maintained trails increased with both increasing visitor numbers and evolving visitor expectations, a process in which the creation of the National Park Service (NPS) surely played no small part. During his tenure with the Army Corps of Engineers in Yellowstone, Hiram Chittenden expanded on preliminary trail building work done by civilian superintendents. Limited federal funding for transportation coupled with long winters and rugged terrain meant concern for trail building was secondary to the importance of road building, and the park’s first designated trails were barely visible on the landscape (figure 1). By 1881, however, Yellowstone had over 200 miles of trails in addition to the Grand Loop and entrance roads. After the turn of the century, equestrian clubs and outdoor enthusiasts “rediscovered” Yellowstone, this time as a place to ride saddle-horses. Dude ranchers like Howard Eaton brought large numbers of tourists on horseback and took advantage of established trails or fanned their tour groups out across the landscape (figure 2), camping where there was suitable water, grass, and space for the horses. Saddle-horse tour leaders often followed game trails or scouted out the most forgiving topography and, in the process, helped to lay out routes for future NPS-sanctioned trails.

In 1923, the NPS celebrated the official opening of the Howard Eaton Trail (HET), a park-encompassing, 157-mile bridle trail that followed, more or less, the Grand Loop Road. The HET was not really a new trail so much as it was a stitching together of older trails into a single loop. Building and then promoting use of the HET, however, allowed the NPS to compete with its older, more-established agency rival, the U.S. Forest Service, for a share of the public interested in trail riding on public lands. The HET offered saddle-horse riders a route through Yellowstone that allowed them to see all the park’s must-see sites without the distraction and danger of sharing the road with automobiles. The HET opened just five years after the NPS took over administration of the park from the U.S. Army, six years after automobiles replaced horses on the Grand Loop, and seven years after the creation of the NPS. The HET proved Yellowstone could satisfy the recreational needs of trail riding enthusiasts, equestrian clubs, and individuals looking for a more rustic or “cowboy era” national park experience in the American West.
During the 1930s, Works Progress Administration money and Civilian Conservation Corps labor allowed extensive new trail building as well as the improvement of existent trails at a time when the popularity of horseback riding was giving way to hiking. Yellowstone’s trails were widened, graded, supplemented with bridges where they crossed streams or passed through marshy areas (figure 3) and were even oiled to keep down the dust. Trail heads appeared on the Grand Loop, allowing visitors to leave their cars for a day hikes or longer backpacking trips into the interior. Records indicate park managers were aware of the environmental impact resulting from more and better (improved) trails, but it was considered necessary to provide the public with more access and a greater number of recreational options.

By the 1970s, environmental preservation and restoration became more important as principles guiding park management, and park trails once again reflect the change. Over time, trails through ecologically-sensitive and geothermally-active areas were rerouted or closed completely. Maintenance of the HET ended, and only three short segments remain today. The designation of grizzly bear habitat and wolf reintroduction areas necessitated closing trails in those specific parts of the park. At the same time, a few new "nature trails" were created to showcase regeneration after the 1988 fires. Hence, trails have long been a part of Yellowstone’s history and landscape. Their location, length, condition, and targeted users reflect on-going park management goals and administrative policies and limitations. By combining historical materials and modern techniques, this presentation offers a glimpse into the role of trails in several aspects of Yellowstone’s history as a "public park and pleasuring-ground for the benefit and enjoyment of the people."

Figure 1: This photograph of an early trail through a meadow near Biscuit Basin was taken by the trail maintenance crew prior to improvements in 1936. The original title is “Present trail before maintenance work was begun, Biscuit Basin, July 28, 1936” and is credited to Jacobson. NPS Photo.

Figure 2: This undated photograph of a Howard Eaton tour with Mt. Sheridan in the background was probably taken between 1912 and 1914, but no date or photographer’s name is provided. NPS Photo.

Figure 3: This photograph of newly-constructed bridge entitled “Trail Bridge Solfatara Meadows, August 1937" was most likely taken by trail maintenance crews. NPS Photo.
Contaminated with heavy metals for more than 80 years, Soda Butte Creek at Yellowstone National Park's (YNP) northeast corner is being removed from Montana's 303(d) Impaired Waters List established under the Water Pollution Control Act, commonly referred to as the Clean Water Act. Soda Butte Creek flows from the high mountains situated east of the park west to meet the Lamar River. Over 150 years ago and before the establishment of YNP, trappers and prospectors discovered gold, copper, and silver deposits in the headwaters of Soda Butte Creek. Mining operations began in the 1870s in the mountains surrounding the new mining camp of Cooke City. Operating from 1933 to 1953, the McLaren Gold Mines Company was one of the longest-running and last active mining operations in the area. Two decades of ore milling created a 10-acre tailings impoundment which covered the channel and floodplain of Soda Butte Creek. A dam break occurred in the summer of 1950 following heavy rains releasing tailings to Soda Butte Creek. Forty years later, Meyer (1993) mapped bright orange-red sediments containing elevated levels of iron, copper, and lead from Cooke City more than 15 miles (24 km) downstream, and concluded the likely source was the 1950 release. The Yellowstone fires of 1988 heightened concerns of flooding and another tailings release, resulting in interim actions directed by the U.S. Environmental Protection Agency to stabilize the impoundment.

Reclamation of the abandoned mines in the area began in 1998 with work performed by the U.S. Forest Service in the New World Mining District above Cooke City. The Montana Department of Environmental Quality (DEQ) Abandoned Mine Lands Program completed the reclamation of the McLaren Tailings over a five-year period from 2010 to 2014. The project included excavation of the tailings, amendment of the tailings with lime to neutralize acidity, pumping and treating contaminated groundwater, construction of a mine waste repository, and reconstruction of the sections of Soda Butte Creek and Miller Creek which were formerly covered by the impoundment.

In 2015 and 2016, the NPS Water Resources Division, Greater Yellowstone Inventory and Monitoring Network, and YNP teamed up with the Montana DEQ to conduct a longitudinal study of water quality in upper Soda Butte Creek (figure 1). The overarching goal was to assess water quality during the initial phase of recovery post-reclamation. To that end, the project had the following objectives: (1) compare metal concentrations from a location downstream of the McLaren Tailings site before and after the completion of reclamation work, (2) inventory metals throughout the upper Soda Butte Creek drainage and assess basin-wide water quality, and (3) document benthic sediment chemistry post-reclamation to
consider how it aligns with current water quality data from Soda Butte Creek’s mainstem and tributaries.

Previous studies identified both natural and anthropogenic sources contributing metals measured in Soda Butte Creek upstream of YNP. The highest concentrations of metals in the watershed occurred in seeps and discharges from the tailings impoundment. However, metals sources were also identified in two tributaries (Woody Creek and an Unnamed Tributary) containing no significant mining-related disturbances.

Investigation results indicated dramatic improvements in water quality immediately downstream of the tailings impoundment. In the decade prior the reclamation project, only 4 of 31 sampling events (13%) indicated compliance with Montana water quality standards. During this period, iron exceeded the Montana water quality standard (1.0 mg/l) in 20 of the 31 samples collected. The current data indicates 10 out of 11 sampling events (91%) met the Montana water quality standards, with no exceedances of iron (figure 2). Benthic iron levels measured in 2015 below the McLaren site (2-3% iron) are near background levels for floodplain and benthic sediments of this region. However, copper and lead levels in sediments below the McLaren site were generally higher than at other monitoring locations. Additional investigations will be performed to evaluate the occurrence and sources of these metals in sediments.

At the northeast park boundary, a total of 6 iron, 3 copper, and 4 lead exceedances were documented in the 31 sampling events during the decade before reclamation. Post-reclamation, we documented only 2 iron exceedances during 11 scheduled sampling events. There were no exceedances of copper or lead. The iron in Soda Butte Creek is readily traced to the two tributaries neither of which has any identified mine-land disturbances. As a result, water quality conditions in Soda Butte Creek now appear to be dominated by non-anthropogenic sources of metals.

The collaboration between the Montana DEQ and the National Park Service was critical to the planning and execution of the McLaren Tailings Reclamation Project. This group venture also made possible the current inventory of water quality in the upper Soda Butte Creek drainage. Removing Soda Butte Creek from the 303(d) Impaired Waters List marks the first time in Montana a water body has been delisted for all metal impairments following an abandoned mine cleanup. This cleanup represents a milestone in the restoration of Soda Butte Creek from mining-related impacts and the stewardship of the Greater Yellowstone Ecosystem (figure 3).

References

Both terrestrial and freshwater aquatic management practices are key contributors to maintaining a healthy, connected landscape. Despite being heavily siloed in research and management (Stoms et al. 2005), the terrestrial and freshwater realms are not two independent systems, but intertwined components of a single system that should be considered holistically. Cross-realm management, which explicitly considers the connections between terrestrial and aquatic realms, is a promising new direction in natural resource management that has great potential to benefit ecosystem functions that are not realm-specific, such as connectivity, and to inform more efficient management decisions. The justifications for and advantages of integrating terrestrial and freshwater management are manifold. Threats to ecosystems (e.g., urbanization, pollution, grazing) are often shared across realms or propagated between realms, and their impacts can be best addressed by considering both realms simultaneously (Adams et al. 2014). Many ecological or geophysical processes rely on connections between terrestrial and freshwater systems (e.g., sedimentation, nutrient pollution; Beger et al. 2010). Some species occupy both terrestrial and freshwater realms at different times of day, in different seasons, or at different points in their life cycle. For instance, amphibians use wetlands during the breeding season but terrestrial uplands for the remainder of the year, and some waterfowl forage in freshwater but nest in uplands. Connectivity between realms is critical for such species (Beger et al. 2010). However, examples of successful applications of cross-realm management frameworks remain rare.

We piloted a process for prioritizing cross-realm management actions in the Missouri Headwaters Basin (MHB) of southwestern Montana and northwestern Wyoming (figure 1). The objectives of the project were to (1) examine how joint actions can be prioritized and applied on the ground and (2) develop a repeatable approach that can be applied to other areas. We first developed a conceptual model of ecological integrity in the MHB that identified relationships between key ecological targets, threats to those targets, and potential management actions to address identified threats. The conceptual model was developed collaboratively with regional stakeholders from state and federal government agencies, NGOs, and academia. We selected five targets to describe ecological integrity in the MHB (stream health, normative flow regime, upland vegetation composition and structure, riparian potential, and within-habitat connectivity) and nine conservation or restoration actions that could be applied in the MHB to preserve or improve the condition of these targets (forest fuels management, grazing management, soil health management, irrigation adjustment, road decommissioning, bridge and culvert upgrades, stream and riparian restoration, land protection, and woody encroachment control; figure 2). We compiled spatial data representing the condition of targets, threats to those targets, and possible locations for implementing conservation or restoration actions.

We then integrated the conceptual model and spatial data into a conservation prioritization tool to allow stakeholders to identify areas where conservation actions can simultaneously yield the greatest benefits for multiple conservation targets, and to do so in a quantitative, repeatable, and defensible way. We made use of an existing systematic prioritization algorithm and software tool (Zonation;
Moilanen et al. (2014), creating a custom application with simple user interface tailored to the MHB (figure 3). Zonation is a powerful spatial prioritization method, made more powerful by its ability to integrate and consider the impacts of directed connectivity in freshwater systems when identifying priority areas. This means, for example, that conservation and restoration of headwater streams with potential to benefit downstream targets can be prioritized more highly. We provide a demonstration of this tool, as well as examples of how natural resource managers, conservation organizations, and other stakeholders can apply the tool to quickly, easily, and flexibly evaluate where to implement conservation action to achieve the greatest co-benefits for a variety of desired conservation targets, in both terrestrial and freshwater realms.

References
AN ICONIC MACROINVERTEBRATE IN PERIL? SALMONFLY EMERGENCE PATTERNS AND CLIMATE-DRIVEN RANGE CONTRACTION

Dr. Lindsey Albertson, Montana State University
Heidi Anderson, Montana State University
Dr. David Walters, US Geological Survey

Aquatic insects hold ecological, cultural, and economic value as vital components of stream food webs that support trout fisheries. Yet despite threats from climate change and human disturbance, few studies have identified sensitivity of different aquatic insect populations to these environmental drivers or have documented long-term changes in aquatic insect populations. We compared emergence phenology of the iconic salmonfly (*Pteronarctys californica*) between the Madison and Gallatin rivers in southwest Montana using field surveys. We found that emergence duration was shorter at reach scales, moved predictably upstream as water temperature warmed, and lasted longer along the entire longitudinal length of the Madison compared to the Gallatin River. We coupled historical and current surveys from the Madison River documenting physical and ecological variables over four decades to quantify changes in the abundance, body size, and emergence timing of *P. californica*. Since 1977, salmonflies in the Madison River have experienced a 34% upstream range contraction and 11.8% reduction in adult body size at the most downstream extent of their current distribution. These changes coincide with an observed 1.2°C increase in mean annual water temperature. Salmonfly abundance, body size, and emergence timing were negatively correlated with water temperature across a spatial temperature gradient, and current salmonfly populations on the Madison appear to be constrained by August water temperature. Our water temperature modeling predicts salmonflies could be extirpated from an additional 30-river kilometers of current habitat by 2100, culminating in a total range contraction of 50% since 1977. This finding suggests Madison River salmonflies may be vulnerable to climate change and future human disturbance if warming trends continue. These studies provide empirical evidence of long-term change of an aquatic insect and highlight the importance of combining historical and spatial datasets to explicitly address species’ responses to environmental stressors across space and time.

ARTHROPOD RESPONSE TO RECLAMATION EFFORTS IN GREATER YELLOWSTONE ECOSYSTEM’S NATURAL GAS FIELDS

Michael Curran, University of Wyoming
Dr. Douglas Smith, University of Wyoming
Zoe Sherman, University of Wyoming
Dr. Peter Stahl, University of Wyoming

Anthropogenic land disturbances often result in habitat fragmentation and are generally linked to declines in biodiversity. Ecological restoration, often referred to as “assisted succession,” is a practice used to combat disturbance and declines in biodiversity. Although insects are the most diverse group of animals on earth, relatively few studies have examined insect response to different levels of successional stages on vegetation in fragmented landscapes and none have looked at how insects respond to oil and gas development. From 2014 to 2016, well pads with different vegetation communities were sampled for insects and compared to adjacent “reference sites” in the Pinedale Anticline natural gas field. In all years, there was significantly higher insect abundance and diversity on reclamation sites when compared to reference sites, although insect community structure varied on well pads which contained native forb species compared to well pads which were primarily seeded with native grasses. In 2017, intense sampling of insects was conducted in the Jonah Infill natural gas field and findings were similar to previous studies from Pinedale. Additionally, in 2017, well pads were marked with unique proteins and flying insects were captured at varying distances from well pads to determine how insects were moving throughout the Jonah field (i.e., are these reclamation sites acting as resource islands or population sinks?). Although pollinators are given most attention in previous restoration studies, we focused on all insects including pollinators, herbivores, detritivores, parasitoids, and predators. This talk will discuss the important ecosystem services which insects play,
how insects are responding to reclamation efforts in two natural gas fields, and give suggestions for future management plans.

PILOTING A SOCIAL-ECOLOGICAL FRAMEWORK FOR IMPROVING DROUGHT PREPAREDNESS FOR PEOPLE AND NATURE IN THE UPPER MISSOURI HEADWATERS

Dr. Molly Cross, Wildlife Conservation Society

As global temperatures rise, droughts in the 21st century are hotter, longer, and increasingly exacerbated by human water demands. These more intense droughts are leading to a wide range of ecological impacts, which can have significant socio-economic impacts through changes in ecosystem services. We formed a Science for Nature and People Partnership (SNAPP) working group to develop a definition and framework for ecological drought to guide researchers and decision makers toward more proactive strategies to address the rising risk of drought in the 21st century. The ecological drought framework is organized along two dimensions—the components of vulnerability (exposure, sensitivity, and adaptive capacity) and a continuum from human to natural factors. Using this framework, we can better understand the roles that both people and nature play as drivers of ecological drought impacts, and link that understanding to on-the-ground strategies for reducing vulnerabilities to ecological drought in the future. In addition to describing this new social-ecological framework for drought, we will report on an effort to pilot the framework to understand and reduce ecological drought vulnerabilities in the complex socio-ecological systems of the Upper Missouri Headwaters (UMH). We have been working with drought planners and natural resource managers in the UMH to understand their desire for more or better information on the ecological impacts of drought, and to integrate concepts from our socio-ecological framework into their planning efforts. This pilot project has included several components, including 1) workshops to help drought planners and other stakeholders identify the ecosystem services present in the region which may be affected by drought, 2) interviews to identify a "bottom-up" view of stakeholders' perceptions of ecological drought vulnerability and desire for scientific information to aid drought response and preparation, and 3) a compilation of examples of nature-based strategies for reducing ecological drought vulnerabilities.

DROUGHT IN THE UPPER MISSOURI HEADWATERS: WATER AND LAND MANAGER PERSPECTIVES OF VULNERABILITY AND ECOLOGICAL IMPACTS

Dr. Amanda Cravens, U.S. Geological Survey
Dr. Jamie McEvoy, Montana State University
Dionne Zoanni, Montana State University
Dr. Shelley Crausbay, Conservation Science Partners
Dr. Aaron Ramirez, Reed College

In the 21st century, ecosystems are increasingly vulnerable to the impacts of drought (Crausbay et al. 2017). This vulnerability has effects not only on biodiversity, but also on human health, safety, and livelihoods due to our dependence on the goods and services ecosystems provide. These ecological drought impacts are particularly important in landscapes—like Montana's Upper Missouri Headwaters—where ecosystem-dependent activities like fishing, ranching, and tourism are major economic drivers. Despite the importance of ecological drought impacts to local communities and economies, they remain poorly understood compared to the more-recognized impacts drought has on agriculture and municipal water supplies.

This research examines how managers and other stakeholders understand the problem of drought and perceive vulnerability in southwestern Montana. We interviewed a diverse set of individuals (n=44) connected with the State of Montana's demonstration project of the National Drought Resilience Partnership (NDRP). We analyze each person's understanding of drought and the extent to which their conception does or does not account for ecological impacts of drought. We use the results of this analysis of drought perceptions to divide the individuals in the study into three groups: those who understand drought as a problem primarily for human water availability, those who understand drought as a problem primarily for ecosystems, and those who understand drought as an
interconnected problem. We then use these groupings to compare how the three groups understand the component aspects of vulnerability: exposure, sensitivity, and impacts of concern. The results comprise a bottom-up assessment of vulnerability as understood by Montana demonstration project NDRP partners and suggest how individuals’ or organizations’ perceptions of drought influence understandings of drought vulnerability.

SESSION SIX: Community/Skills Building

Wildlife Captures

WORKSHOP: WILDLIFE CAPTURES: WHAT THEY ENTAIL AND HOW THEY HAVE EVOLVED

Erin Stahler, Yellowstone National Park

Most people can think of an old wildlife documentary or video that was ethically acceptable fifty years ago but wouldn’t hold up to modern day ideals and standards. As a young biologist, I used to envy the stories about how easy it was to capture and collar animals. There was less training involved, less oversight, collar technology was relatively primitive, and there was no social media. Think of how much time would be saved! But the changes and evolution of wildlife capture techniques should be seen as a positive and not a hindrance. Every wildlife biologist has an ethical responsibility to think about the costs and benefits of capturing and collaring and to provide the best care possible. Reassessing capture plans, completing IACUCs (Institutional Animal Care and Use Committee), and learning GPS programming software to get the best battery life are all examples of things we do or should be doing to mitigate the costs of collaring an animal. Learning about veterinary care but gaining experience can be time consuming and there are a variety of safety issues involved with capturing wildlife (e.g., handling drugs, zoonotic diseases). Some wildlife programs contract out to companies that specialize in wildlife capture; however, transferring the process doesn’t mean the ethical responsibilities are voided. Wildlife captures always have a level of unpredictability no matter how much preparation is involved. This vulnerability, coupled with the inherent controversy surrounding collaring and tagging wildlife, often promotes secrecy. But how do we learn from mistakes if it’s taboo to talk about it? And how does this secrecy augment the public’s opinion about collaring animals? Education and outreach certainly would at least enhance transparency. Question and answer sessions on social media outlets, like Facebook or Instagram, have been utilized by Yellowstone National Park and have had relatively positive results although they should be used cautiously.
ENSURING SCIENCE SERVES DECISIONS—STRATEGIC THINKING ON YELLOWSTONE CHALLENGES

This interactive plenary workshop session will feature:

Dan Wenk, Superintendent, Yellowstone National Park
Mary Erickson, Forest Supervisor, Custer Gallatin National Forest
Ray Rasker, Headwaters Economics
Paul Cross, USGS Northern Rocky Mountain Science Center
and additional GYE senior managers and innovative scientists

Facilitator: Robin O’Malley, Director, USGS North Central Climate Adaptation Science Center

THIS DISCUSSION RELIES HEAVILY ON AUDIENCE ENGAGEMENT!

The GYE benefits from a substantial body of scientific work conducted by federal, state, tribal, academic, and other partners. That work is increasingly linked in a positive way to specific decisions and challenges identified by managers, but there may be a need to integrate work more effectively or better address complex, large-scale issues. This session will provide an opportunity to reflect on the major challenges and decisions facing managers in the region, and to provide an overall road map of the major needs and gaps in knowledge important for managing natural resources in the GYE. The session will also provide an opportunity to advance efforts to ensure priorities are placed on collaboratively developed actionable science.

To prepare for this discussion, please contemplate these questions throughout your time at the conference:

• What are the key challenges and decisions facing resource specialists and managers in the GYE over the coming decade or longer?

• What role does science play in these decisions?

• Is the needed science available, and if not, what are the major areas of need for additional data, monitoring, research, synthesis, or other scientific support

Please feel free to use the Whoova app to communicate your thoughts to us at any time.

OUTPUT FROM THIS DISCUSSION SESSION WILL HELP INFORM SCIENCE INVESTMENTS IN THE REGION.
VOICE OF A RIVER
Ashley Siana, Montana State University

Voice of a River is an in-progress student film that focuses on the ecology of the Yellowstone River. The film is told through the perspective of the Yellowstone River and sheds light on the proposed gold mining in Paradise Valley that threatens the river and the Greater Yellowstone Ecosystem. The film aims to highlight the diverse ecology that is supported by America’s longest free-flowing river.

THE EVER CHANGING WIND
Dena De Kryger, Montana State University
Cathy Trainor, Montana State University
Camille Del Duca, Montana State University

The Ever Changing Wind is a short film about the ubiquitous reach of the wind, an ecological variable that affects everything, both biotic and abiotic. This poetic piece personifies the wind through descriptive first person narrative and wildlife footage shot within Yellowstone National Park in February 2018. Just as the wind “touch[es] all things,” climate change affects all areas of our planet. The changing climate alters movement patterns and seasonal winds, which in turn affect landscapes and geological formations, weather and precipitation, flora and fauna, wildlife relationships, and human interactions with nature. With its brevity and fluidity, The Ever Changing Wind encapsulates the parallel relationships between wind and wildlife, and changing climate and the world.

THERMOPHILES: A HIDDEN WORLD
Hugo R. Sindelar, Montana State University, Tami Blackford, Yellowstone National Park
Bianca J. Klein, Yellowstone National Park
David Krueger, Yellowstone National Park

Thermophiles: A Hidden World is an educational film about thermophiles, microscopic organisms in the Yellowstone ecosystem that visitors admire because of the vibrant colors they create in thermal areas. However, visitors often have little or even no knowledge about thermophiles themselves. The film will pair interviews with a scientist and an interpretive ranger with stunning visuals of Yellowstone’s thermal features to help the viewer understand the importance of thermophiles in the Yellowstone ecosystem. The story will focus on the different types of thermophiles, why they are different colors, how they survive high temperatures, and where they live. The film will also help viewers connect their experience in the park to the larger world by sharing how thermophile research revolutionized DNA sequencing and offers clues into early life on Earth. The goal is to use entertaining media to provide visitors with information that will deepen their experience in Yellowstone National Park by delving into the often-overlooked world of thermophiles. The film will make use of infographics and a conversational tone to connect with the viewer using a style that has become popular on social media and YouTube.
INTERPRETING HUMANS IN YELLOWSTONE’S NATURAL WORLD
Prof. Robert Pahre, University of Illinois
This poster argues Yellowstone should do more to interpret the ways that humans have engaged with Yellowstone’s wildlife, nature, and wilderness, and with one another. This would not only help interpretation better connect with park reality but also improve visitor education in ways that will likely reduce impact. The poster begins by reviewing the ways that park visitor centers, waysides, signs, brochures, and the website interpret human interaction with Yellowstone’s resources in three areas: indigenous peoples in the park; the tourism industry, both historic and modern; and recreational engagement. First, stories of indigenous peoples are found in various places, especially at the Albright and Canyon visitor centers and the Nez Perce and Obsidian waysides. The park could strengthen this material and include the stories of Indian removal from the park. Second, the park does very little to interpret the tourism industry except around Fort Yellowstone. Each development center should include its own story so that visitors can understand how their own presence affects Yellowstone’s resources. The Museum of the Rockies has had exhibits showing what can be done in this regard. The park should also discuss the economics of the tourism industry out of Fort Yellowstone. Each development center should include its own story so that visitors can understand how their own presence affects Yellowstone’s resources. The Museum of the Rockies has had exhibits showing what can be done in this regard. The park should also discuss the economics of the tourism industry, so the visitors and political figures understand the park’s importance as a regional economic driver. Finally, the greatest interpretive need lies in the area of recreation. The park has added signs in the Lamar Valley interpreting wolf-watching. Doing something similar for fishing, boating, hiking, backpacking and wilderness, and geyser watching would be appropriate. The park essentially ignores the sorry history of bear feeding and resulting management actions, a topic where interpretation can directly support improvements in visitor behavior toward all wildlife species. As a whole, these changes will show visitors that Yellowstone is a human landscape as well as a natural one.

LABORATORY YELLOWSTONE & THE DNA REVOLUTION
Robert Lindstrom, NPS, retired
This poster is the story of bioprospecting in Yellowstone National Park and its impact on the global human society; as told by the NPS research permit coordinator during the “golden age of bioprospecting,” before it was legal to patent public owned research specimens (intellectual property rights). Foot-prints of researchers, impacts of possible cross-contamination of the fragile geothermal ecosystem by researchers from around the world was the subject of my year 2000 biennial conference presentation the “Invisible invasion: potential contamination of YNP hot springs by Human Activity”.

Following up, the new book tells the story of Thermus aquaticus (Taq); discovered by Professor emeritus Tom Brock, whose original research led to the discovery of “Life at High Temperature,” which led to development of the Nobel Prize winning PCR (Polymerase Chain Reaction). PCR is used by every hospital in the civilized world for detection of disease and has an estimated gross biotechnology industry worth of over a trillion USD. Income taxes paid to the U.S. Treasury by PCR industry employees more than covers the annual operating budget of YNP.

“The infinitely small, sometimes has infinitely large impacts on human society,” said Louis Pasteur, holder of the very first U.S. biotechnology patent in 1875.

Dr. Brock’s years of research from 1968 to 1975 left many footprints in Yellowstone, but today, it seems all remains undisturbed to my cameras eye. To my knowledge, the only noticeable damage to the fragile geothermal ecosystem in 40 years of observation was through natural processes (drying out) or through official administrative/maintenance/road construction.

OUR LAST CAST: THE FUTURE OF FLY FISHING IN THE AMERICAN WEST
William Griffiths, Montana State University
Fly fishing for salmonid species is iconic to the American West. Anglers have been at the forefront of conservation efforts and stewards to this nation’s rivers and streams for over 100 years. But we face a new challenge—the age of the Anthropocene. Dramatic losses of cold water habitat are predicted to occur in the 21st century due to human-caused climate change, impacting human and salmonid communities across the American West. Signs of these negative changes are already transpiring and predicted to worsen. Unfortunately, there are still many in fly fishing communities that do not know of...
these imminent changes. My research focuses on communicating the consequences of current and future climate change on freshwater ecosystems. The culmination of my project—a short book—conveys the urgency of the impacts we face in a way that is accessible not only to guides, outfitters, and anglers but everyday citizens. The book will explain the potential future effects of climate change on the social, economic, and ecological aspects of fly fishing communities on the Deschutes, Yellowstone and Madison, and Salmon rivers within their corresponding states (Oregon, Montana, and Idaho). There is a pressing need to convey these concepts so we can save salmonid species in the West.

CONNECTING MICROBIAL INTERACTIONS WITH MACROSCOPIC ECOLOGICAL EFFECTS IN NEW ZEALAND WILDLANDS, WITH CROSS RELEVANCE TO THE GREATER YELLOWSTONE ECOSYSTEMS

Dr. Stanley Bellgard, Landcare Research LLC
Dr. Maj Padamsee, Manaaki Whenua Landcare Research
Prof. Stephen Williams, University of Wyoming, S.E. Williams & Associates. LLC

New Zealand has an unusual biogeography that provides a refuge for a unique array of wildlife and plant biomes. The island nation, named Aotearoa, “Land of the Long White Cloud” by the Mori, has undergone a range of modifications, which has seen the extirpation of number of these species especially macro fauna, e.g., bird species. Less understood and quantifiable is the impact of foreign microbes on plant and animal assemblages.

This poster explores some of these microscopic interactions and the consequences they have both on the target organism and through flow-on effects which resonate throughout the ecosystem resulting in much broader scale impacts. Our particular case studies will focus upon the impacts of two exotic plant pathogens, *Phytophthora agathidicida* and *Austropuccinia psidii*, upon treasured iconic plants and trees in New Zealand. It is the apparent that there is a phenotypic mismatch between the microbe’s ability to reproduce and spread (i.e., short life history) at a rate that far out-strips the host’s and receiving environment’s ability to respond—as they have much longer evolutionary trajectories, associated with 45 million years of close co-evolution and geographic isolation. Our case studies relate directly to the adaptive management challenges that face the Greater Yellowstone Ecosystems. Common to both systems is an urgent need to integrate research to understand the complex life histories of the invasive organisms and then to quantify their impacts on ecosystem structure and function. Further, threats to cultural and esoteric values from invasive pests need to be given the same strategic priority as biodiversity and economic values. The challenge remains to reverse the damage and attempting to engineer resilience in the remnant ecosystems, to protect them from future damage and restore the mauri “vitality of ecosystems” for current and future generations.

MODELING THE DENSITIES OF CROWDSOURCED OBSERVATIONS OF IDAHO AMPHIBIANS AND REPTILES TO INFORM MANAGEMENT DECISIONS

Patrick Daniel Giltz, Idaho State University

Crowdsourced observation data has emerged as a new source of information for wildlife managers. The iNaturalist mobile app and website allow people to use their smartphones, tablets and other devices to contribute observations of any organism which include photo vouchers, GPS coordinates, and organism identification. These records are housed by the California Academy of Science, and can be easily accessed and exported. In 2016, the Idaho State University Herpetology Lab initiated the Idaho Amphibian and Reptile iNaturalist Project to increase the amount of data available for these species groups. After two years, there are over 1100 observations contributed by more than 250 people. If these data are analyzed and interpreted correctly, they could be used to help conserve amphibians, reptiles, and other non-game species. Because the “presence only” data lack negative information and have no underlying sampling design, the factors influencing the observations must be clearly understood before the information can be used effectively by wildlife managers. To help improve overall understanding of some of these factors, I am designing a spatial statistical model that will use our data to model the predicted number of observations as a function of both animal ecology and human social influences. The first category of independent variable, animal ecology, incorporates data from species richness maps with information for freeze-free days in Idaho to account for animal presence and
activity. The second independent variable category accounts for the human influences on observations, using both the Human Impact Index and U.S. Census population blocks. The predictive values for observation density generated with this model will be used as a baseline for the expected number of observations in any area of the state. Resource managers can then compare these values to the actual number of observations received and detect potential problems sooner than previously possible.

ATLAS OF YELLOWSTONE, SECOND EDITION

Dr. W. Andrew Marcus, University of Oregon
James E. Meacham, University of Oregon
Ann Rodman, National Park Service
Alethea Steingisser, University of Oregon

Production on the second edition of the Atlas of Yellowstone is now underway. The first edition’s major overarching geographic themes—Yellowstone is connected across different spatial extents, Yellowstone is dynamic, the interaction of humans and nature, and the importance of Yellowstone as a place—remain prominent in providing focus and continuity throughout the atlas. The second edition will expand on topics and concepts from the first edition including the evolution of “America’s best idea” and how that concept has been embodied since the 1872 landmark designation of the park. The new atlas will explore the Yellowstone of the future and its significance in large-scale landscape conservation in the Greater Yellowstone Ecosystem and broader connections to the American West. Challenges facing the park with rapid increase in visitor use, climate change, and other ecological pressures are also covered. New topics will be created, and existing topics updated with new data and visualization techniques and recent scientific discoveries. New maps and graphics will include data from the recently published research in historic wildlife observations, advancements in wildlife migration tracking and predator-prey interactions, ongoing studies on visitor use, and measurements of night sky impacts. The publication of the second edition will coincide with the 150-year celebration of Yellowstone National Park.

WHAT HINDERS THE IMPLEMENTATION OF NON-LETHAL WOLF DETERRENTS?

Eva Drinkhouse, Duke University

Lethal control is criticized as inhumane and counter-productive. Fortunately, non-lethal options can help reduce depredations. Studies have shown that non-lethal measures may be superior to lethal means, yet Wildlife Services still relies on lethal control. This study intends to describe what forces underlie this disconnect and determine how stakeholders can increase the use of non-lethal deterrents.

The study was limited to the Greater Yellowstone ecosystem. Purposeful and network sampling was used to target experts. NVivo software was used to analyze 34 semi-structured interviews from environmental and wildlife non-profits, landowner and agricultural associations, and wildlife management agencies.

The study found that the primary reason non-lethal methods are not used more frequently is cost. Ranchers feel non-lethal methods are not cost-effective given their limitations on large operations and over long time periods. Additionally, relationship-building is paramount. Participants recommended organizations employ representatives in situ or have their representatives remain in the area for the long-term. Participants also recommended having one-on-one meetings and offering something beneficial to ranchers, e.g., cost-sharing or convincing evidence.

Education was proposed to motivate greater non-lethal implementation, but should be conceived as information exchanges. Even better is facilitating a platform for ranchers to share their own successes. Peer-to-peer communication is more convincing and goes along with presenting ideas and opportunities instead of dictating strategy. Furthermore, participants stressed that programs should be based on rancher ownership as much as possible.

In terms of Wildlife Services’ role, non-profits should be open to collaboration. Although some operators may deserve their negative reputation, there are others willing to try non-lethal. Working with Wildlife Services can allow non-profits to leverage existing trust and take advantage of their unique skill sets. However, there must be frank discussion about goals to counteract concerns about cultural biases toward lethal management and to ensure that each stakeholder accomplishes something.
BRAIDED CHANNELS: TRACING THE CREATING OF RECREATION CULTURE IN GRAND TETON NATIONAL PARK THROUGH SCENIC RIVER RAFTING

Dr. Yolonda Youngs, Idaho State University

Grand Teton National Park (GRTE), with over 3 million visitors in 2016, has a long, complex, and rich cultural history of outdoor recreation, commercial guide and outfitter services, and tourism development. Each of these elements contributes to the park's and Greater Yellowstone's human imprint and changing use. Thus, this poster connects with the conference theme of Cultural Resource Protection and Education by framing scenic river rafting as an important part of GRTE's history and cultural resource. The park's iconic Teton Mountain range and scenic upper Snake River have inspired and shaped mountaineering and river rafting cultures that parallel other commercial guiding industries that developed across the American West in the wake of World War II. Military surplus boats and other gear, combined with broader changes in society, an improved economy, and a recreation boom after the war, sparked the birth of commercial river running in the western United States. Yet the pioneering contributions of guides on the upper Snake River in Grand Teton National Park to rafting techniques, boat and equipment design, and the economic and political context of commercial river running is often overlooked in studies of the American West, outdoor recreation, and environmental history and geography. This poster addresses that gap by exploring how social, political, and economic forces shaped ideas of environmental stewardship for guides, the development of commercial river running and park recreation management strategies on the upper Snake River in the mid-20th century. Results from this work suggest new avenues for historical research in outdoor recreation.

PATHOGEN MOBILITY ACROSS ANTHROPOGENIC LANDSCAPES IN THE GREATER YELLOWSTONE ECOSYSTEM

Sabrina Bradford, University of Colorado

Pathogen pollution is an ecosystem stressor in the Greater Yellowstone Ecosystem that is deeply entangled with human-wildlife conflict. In the early 1900s, sarcoptic mange was intentionally introduced into the ecosystem as part of predator eradication efforts. By contrast, the spillover of brucellosis from domestic cattle to elk and bison was accidental with long-term socioeconomic consequences on the ranching industry in the GYE. Within the context of evaluating the impact pathogens have on human-wildlife conflict within the Greater Yellowstone Ecosystem, I examined the vulnerability of humans to potential *Echinococcus granulosus* infection. This parasite requires two hosts to complete its life cycle and causes cysts to develop in the liver, lungs, or brain of the intermediate host. Domesticated dogs and grey wolves are definitive hosts, while humans and ungulates are intermediate hosts. The people interviewed for this study live in the Greater Yellowstone Ecosystem and own domesticated dogs on landscapes where humans, ungulates, wolves, and domesticated dogs are sympatric. The responses to the interview questions yielded information regarding transmission risk between infectious definitive hosts and likelihood of a dog owner becoming an intermediate host. Interviews were used as the method to gather this information and questions were asked to determine which risk factors significantly influenced the susceptibility of humans and domesticated dogs to this parasite that causes hydatid disease.
While debate exists related to the origin of *Echinococcus granulosus* in the Greater Yellowstone Ecosystem, domestic cattle and domestic dogs may act as vehicles for pathogen pollution, giving this parasite greater mobility across anthropogenic landscapes. As a result of these factors, *Echinococcus granulosus* is examined as an ecosystem stressor.

**RESPONSE OF OSPREYS AND BALD EAGLES TO CUTTHROAT TROUT DECLINES AT YELLOWSTONE LAKE**

Brenna Cassidy, University of Montana  
Dr. Douglas Smith, Yellowstone National Park  
Dr. Lauren Walker, Yellowstone National Park

During the nesting season in Yellowstone National Park (YNP), ospreys (*Pandion haliaetus*) and bald eagles (*Haliaeetus leucocephalus*) feed heavily on cutthroat trout (*Oncorhynchus clarki bouvieri*), particularly territories in and around Yellowstone Lake. Lake trout (*Salvelinus namaycush*) were discovered in Yellowstone Lake in 1994 after being illegally moved from a nearby lake in the late 1980s, as indicated in chemical patterns from lake trout otoliths. After the lake trout invasion, cutthroat trout populations decreased dramatically. Historically, more than half of all breeding pairs of ospreys and bald eagles nested near and foraged at Yellowstone Lake. The changing fauna of the lake has implications for successful breeding by these birds. Since the late 1980s, we have documented steep declines in an index of cutthroat trout abundance and in osprey productivity and nesting success. The number of osprey pairs breeding along the lake shore has declined from 39 in 1987 to only 2 in 2017. Bald eagle productivity and nesting success also declined over the same period, but at a slightly slower rate. In contrast to ospreys, the number of bald eagle pairs increased over the study period. While ospreys are strictly piscivorous, bald eagles are more flexible and may have switched to target vulnerable young waterfowl and other prey sources. Even though the recovery of cutthroat trout is vital to maintaining a breeding population of osprey at Yellowstone Lake, cutthroat trout may be less important for the Yellowstone Lake bald eagle population. Since humans introduced this invasive species to the ecosystem, managers will continue researching and addressing changes in the lake ecosystem structure that have detrimental effects on trophic links. This study gives them another tool in the fight against invasive species.

**ASSESSING THE IMPACTS OF CLIMATE-ALTERED FIRE REGIMES ON PROJECTED EXTINCTION RISK OF WHITEBARK PINE IN THE GREATER YELLOWSTONE ECOSYSTEM**

Elizabeth Pansing, University of Colorado  
Dr. Diana Tombeck, University of Colorado Denver, Dr. Michael Wunder, University of Colorado Denver

Climate change is expected to cause local ecosystem state changes, population extirpations, shifts in geographic distributions, and altered demographic rates. Most climate models for forested systems in western North America predict more frequent and more severe fires. These predictions collectively indicate increased extirpation probabilities for slow-growing tree species. Because of long generation times for most tree species, these predictions are difficult to test, but models are useful for exploring potential population-level consequences.

We present a density-dependent, stage-based projection model to investigate the effects of climate-driven changes to fire regimes on the probability of and time to extirpation for a metapopulation of whitebark pine (*Pinus albicaulis*), a long-lived species of management concern in western North America. We parameterized the model using demographic data collected between 1990 and 2017 from whitebark pine communities in areas recovering from the 1988 Yellowstone fires and contiguous unburned areas and from other data within the Greater Yellowstone Ecosystem. We used the model to explore the effects of reducing fire return intervals from 200 years to 30 years over a 100-year time horizon by quantifying population extirpation risk and elasticity of the stochastic growth rate. We did not consider whitebark pine mortality from the spread of exotic disease or native insect outbreaks.

In preliminary model runs for one subpopulation, whitebark pine extirpation occurred in only 6% of iterations, indicating the species is likely to persist despite decreasing fire return intervals. Stochastic elasticity estimates indicate reproductively mature individuals have the highest influence on growth rate. Although preliminary results suggest whitebark pine persistence is likely despite changing fire regimes, they assume nearby seed sources are available. Incorporation of metapopulation dynamics will provide direct assessment of increased risk to the seed source.
GYE CITIZEN SCIENCE EFFICACY: EXPLORING PLACE ATTACHMENT AND STEWARDSHIP

Prof. Philip Halliwell, Prescott College

Citizen science is an emerging approach to conducting research in the National Parks System. As national parks work to cultivate stewards for their second century, this research strategy is viewed as one that may support valuable scientific efforts while engaging and connecting participants with parks. Citizen science enlists the help of the public in various elements of the research process, providing valuable scientific insights and a unique educational experience for participants. As this practice is increasingly leveraged, understanding the impact it has on those who are involved is important. Although the benefits of citizen science have been explored, gaps exist in understanding certain participant outcomes. Gaining a greater sense for how participants may foster a bond with place and illuminating motivations for stewardship is an area that could benefit from additional research, particularly in a national park setting. Accordingly, this phenomenological research study leverages a mixed methods design to understand the experience in Grand Teton and Yellowstone national parks. It seeks to realize if such an effort impacts an individual’s attachment to the parks and considers what motivations for stewardship might result from attachment. Also, it attempts to determine if there are certain elements of a citizen science experience that play a key role in cultivating place attachment and stewardship. Members of the Rocky Mountain Sustainability and Science Network (RMSSN), an organization that involves undergraduate students in national park citizen science work, will be studied using pre-post surveys, as well as focus groups to evaluate bonding and stewardship. RMSSN volunteers will contribute to ongoing pollinator research in both parks in late spring 2018. The effectiveness of such an experience in cultivating place attachment and stewardship will be reviewed with preliminary findings prepared for early fall 2018.

"SNAKING" OUR WAY THROUGH ODONATA DISCOVERY: UNDERGRADUATE CITIZEN SCIENCE PROJECT UNCOVERS POTENTIALLY NEW DRAGONFLY SPECIES

Sarah Whipple, Colorado State University

In the summer of 2017, five undergraduate students from across the country participated in a NSF funded research project focused on citizen science pollinator studies in the GYE. Long term, this project hopes to address multiple questions regarding the validity of citizen science projects, such as: Can students and citizen scientists detect pollinator decline within national parks? Are citizen science applications effective in creating accurate pollinator observations? Finally, using humans, technology, and citizen science applications, which is most useful in tracking pollinator species diversity? Students spent eight weeks photographing a diverse group of species using iNaturalist, a citizen science mobile application, to assist in data collection and identification for the GYE databases. Studies were completed on 11 transects throughout the GYE in order to measure a diverse range of species based on the park’s elevational gradients.

As a result of sweep netting efforts and macro photography skills, students may have discovered a new species of Snaketail dragonflies (Ophiogomophus) within Yellowstone through their citizen science project. While dragonflies are not directly considered pollinators, the students’ efforts showcase the direct benefits of citizen science to biodiversity discoveries within public lands. In addition, these students were considered untrained entomologists, showcasing the ease of finding new species when least expected. Utilizing citizen science and the crowdsourcing capabilities of online curators has allowed for a more significant output than the park anticipated. Because of this discovery, students plan on resampling the 11 transects this summer with hopes of collecting the new specimen for further analysis by dragonfly experts. This presentation will highlight how students were able to successfully implement citizen science projects so that it allowed for such discovery, as well as present the many unknowns that will occur for the project, identifiers, and Yellowstone National Park moving forward.
IMPACT TO RECOVERY, MONITORING, AND MANAGING YELLOWSTONE NATIONAL PARK’S BACKCOUNTRY: A CASE STUDY
Amanda Bramblett, Yellowstone National Park
Sue Mills, Yellowstone National Park

Yellowstone National Park is known worldwide for its natural and cultural resources as well as wilderness experience for park visitors. Recreational activities provide an opportunity for park visitors to have an unparalleled experience within a wilderness setting. These recreation activities also cause environmental impacts that park managers face while trying to preserve wilderness character. Parks are seeing an increase in visitation and recreation leading to increases in resource impacts, challenging managers to balance environmental degradation and preserve the visitor experience as mandated by the Organic Act. Yellowstone’s Resource Impact Project aids managers to identify impacts associated with backcountry use.

By using GIS/GPS technology, the project is monitoring and quantifying human-caused resource impacts in a repeatable systematic long-term approach, using geographic site data. The information gives managers the ability to access geo-spatial data and interpret the extent, level, and location of the resource impacts on a temporal basis. Impacts typically occur at designated backcountry campsites, in stock use areas, and established trails, as well as roadsides and parking areas. Impacts commonly resulting from human recreational activities include: decreased density and diversity of flora, introduction of invasive plant species, undesignated social trails, soil erosion and compaction, and fragmentation of wildlife habitat.

Temporal and spatial data on a backcountry campsite has shown significant resource impacts from 2007 to 2014; based on this data, park managers initiated a 10-week rehabilitation project of this site in 2015. A reassessment of the site in 2017 shows the campsite overall has retained the vegetation in the rehabilitated area, lowering the amount of bare ground and impacted areas and reducing the number of social trails present at the site. The spatial and temporal data quantifies impacts and aids in establishing criteria for “levels of acceptable change” to keep management decisions relevant in a changing landscape.

POTENTIAL PATHS FOR MALE-MEDIATED GENE FLOW TO AND FROM AN ISOLATED GRIZZLY BEAR POPULATION
Christopher Peck, USGS, Interagency Grizzly Bear Study Team
Dr. Frank Van Manen, USGS, Interagency Grizzly Bear Study Team
Dr. Cecily Costello, Montana Fish, Wildlife & Parks
Mark Haroldson, USGS, Interagency Grizzly Bear Study Team
Lisa Landenburger, USGS, Interagency Grizzly Bear Study Team
Lori Roberts, Montana Fish, Wildlife & Parks
Dan Bjornlie, Wyoming Game and Fish Department
Dr. Rick Mace, Montana Fish, Wildlife & Parks (retired)

For decades, grizzly bear populations in the Greater Yellowstone Ecosystem (GYE) and the Northern Continental Divide Ecosystem (NCDE) have increased in numbers and range extent. The GYE population remains isolated; and although effective population size has increased since the early 1980s, genetic connectivity between these populations remains a long-term management goal. We delineated potential paths for male-mediated gene flow between the populations. We first developed step-selection functions to generate conductance layers using landscape features associated with non-stationary GPS locations of 124 male grizzly bears (199 bear years). We used a randomized shortest path (RSP) algorithm to estimate the average number of net passages for all grid cells in the study region when moving from an origin to a destination node. Repeating this process for 100 pairs of random origin/destination nodes, we identified paths for three levels of random deviation from the least-cost path. We observed broad-scale concordance between model predictions for paths based on NCDE individual versus GYE individuals for all three levels of movement exploration. Models indicated male grizzly bear movements could involve a variety of routes; verified observations of grizzly bears outside occupied range supported this finding. Where landscape features concentrated paths into corridors, they typically followed neighboring mountain ranges. The RSP layers provide detailed, spatially-explicit information for agencies and organizations to identify and prioritize conservation measures that maintain or enhance the integrity of areas conducive to male grizzly bear dispersal.
RESTORATION OF NATIVE FLORA IN THE GARDINER BASIN
John Klaptosky, Yellowstone National Park

The Gardiner Basin is part of the northern Boundary Lands Area (BLA) acquisition made in the early part of the 20th century, primarily for winter range habitat for wildlife migrating out of Yellowstone NP. Historically, little is known about the character of early vegetation communities in the Gardiner Basin. What is known is that some 530 acres of irrigated hayfields were under production in the Gardiner Basin area of the BLA and that limited haying operations continued through 1935 for the purpose of winter wildlife feeding. By 1936, some 300 acres of cultivated hayfields were targeted for revegetation, preferably with native grasses. Attempts to revegetate the abandoned hayfields with native range grasses met with little to no success, so it was decided to seed with the non-native perennial crested wheatgrass, which establishes easily, is drought resistant, and persistent. Due to its persistence and longevity, crested wheatgrass dominated the Gardiner Basin area for many decades. In recent decades, crested wheatgrass has been replaced by winter annual weeds desert alyssum, cheatgrass, and annual wheatgrass, along with a consortium of other annual weeds.

In 2002, an interagency/interdisciplinary working group addressing pronghorn biology and management in Yellowstone strongly recommended using current restoration techniques to convert the former hayfields to native plant communities. In 2009, a pilot project to restore native flora in the Gardiner Basin began with the spray treatment of weeds and the seeding of cover crops in fenced enclosures near Stephens creek, the Cinnabar townsite, and the Reese creek area. As of 2017, all enclosures have some level of native plant establishment. Winter annual weeds continue to pose the greatest challenge to establishment and sustainability of native flora. Trials of a relatively new herbicide Esplanade are underway and may provide a solution to these challenges, increasing the potential for native flora restoration.

ICE PATCH RESEARCH IN THE TETON MOUNTAINS
Marcia Peterson, Office of the Wyoming State Archaeologist

Since 2015, I have been investigating ice patches in the Jedediah Smith Wilderness Area of the Caribou...
Targhee National Forest and Grand Teton National Park. To date, I have recovered one prehistoric and several historic artifacts. The prehistoric artifact is a modified whitebark pine stick of unknown function that dates to 3158-2960 cal BP. The historic artifacts include one 1940s wallet, one carved Boy Scout walking stick, and two additional modified pine sticks that date to the protohistoric/historic periods. Also, numerous paleobiological specimens have been collected. These include two wood samples from dead trees and several bison bones melting from the ice patches. The wood samples were identified to species and/or radiocarbon dated, if possible; these data were used to reconstruct past tree line elevations and as proxies for prehistoric climate regimes. The bison bones were identified to element, if possible, and radiocarbon dated. These data have been used to reconstruct the prehistoric lifeways of bison in the higher elevations of the Greater Yellowstone Area. This poster presents the combined results of these investigations and their implications for future ice patch research in the Tetons.

THE NATIONAL ECOLOGICAL OBSERVATORY NETWORK IN THE NORTHERN ROCKIES

Sean Hauser, Battelle Ecology, Inc.
Billy Smallen, Battelle Ecology Inc./National Ecological Observatory Network
Andrew Stimetz, Battelle Ecology Inc./National Ecological Observatory Network
Amy Jacobs, Battelle Ecology Inc./National Ecological Observatory Network

NEON is a large science facility that is funded by the National Science Foundation and operated by Battelle. At 81 sites located in 20 unique ecoclimatic domains spanning from Puerto Rico to Alaska, NEON implements ground-based and remote sensing protocols to collect environmental and biological data that characterize complex, rapidly changing ecological processes. NEON’s open-access dataset enables scientists, planners, and decision makers to examine critical ecosystem functions such as biodiversity, biogeochemistry, ecohydrology, and infectious diseases at multiple spatial and temporal scales over the 30-year duration of the observatory.

NEON began construction in November 2017 in Yellowstone National Park at two sites along the northernmost section of Grand Loop Road. An aquatics site at Blacktail Deer Creek will provide data on water chemistry samples, aquatic biology observations, and groundwater conditions. A terrestrial site that is centered around Blacktail Deer Drive will include an instrumented tower that will collect atmospheric and soil measurements, as well as 63 locations where field teams will collect samples and observations of various floral, faunal, and microbial groups. Lastly, an Airborne Observation Platform will collect high-resolution remote sensing data during annual flights over both sites.

All of the data collected at these sites will be available for free on NEON’s Public Data Repository, which will incorporate the information collected in the Northern Rockies into a continental-scale dataset. This primary function of the NEON project can be expanded through an Assignable Assets Program, which will allow Principal Investigator-driven research and environmental studies to request supplementary resources from NEON’s instrumentation infrastructure, observational sampling locations, and/or mobile deployment platform. This will allow the NEON sites at Yellowstone to serve as a long-term, high-quality ecological backdrop that can be integrated into existing and future research focused on understanding the impacts of environmental or land use change in the Greater Yellowstone Ecosystem.

REWILDING: A SOCIAL PHENOMENON

Michael Overton, Utrecht University

In an epoch in which humans’ containment of formerly wild landscapes is more pervasive than ever, grizzly bears, wolves, and bison are reclaiming space in the Greater Yellowstone Ecosystem. They are helped along by some people and held back less effectually by others, both whose work centers on those wild things and to whom wild things, as embodied wilderness, are meaningful and motivating. I conceptualize five ways in which people construct and reaffirm motivating “wildness values” in their everyday work around grizzly bears, wolves, and bison. I contribute to the vocabulary of moral anthropology, depicting the “moral” by arguing that wild things elicit “wildness values” which are durable and moral in nature. As such, wildness values underpin practices and are reaffirmed through those practices. Drawing upon interviews and observational data gathered over six months during 2017-2018 in and around the Yellowstone National Park, I show how and why people contribute to rewilding, and how and why this is also contested.
A QUALITATIVE STUDY ON CHINESE VISITORS IN GRAND TETON NATIONAL PARK

Rui Li, The Pennsylvania State University
Dr. Zachary Miller, The Pennsylvania State University
Dr. Bing Pan, The Pennsylvania State University
Dr. Derrick Taff, The Pennsylvania State University
Dr. Peter Newman, The Pennsylvania State University

Like most of the national parks, Grand Teton National Park (GRTE) is witnessing a rapid increase in domestic and international visitation over recent years. Meanwhile, visitor use is also changing. According to a recent study in Yellowstone National Park, Chinese visitors made up 34% of all international visitors (17% of all visitors). GRTE is likely to have a similar booming Chinese visitation, which may pose new challenges for managers in GRTE in a cross-cultural context. While NPS units have made efforts to better adapt to these changes, the behaviors, expectations, experiences, and motivation of the Chinese visitors are still poorly understood. Recent research in the Greater Yellowstone Ecosystem (GYE) shows international visitors may have different interactions and experiences with resources in these parks (Miller et al. 2018). One of the most significant traits of Chinese visitors different from domestic visitors is they often travel to U.S. national parks in tour groups. However, little is known about Chinese visitors’ trip planning, visitation behaviors, and experience in U.S. national parks. Past studies regarding international travelers, especially Chinese tourists, are also limited in GRTE. The purpose of this research is to better understand Chinese visitors’ decision-making processes, expectations, and experiences to protect park resources while providing quality experiences for this unique population.

Differences in cultures and behavioral norms between management practices in the U.S. park systems, Chinese visitors, and domestic visitors may create misunderstanding and confusion that can lead to regulation violations and conflicts. Visitors from Eastern cultures have different beliefs, experiences, and contexts compared with those from Western cultures. They hold distinctive values and have different perceptions towards the idea of wildlife, environment, and nature preservation (Miller et al. 2018). Language barriers also play an important role in the communication process. Without the understanding of what is acceptable or not within parks, Chinese visitors behave according to their own understanding which may be proper in another cultural context but prove to pose threats to natural and historical resources in GRTE. Importantly, differences among Chinese and domestic visitors means that management approaches that have been effective for domestic visitors may be less so for Chinese visitors. For instance, simply translating current information into Chinese from English may not target the right beliefs or have the right context for Chinese visitors. Without an in-depth understanding of Chinese visitors, management methods may lose their effectiveness in this unique population. Ultimately, the results from this research will help inform management methods for NPS to influence Chinese visitors in a manner that aligns with the management mission, which means optimizing tourists’ experience and preserving resources at the same time.

Informed by our study results, managers could better reach Chinese visitors before they arrive, communicate more appropriate messages, and adopt specific practices to reduce inappropriate visitor behavior and create a better experience for all visitors to GRTE and the GYE.

To address the purpose of this study, we have developed three broad themes with examples of research questions.

Decision making process: How are Chinese visitors discovering GRTE? What information sources are they using, and when are they using them? What experiences and aspects are influencing their decisions? Expectations: What are Chinese visitors’ expectations when visiting GRTE? What is their previous experience with travel to nature-based destinations, outdoor recreation, and travel to the U.S.? Experiences: What kind of experiences are they having in the GRTE? What is different from their expectations, and how does that affect them? How are they sharing these experiences with others both on their trip and back home?

Data will be collected from June 15 to August 15, 2018. This research will intercept two populations: Chinese visitors and Chinese tour guides/companies.

We believe Chinese tour guides may have unique knowledge related to our questions that could greatly inform future management. We will intercept two populations of Chinese visitors: 1) groups on tour buses, and 2) those traveling individually at lodges and visitors centers in GRTE. Approximately 40-60
Chinese visitors will be interviewed altogether. About half of them will consist of travelers in groups, and the other half will be individual travelers. To intercept Chinese tourists on tour busses and individual visitors, we plan to conduct intercepts at lodges and visitor centers for face-to-face, semi-structured interviews. Upon their permission, we plan to record the interview in order to better transcribe the data and conduct data analysis in the future.

We also plan to interview approximately 20 tour guides. To access tour guides, we will identify Chinese companies that provide international tours to U.S. national parks via official websites. We will then set up specific times to do face-to-face, semi-structured interviews with them. Although the interviews will address the same research questions, the interview schedule will change to address the tour guides. Tour guides will also be interviewed on-site.

References

ACOUSTIC MONITORING IN WETLANDS OFFERS OPPORTUNITIES FOR PARTNERSHIP, CITIZEN SCIENCE, AND RESEARCH ON CLIMATE CHANGE

Mary Levandowski, Montana State University

Analyses show wetlands in the Greater Yellowstone Ecosystem (GYE) may be vulnerable to environmental stressors (i.e., current changes in climate patterns increase drying.) The Greater Yellowstone Inventory and Monitoring Network began monitoring wetlands in the GYE in 2005.

While this monitoring effort has focused on amphibian species, 70% of Wyoming bird species also utilize wetlands. There is an opportunity to expand current long term monitoring efforts to better understand what bird species inhabit these wetlands. In partnership with the National Park Service and Montana State University, acoustic monitoring technology was deployed in selected wetland sites in Grand Teton National Park in 2017 to capture a broader diversity of taxa.

Results from this effort demonstrate how acoustic data allows us to characterize and detect wetland use by audible species that might otherwise not be detected through traditional observational surveys. This effort provides valuable information about species associated with potentially vulnerable wetlands, the opportunity for collaborations, and the possibility for unique citizen science projects in the future.

THE NATIONAL ECOLOGICAL OBSERVATORY NETWORK: CONTRIBUTING TO UNDERSTANDING OF CHANGE

Dr. Dave Barnett, Battelle Ecology, Inc./National Ecological Observatory
Dr. Eric Sokol, Battelle Ecology, Inc./National Ecological Observatory
Dr. Brandon Jensen, Battelle Ecology, Inc./National Ecological Observatory

The National Ecological Observatory Network (NEON) is designed to improve understanding and forecasting of ecological change across spatial scales and over decades. The Observatory provides open data that characterize and quantify processes and patterns of organisms, soil, atmosphere, fluxes, and landcover from 81 sites across the United States. In 2018, data collection on terrestrial and aquatic organisms, soil, and high-resolution remote sensing began at the Blacktail Plateau.

These data, designed for 30 collection years, will augment existing scientific inquiry, serve as a long-term and consistent background data stream, and support new questions and management. Examples include regular remote sensing collections extend a long history of airborne observations on the northern range. The combined air and ground data will support near-annual characterizations of landcover, disturbance, tree mortality, and productivity applicable to questions about ungulate movement, impacts of invasive plant species, and future landscape states.

The park's Climate Change Monitoring Sites bracket the NEON observations with low elevation sites near Gardiner to Mt. Washburn. A park-NEON collaboration is generating comparable ground beetle data to enable long-term insight on patterns of carabids exposed to the diverse environmental forcing factors at different elevations.

The NEON aquatic observations on Blacktail Deer Creek will provide baseline data prior to and for years after removal of invasive fish species, describing impacts to aquatic organisms, stream morphology, hydrology, and water quality.
This collaborative approach to understanding change necessitates that NEON produce informative and useful data. With Technical Working Groups, NEON is assessing the capacity of data to detect trends in species populations and diversity across space and time. The statistically rigorous framework will be applied to Yellowstone as data become available. The goal is to optimize toward the efficient and informative data to support research, educators, the public, and managers in understanding and responding to ecological change.

YELLOWSTONE STORIES: AN EXPLORATION OF INTERPRETER SELF-EFFICACY BELIEFS AND THEIR ART & SCIENCE OF PROGRAM DELIVERY

Kamille Winslow, University of Wyoming
Ana Houseal, University of Wyoming

National parks offer an enormous opportunity for National Park Service interpretive rangers and their not-for-profit interpretive guide partners to affect the environmental literacy of visitors in a meaningful way. Interpreters deliver a variety of experiences to enhance visitor knowledge, provoke cognitive and emotional meaning, and encourage appreciation of and stewardship behavior towards diverse resources. Visitor outcomes are the typical unit of analysis to understand an interpreter's delivery of interpretive programs. However, the capacity to design relevant program characteristics and to craft a provoking delivery begins with an interpreter's self-efficacy beliefs. Self-efficacy beliefs provide a compass for interpretive practice and are oriented by motivating reflection on their past performance, present modeled behavior, and social feedback.

The art and science of how an interpreter effectively facilitates an eudaimonic visitor experience stands on the shoulders of many contributors: Tilden (1957), Ham (1992, 2007), and Beck and Cable (2011). Empirical research is needed to explore and better identify the relevant “pieces” of interpretation in the 21st century and how they connect within the existing theoretical framework of interpretation (Knapp and Benton 2004).

The case studies herein offer a chance to learn why Yellowstone interpretive guides do what they do, providing new insight into how visitors are constructing meaning between culture, science, and the environment. Surveys, pre- and post-interviews, and program observations are used to explore: (a) the alignment of an interpretive guide’s self-efficacy beliefs and program delivery, (b) the stories of developing an interpretive identity, and (c) the innovative communication techniques of the 21st century. Results may enhance interpretive training programs with new educational materials on the interpretive opportunity, adding “know your interpretive identity.” Deliberate, reflective practice (Dewey 1910, Schon 2000) may empower interpreters to effectively integrate innovative communication techniques into their practice, aligning interpretive program development, delivery, and outcomes.

PATTERNS AND DRIVERS OF LIVESTOCK DEPREDATION ALONG THE EASTERN FRONTIER OF THE GREATER YELLOWSTONE ECOSYSTEM

Avery Shawler, University of California, Berkeley
Dr. Arthur Middleton, University of California, Berkeley

In the Greater Yellowstone Ecosystem (GYE), the expansion of wolves and grizzly bears from core wilderness areas to nearby rangelands has led to increased predation on livestock, including chronic conflict in some areas. Understanding patterns and drivers of depredation is important to the management of both wildlife and livestock in shared landscapes.

We are initiating a new, collaborative research project to understand the environmental and behavioral drivers of wolf depredation in the Shoshone and Greybull watersheds in the Absaroka Range between Yellowstone National Park and Cody, Wyoming. Our specific questions are: 1) How do wolves select habitat and prey, and how do these change when elk migrate? 2) What are the environmental drivers of wolf-livestock encounters and livestock depredations? 3) How do cattle respond behaviorally to the risk of predation?

To determine how wolves utilize resources in a shared landscape, we will deploy GPS collars on wolves and quantify wolf habitat selection and predation patterns in summer and winter, as defined by elk migrations. To assess wolf predation patterns, we will visit clusters of GPS locations. We will evaluate environmental influences on depredation given an encounter, whereby encounters are defined as events during which collared cattle and wolves
are within close proximity of one another. We will evaluate proactive cattle responses to wolves by fitting a resource selection function using cattle GPS data with wolf selection as a covariate, as well as reactive responses by calculating movement rates and tortuosity in high risk areas and after encounters with wolves.

The ultimate goal of this research is to understand the conditions that lead to depredations and inform managers seeking to reduce the frequency and magnitude of conflicts.

HABITAT AND LAND-USE EFFECTS ON SCAVENGING RATES AND POTENTIAL BRUCELLOSIS TRANSMISSION IN SOUTHWEST MONTANA

Kimberly Szcodronski, U.S. Geological Survey
Dr. Paul Cross, U.S. Geological Survey

Brucellosis, a bacterial disease caused by *Brucella abortus*, is a major concern in the Greater Yellowstone Ecosystem (GYE) due to potential transmission from elk (*Cervus elaphus*) to livestock. *B. abortus* can lead to abortion in infected animals and is primarily transmitted among elk and between elk and livestock when individuals contact infected abortion materials. Therefore, the risk of transmission may be a function of how long abortion materials remain on the landscape. Previous studies suggest scavengers play a vital role in the persistence of *B. abortus* on the landscape and the dynamics of brucellosis transmission, and the rate of fetus removal by scavengers may vary spatially and among scavenger species.

To investigate fetus removal by scavengers, we are placing bovine fetuses and placentas in various habitat types within suitable elk habitat in the northwestern GYE during the brucellosis transmission risk period from February to June. We are using remote cameras to quantify the scavenging rate of abortion material, as well as the community of scavengers that participate in fetus removal. Preliminary estimates suggest abortion materials were scavenged at a mean (SE) rate of 84 hours (±8.5) across all habitat types. Abortion materials were consumed by a wide variety of scavengers, including magpies, ravens, red-talked hawks, eagles, turkey vultures, pine martens, skunks, foxes, coyotes, wolves, mountain lions, and black bears. The purpose of this project is to estimate the length of time fetuses remain on the landscape and estimate how habitat and scavenger communities may impact brucellosis transmission. This research will help identify management options aimed at decreasing the risk of brucellosis transmission from elk to livestock in southwest Montana.

THE TESTIMONY OF TRASH: REFUSE DUMPS AND TOURISM IN YELLOWSTONE NATIONAL PARK

Dr. Beth Horton, Yellowstone National Park

There is a wealth of historical archaeological resources in Yellowstone, and the development of the park is directly connected to larger socioeconomic changes occurring across America. Construction activities in June 2016 near Fishing Bridge uncovered a refuse dump associated with late 19th to mid-20th century tourism in Yellowstone National Park. A variety of artifacts associated with the hotels were recovered, such as bottle glass, ceramic fragments, animal bone, metal artifacts, and other items. These refuse sites grant us a somewhat unique view of leisure and tourism development in a remote park environment over the past 140 years, a viewpoint that is unavailable in most other places in North America. As important sources of information refuse dumps provide insight into the various beverages, foods, and medicines people were consuming, as well as their participation in local and regional economies.

19TH CENTURY AMERICAN INDIAN CONNECTIONS TO WILDLIFE MIGRATION IN WYOMING

Gregory Nickerson, Wyoming Migration Initiative
Dr. Matthew Kauffman, University of Wyoming
Emilene Ostlind, University of Wyoming
James E. Meacham, University of Oregon
Alethea Steingisser, University of Oregon

The indigenous geography of the 19th century Greater Yellowstone Ecosystem and Wyoming included a deep understanding of mountain geography and ungulate migration corridors. Historical figures like the Crow chief Arapoosh explained in the 1830s how his people took advantage of elevational gradients between mountains and plains to hunt migratory ungulates. Today, biologists are able to study in detail the nutritional benefits of ungulates migrating to high elevation in summer and escaping to dry basins during the winter. Indigenous hunters in Wyoming recognized these same dynamics,
drawing upon 10,000 thousand years or more of close observation. As part of the Wyoming Migration Initiative's research for Wild Migrations: Atlas of Wildlife Migrations, we collected and mapped with the help of the University of Oregon Infographics Lab a selection of about 300 indigenous place names from seven tribes. We also researched tribal travel routes across mountains and plains that were documented by anthropologists, military surveyors, and others. When these 19th century tribal travel routes are compared with today's migration maps of mule deer and elk, we can get a glimpse of how people and wildlife may have interacted in the past, tracking the same seasonal cycles of abundance and scarcity, and making similar migratory movements across the landscape. With the publication of Wild Migrations: Atlas of Wyoming's Ungulates we will share this information with the public, as well as through the social media channels of the Wyoming Migration Initiative.

ROLE OF CLIMATE, HABITAT CONNECTIVITY, AND FORAGE ON THE DISTRIBUTION OF AMERICAN PIKA (OCHOTONA PRINCEPS) IN THE GREATER YELLOWSTONE ECOSYSTEM

Kaitlyn Hanley, Clemson University

Dr. David Tonkyn, University of Arkansas - Little Rock

Human-mediated climate change will place particular strains on alpine species in the Greater Yellowstone Ecosystem (GYE), as they are specialized for cooler, high-elevation climates and already isolated into relatively small habitats. The American pika (Ochotona princeps) is one species considered threatened by climate change, with some extirpations attributed to warming temperatures. However, other research has suggested that habitat connectivity and quality can also influence population survival. We explored the effects of all three on the distribution of pikas in their talus habitats in the GYE. We surveyed for pikas at 161 talus sites in the Beartooth Mountains, northeast of the park, and 16 more on Bunsen Peak, Mount Washburn, and the Hoodoos within the park. At 49 of the Beartooth sites and all 16 park sites we used line transects to measure latrine densities, as indicators of pika densities, and vegetation, as measures of habitat quality and forage quantity. We used dataloggers to measure the annual microclimate within and on the surface of the talus at subset of these sites (Beartooths – 22, Mount Washburn – 5, Hoodoos – 2). We classified the talus habitat over larger regions using NAIP aerial imagery. Talus is common at higher elevations in the Beartooths but not in the park and could provide a climate refuge for pikas. Lower elevation talus experienced colder minimum winter temperatures, shorter periods of snowpack, and warmer maximum summer temperatures, restricting activity. Finally, latrine density increased with quality of forage (measured by the relative abundance of forbs to grasses, 0.01) but not the quantity, suggesting that habitat quality may buffer the harmful effects of warming climate. We are now using the biophysical model Niche Mapper™ to calculate the thermoregulatory ability of pikas directly and combine that with habitat quantity and quality to characterize the distribution of pikas in the GYE.

GOPOLLINATORS: A CITIZEN SCIENCE AND TECHNOLOGY APPROACH TO POLLINATOR STUDIES WITHIN THE GYE

Sarah Whipple, Colorado State University

Dr. Gillian Bowser, Colorado State University

Tamera Breidenbach, Colorado State University

Benjamen Duffy, Colorado State University

Dr. Diane Husic, Moravian College

In the summer of 2017, undergraduate students from across the country participated in a NSF funded research project focused on citizen science pollinator studies in the GYE using innovative technological field methods. Long term, this project hopes to address multiple questions regarding the validity of citizen science projects, such as: Can students and citizen scientists detect pollinator decline within national parks? Are citizen science applications effective in creating accurate pollinator observations? Can technology, such as GoPro cameras, enhance data collection methods in a non-invasive way? Finally, using humans, technology, and citizen science applications, which is most useful in tracking pollinator species diversity? Students spent eight weeks photographing a diverse group of species using iNaturalist, a citizen science mobile application, to assist in data collection and identification for the GYE databases. Studies were completed on 11 transects throughout the GYE in order to measure a diverse range of species based on the park’s elevational gradients.

Preliminary data using citizen science and technology field methods was completed by the student team in 2017, leading to over 1,000 pollinator observations and over 300 species identified.
students collecting and identifying pollinators, curators within iNaturalist have also followed this project, thereby improving the accuracy of these records for future use. From a technology perspective, GoPro cameras were most effective in tracking pollinator functional groups such as flies, but further research and field design will need to occur in order to make this data more reputable. Field collection for this project will continue in summer 2018 so that species diversity can be verified over time. This poster will highlight how students were able to successfully implement citizen science and technology into field research projects so that long term the GYE has a better idea about the scope of diversity present within the parks in order to make this data more reputable.

**WOLVES ON THE PROWL: ANIMAL GEOGRAPHIES AND THE ORIGINS OF THE YUKON-TO-YELLOWSTONE INITIATIVE**
Will Wright, Montana State University

In 1991, biologist Paul Paquet of the World Wildlife Fund collared a wolf called “Pluie” in southern Alberta to track the animal’s long-term movements using GPS technologies. Paquet assumed the predator had been killed by a hunter and thrown in the bed of a pickup truck with the radio-transmitter still attached since the animal traveled such a great distance, an area ten times larger in size than Yellowstone National Park. Two years later, however, his research team re-captured the living creature that had crossed two nations (Canada and the United States), five states (Alberta, British Columbia, Washington, Idaho, and Montana) and thirty different political jurisdictions in all.

In this case, Paquet tracked how wolves ranged over large expanses and often exceeded the confines of a single protected area like Yellowstone. The idea that a barrier of law could be drawn around a place to conserve its biological resources—which stands at the core of national parks—was not practical. Wolf geographies called into question the territorial sovereignty of park sites and nation-states. From this core insight, my research approach combines the methodologies of environmental and borderlands history. The former explores the role of nature in shaping the past while the latter examines how boundaries are constructed and contested over time. This presentation follows gray wolves from this joint perspective to understand how this iconic species is remaking conservation spaces and restructuring some of the guiding principles of natural resource management.
The capture and marking of wildlife has been vital to our understanding of the Greater Yellowstone Ecosystem's ecology and the influence of the human footprint. The process for capturing and marking wildlife has evolved considerably over the last 50 years. What was once widely considered safe or ethical in the past may not be acceptable today, and new technologies have advanced methods. As a result, capture programs have changed in complexity regarding training, compliance, and choosing specific methods and equipment. The decision making process to develop and execute a successful wildlife capture program can be overwhelming and time-consuming. The main focus of this workshop is to disseminate information about long-term wildlife capture programs in the Greater Yellowstone Ecosystem and how they have evolved to make wildlife captures safe and more humane. This workshop will be approximately 90 minutes in length. The first half will be spent reviewing the history of wildlife capture in the GYA, describing current programs, and discussing changing capture methods and equipment used. In addition, we will discuss ethics of animal captures, mitigating human impacts, and alternatives to capture. The second part of the workshop will describe specific capture and handling techniques and review common equipment and sampling protocols used by biologists. This will include hands-on examination of captures kits used by Yellowstone biologists for species like wolves, cougars, and elk. Additionally, we will examine present telemetry and GPS tracking collars and discuss the advancing technologies, benefits, and limitations. Participants are encouraged to attend no matter their skill level or past experience; however, this is not a wildlife handling or immobilization course. The intent of this workshop is for participants to gain knowledge about how best to develop and incorporate safe, ethical, and effective techniques for the capture and marking of wildlife for research and management.

• THE SOCIAL ENVIRONMENT OF PUBLIC WILDERNESS (Page 37), Corrected title and abstract below:

For the People: The Social Environment of Yellowstone National Park and Visitors' Behavior

Research on visitor use in parks and protected areas informs planning and management efforts to minimize impacts to resources and provide for visitors' quality of experience. The National Park Service (NPS), for example, is mandated “to conserve the scenery and the natural and historic [resources] and to provide for the enjoyment of the same in such manner...as will leave them unimpaired for the enjoyment of future generations.” Balancing the dual mandate—for public use and “unimpaired”—is a growing challenge for managers as visitation to parks increases. To meet this challenge successfully, managers must be equipped with information about visitors and their behavior. This research is an approach to examining how visitors' behavior is influenced by social variables of park environments. Recent studies have utilized
GPS technology to track visitors’ spatial movement and identify behavioral patterns. However, the variables that influence visitors’ spatial behavior (why those patterns occur) are not well understood. The natural environment (inherently associated with parks) attracts visitors and influences their behavior. Parks tend to evoke a romantic notion of nature free from human interference; yet, they have been altered with infrastructure (the built environment) to support visitors’ interaction with the natural environment. Roads, trails, and signage guide navigation patterns; visitor centers and parking lots produce navigational confluences; and lodges, concessions, and other nodes of conveniences attract. The built environment, by design, influences visitor behavior. A third environment of influence, less physically apparent yet significant, also arises as consequence of public interaction with parks—the social environment. Visitors’ behavior is influenced by interaction with other visitors, not by overt design but circumstance. Visitors, by sharing physical space and their experiences in that space, become a part of the environment they occupy. Research has long examined the influence of other people on the quality of visitors’ experience, but less attention has been given to the influence on their spatial behavior. Where it has been examined, the framing is often of displacement—avoiding others, especially crowds. Visitor use, however, is not spatially uniform, rather a universal finding is that visitor use is concentrated (and, evidence indicates, increasingly so). Beyond the inherent qualities of natural resources, and the access and conveniences provided by built infrastructure, how does the social environment influence visitors’ decision-making and spatial behavior? This research examines that question in two contexts—in situ (in the park) and ex ante (before arrival)—and illustrates the social environment as potential benefit and attractant, in addition to potential detriment and repellant. This research expands recent work in the “how” and “when” of visitor behavior to further understand the “why” of visitor behavior. Yellowstone National Park (YNP) will serve as a primary case study. YNP is an ideal case study for several reasons: it offers visitors exceptional autonomy—they have freedom of choice, with nearly all visitors navigating in personal vehicles; the large size and diversity of available experiences offers visitors a variety of choices; its iconic attractions draw disproportionate visitation relative to other developed areas of the park; and it attracts a range of visitor experience levels, many visiting for the first time. Additionally, the park is grappling with rapid visitation increases, especially in the past several years. To inform planning efforts, YNP is conducting a visitor-use management study over the peak visitation season this year (2018). Location specific surveys, via GPS-enabled ablets, will collect visitor responses across a range of social environments and crowding conditions. I plan to analyze these data to understand in situ behavioral responses to the social environment, while my own data from a behavioral intention instrument will inform variables of ex ante influence. Cartographic visualizations of these data will also contribute to the forthcoming Atlas of Yellowstone, 2nd Edition.

Note: Social environment refers to the real, perceived, or anticipated presence of other people and their behavior in a physical environment. It is not used to refer to societal-level institutions, social structure, or culture.