

# Aldo Leopold Wilderness Research Institute

USDA Forest Service, Rocky Mountain Research Station

FY2023 Annual Report



Chris Armatas, Clare Boerigter, Kellie Carim, Kira Hefty, Olga Helmy, Teresa Hollingsworth, Danette Paige, Sean Parks, Lauren Redmore, Jacyln Fox Rushing, Jason Taylor, Kathy Zeller, and postdoctoral contributors Eric Palm and Erana Taylor

January 2024

***Advancing Wilderness Stewardship Through Transformational Science***



**Chris Armatas** is a conservation social scientist. His research focuses on wildlands management and planning through an interdisciplinary, social-ecological systems lens. Chris' desire to work in support of wilderness stewardship stems from years working on the Yellowstone River and exploring the wild places around Yellowstone.



**Clare Boerigter** is a science writer who specializes in wildland fire and serves as the ALWRI Wilderness Fire Research Fellow. She is currently focusing on the challenges, benefits, and barriers to the use of prescribed fire in wilderness landscapes.



**Kellie Carim** is a research ecologist focused on aquatic ecology and freshwater fishes and the benefits of wilderness to freshwater species and ecosystems. Her research has included work on invasive species, conservation genetics, eDNA development and applications, species distribution modeling, and population persistence.



**Kira Hefty** a wildlife biologist whose research has focused on wildlife distribution modeling, biodiversity analyses, habitat assessment, and connectivity. Kira has a diverse background working with land managers and within academia, producing science that is responsive to conservation and management needs.



**Olga Helmy** is a science delivery outreach specialist with a background in field biology. Having worked in the US and internationally with peoples of diverse backgrounds and abilities, Olga strives to make science clear, concise, and accessible. At ALWRI, Olga primarily facilitates communication between research staff and managers-in-the-field.



**Teresa Hollingsworth** is a disturbance and plant community ecologist with a strong interest in the social-ecological consequences of climate change. At ALWRI, she serves as the acting deputy director and has been involved in projects assessing research needs of partners and understanding past Indigenous fuels and fire management in wilderness.



**Lisa Holsinger** is a geospatial analyst with interests in fire ecology research directed toward understanding landscape-level interactions among changing climate, fire regimes, and vegetation. Her expertise is in conducting geospatial and remote sensing analyses to integrate landscape information at multiple scales.



**Danette Paige** is a program assistant, supporting business operations at the Institute. Danette has been with the Rocky Mountain Research Station for 20 years. Prior to joining the ALWRI, Danette worked at the Fire Sciences Lab with the Fire Behavior Project, first in a student temporary position, then as an office automation clerk.



**Jaclyn Fox Rushing** is a social scientist who focuses on outdoor recreation, parks, and protected area management with a specific interest in relevance, diversity, equity, and inclusion. She is energized by relationships with practitioners, stakeholders, rightsholders, and fellow scientists.



**Sean Parks** is a research ecologist who is interested in the relationship between fire and climate, restoring fire as a natural process, improving the ability of satellites to characterize fire effects, and spatial interactions between past wildland fire and subsequent fire events.



**Lauren Redmore** is an environmental anthropologist with experience working across the United States and sub-Saharan Africa in community-based conservation, program evaluation, and policy analysis. Her work centers around questions of how people access and manage natural resources across scale, identities, needs, and values.



**Jason Taylor** is a landscape ecologist and director of the Institute. In addition to many years of leading protected areas management and science programs, Jason has an extensive background in the application of geospatial technologies. Jason's work has spanned the American West, Alaska, and the circumpolar Arctic.



**Kathy Zeller** is a spatial ecologist whose research integrates the fields of landscape ecology, wildlife biology, landscape genetics, and biostatistics. Much of her research is focused on understanding how patterns and processes of human-driven disturbance and climate change affect wildlife populations and large ecological networks.



**Eric Palm** and **Erana Taylor** are post-doctoral researchers supporting wildlife, biodiversity, landscape connectivity, and climate change adaptation research.

## TABLE OF CONTENTS

### **Agency Acronyms**

### **Leopold Institute News**

### **In Summary**

### **Administrative & Support Tasks**

### **Projects** (sorted by 2022-32 Science Charter “Research Priority Areas” or RPAs)

RPA1: Biodiversity conservation

RPA2: Climate change and disturbance

RPA3: Stewardship effectiveness

RPA4: Relevance and inclusivity

RPA5: Shared stewardship

External projects facilitated by Leopold Staff

### **Service and Technology Transfer**

Management/Stewardship Community Service

Science Community Service

Conference and Meeting Presentations

Publications

*Cover Image: Workshop participant takes a moment to watch for spawning fish, at the Selway-Bitterroot Wilderness and Frank Church-River of No Return Wilderness Fire Science Workshop. June 2023.*



## AGENCY ACRONYMS

ALWRI – Aldo Leopold Wilderness Research Institute (Leopold Institute)

BLM – Bureau of Land Management

DOI – U.S. Department of the Interior

FWS – U.S. Fish and Wildlife Service

IWSC – Interagency Wilderness Steering Committee

NGO – Non-Governmental Organization

NPS – National Park Service

NOAA – National Oceanic and Atmospheric Administration

NWPS – National Wilderness Preservation System

OMB – Office of Management and Budget

PNW – Pacific Northwest Research Station

R&D – USDA Forest Service, Research and Development

RMRS – Rocky Mountain Research Station

USDA – U.S. Department of Agriculture

USFS – USDA Forest Service

USGS – U.S. Geological Survey

WSR – Wild and Scenic Rivers

## LEOPOLD INSTITUTE NEWS

Core work at ALWRI continued to include research, collaboration, and science delivery. Collectively, we advanced a significant number of quality projects, work that was highlighted in high-profile outlets like CBS News, High Country News, and the Atlantic. The long awaited “Benefits of Wilderness” report (*A perpetual flow of benefits: wilderness economic values in an evolving, multicultural society*) was completed and published. A report on the barriers and opportunities around prescribed fire in wilderness (*Prescribed fire and U.S. wilderness areas: barriers and opportunities for wilderness and fire management in a time of change*), sought after by wilderness managers, was released. The team actively shared our work with managers, scientists, practitioners, and the public through presentations, trainings-events, and a variety of other outreach efforts and materials. We worked closely with Arthur Carhart National Wilderness Training Center staff on diversity, equity, and inclusion efforts, updating of stewardship toolboxes, and wilderness training courses. We worked intentionally to build relationships with and advance projects meaningful to Alaska Native and Native American communities. We supported the work of the Forest Service International Programs (in southern Madagascar), the IWSRCC Tribal Task Team, and the Interagency Visitor Use Management Council. We provided leadership for the National Wilderness Workshop and for the developing World Wilderness Congress. We published over 20 scientific products, served as journal editors and on editorial boards, gave presentations at national and international conferences, guided students, gave guest lectures, and so much more.

In March of 2023, our team met for a two-day retreat at the historic Powell Ranger Station, on the nearby Lochsa River. There, we focused efforts on communication, team-building, science delivery, advancing priority and collaborative research projects, as well as identifying future interdisciplinary cooperative opportunities.

Our roughly 40 projects, along with publications, presentations, and outreach efforts advanced or completed, are described in the report. Below are a few specific news items of note.

- **Sean Parks and Kathy Zeller** received Best Scientific Publication Award from the Rocky Mountain Research Station for their work on [threats to the global protected area network under climate change](#).
- **Clare Boerigter** joined ALWRI as a Wilderness Fire Research Fellow and science writer. Clare works closely with Sean Parks and colleagues, writing about research around wilderness fire management, including the challenges, benefits and barriers to the use of prescribed fire and fire-use fires on wilderness landscapes.
- **Kira Hefty** joined our team as a biological scientist. She will contribute to a broad range of biological and ecological research projects at ALWRI, including providing leadership for our RAD is Wilderness Project.
- **Jaclyn Rushing** joined our team as a social scientist. She will contribute to a broad range of social science projects at ALWRI, from visitor use and recreation ecology to RAD and more.
- **Olga Helmy** joined our team as the science delivery specialist. She will work to enhance sharing of scientific findings to a broad array of audiences and grow ALWRI’s outreach effort toward becoming a center of excellence for wilderness science delivery and communication.
- **Lisa Holsinger** retired after 30 years of federal service with the National Marine Fisheries Service and Forest Service R&D, including 10 years at ALWRI. Lisa served as a geospatial wizard, working on projects related to fire and climate change. She will be missed as she enjoys skiing and traveling in her retirement.
- **Kellie Carim** served a detail from July – November of 2023, in the U.S. Forest Service Washington Office, as the National Program Lead for Watershed and Aquatic Ecology Research.
- **Teresa Hollingsworth** served a detail as the Senior Science Advisor for the Station, advising the Station Director, developing the Deputy Chief’s Review, among other responsibilities.

## IN SUMMARY (TASKS AND PROJECTS)

### **Admin/Support Tasks**

AT-1 Refresh Leopold.wilderness.net

AT-2 Develop an ALWRI Science Delivery Plan

### **Projects (by 2022-32 Science Charter RPA)**

#### ***RPA1 - Biodiversity Conservation: Develop an understanding the values, opportunities, and challenges for wilderness to support biodiversity conservation in an era of unprecedented change***

- 1-1 A Landscape Conservation Design for the Crown of the Continent Ecosystem
- 1-2 Modeling connectivity to inform planning
- 1-3 Wildlife connectivity assessment for the western United States
- 1-4 Contribution of wilderness to wildlife genetic viability
- 1-5 Aquatic community assemblages within and adjacent to wilderness
- 1-6 The role of wilderness and wild and scenic rivers in promoting persistence of bull trout
- 1-7 Pyrodiversity and aquatic species distribution in wilderness
- 1-8 Current and projected distribution of lamprey species in wilderness and wild and scenic rivers
- 1-9 Species diversity of freshwater lamprey and relevance to wild and scenic river ORVs
- 1-10 Local adaptation of westslope cutthroat trout to wilderness
- 1-12 Connectivity across the sagebrush biome

#### ***RPA2 - Climate Change and Disturbance: Improve knowledge about the impacts and consequences of climate change and climate-disturbance interactions, including wildland fire, relevant to wilderness stewardship***

- 2-1 Climate connectivity assessment of protected areas
- 2-2 Altered fire regimes across North America
- 2-3 Ecosystem response to fire in wilderness
- 2-4 Contrasting historical and contemporary fire severity
- 2-5 Does pyrodiversity beget biodiversity?
- 2-6 A complex assessment of fire history and Indigenous stewardship
- 2-7 Effects of management, climate change, and disturbance on wildlife biodiversity

#### ***RPA3 - Stewardship effectiveness: Examine the effects and effectiveness of wilderness stewardship decisions, including the potential for and effects of management interventions***

- 3-1 Wildlife responses to recreation noise
- 3-3 Quantifying brown bear response to bear viewing sites
- 3-4 Monitoring protocol for a recreation Outstanding Remarkable Value
- 3-5 Benefits, costs, and challenges of prescribed fire in wilderness
- 3-6 Ecological benefits and impacts of fish stocking in wilderness
- 3-7 Isle Royale (NPS) - Evaluating a RAD framework to address climate change in wilderness
- 3-8 Black Ridge Canyons Wilderness (BLM) - Evaluating a RAD for climate change in wilderness
- 3-9 Whitebark pine, range-wide wilderness assessment (USFS) - Evaluating RAD in wilderness
- 3-10 Sonoran pronghorn in Cabeza Prieta and Kofa NWR (FWS) - Evaluating RAD in wilderness

***RPA4 - Relevance and inclusivity: Expand our understanding of wilderness relevance, experiences, inclusivity, and use amid social-ecological change***

- 4-1 Developing a visitor use survey to support wilderness stewardship planning
- 4-2 Understanding trends in recreation patterns and experiences
- 4-3 A framework for wild and scenic rivers user capacity determinations
- 4-4 Wilderness Condition Monitoring support
- 4-5 Understanding natural resource governance and stewardship in China
- 4-6 Relevance, diversity, and inclusion in California desert wilderness
- 4-7 African American wilderness heritage
- 4-8 Understanding the role of affinity groups in improving wilderness access
- 4-9 Empowering underrepresented groups in wilderness
- 4-10 Leading a “Wilderness for a Diverse America” special issue

***RPA5 - Shared Stewardship: Improve our understanding of co-production approaches and abilities to harmonize multiple knowledge systems towards more inclusive wilderness stewardship***

- 5-1 Evaluating decision making and knowledge engagement toward more effective science delivery
- 5-2 Shared stewardship for wilderness management in Alaska
- 5-3 Advancing integration of public engagement approaches
- 5-4 Understanding indicators of success for trail management partnerships
- 5-5 Developing and evaluating shared stewardship approaches in high-use wilderness areas
- 5-6 A synthesis of desired conditions for visitor use management
- 5-7 Coproduction of knowledge with the Shoshone-Bannock Tribes on Chinook salmon restoration
- 5-8 Coproduction of ALWRI science plan, delivery, and application
- 5-9 Shared stewardship and monitoring of bull trout
- 5-10 A comparative case study to strengthen Federal-Tribal shared stewardship of WSRs

**EXTERNAL PROJECTS FACILITATED BY LEOPOLD STAFF**

- Ext –1 Economic Benefits of Wilderness Working Group Report
- Ext –2 Powell North American Fire History Working Group





## ADMIN AND SUPPORT TASKS

**AT-1 Leopold.wilderness.net refresh** (Helmy, Hollingsworth, J. Taylor) – Our previous interagency web presence was confusing to navigate, contained multiple versions of the same information, and was out-of-date in a variety of ways. We worked to refresh the website to reflect our new science charter, current research efforts staffing, and adapt to UM’s new web template, while incorporating legacy products into an up-to-date, user-friendly format.

**AT-2 Develop an ALWRI Science Delivery Plan** (Helmy, Hollingsworth, J. Taylor) – In FY23, we initiated work to develop a science delivery plan for ALWRI toward increasing effectiveness of our communication and knowledge transfer efforts. We onboarded a science delivery specialist, initiated team-level conversations around science delivery at an offsite meeting, and we conducted informal surveys to beginning learning about science and decision-making (see more at **RPA 5-1**).

## PROJECTS

### **RPA1- BIODIVERSITY CONSERVATION: DEVELOP AN UNDERSTANDING THE VALUES, OPPORTUNITIES, AND CHALLENGES FOR WILDERNESS TO SUPPORT BIODIVERSITY CONSERVATION IN AN ERA OF UNPRECEDENTED CHANGE**

**RPA1-1 Contributing to a Landscape Conservation Design for the Crown of the Continent Ecosystem (links to RPA2)** (Zeller, Palm) – The Crown of the Continent covers nearly 18 million acres and is a patchwork of federal and provincial lands, Tribal and First Nation lands, wilderness areas, and private lands spanning the U.S.-Canada border. To facilitate planning and management across these jurisdictions, the Crown Manager’s Partnership, a partnership amongst universities and state, provincial, tribal, and federal agencies in Montana, Alberta and British Columbia, is developing a Landscape Conservation Design for the entire ecosystem. Connectivity is a key feature of interest on this landscape and over the last year we have provided connectivity science to inform the Landscape Conservation Design. The first product (currently in review) provides current and future maps of ecological connectivity across the entire ecosystem and quantifies wilderness and other protected in terms of their contribution to connectivity. The second provides information on genetic connectivity for grizzly bears on the Canadian side of the ecosystem and has been published in [Molecular Ecology Resources](#).

**RPA1-2 Modeling connectivity to inform planning (links to RPA3)** (Zeller, Hefty) – The 2012 planning rule requires national forests to evaluate, protect and/or restore connectivity as part of their forest plans. Many national forests are starting, or will be starting, their forest plan revisions in the coming years yet are lacking information on connectivity. In FY23 we worked toward providing national and Region 1 connectivity maps to serve as a starting point for planning teams to think about connectivity. Connectivity maps will be based on general species groups that are associated with various cover types, canopy cover, sensitivities to human development, and dispersal distances. We also advanced work on a web viewer to make the maps available to the planners and the public.

**RPA1-3 Wilderness contributions to wildlife connectivity across the western United States (WildConnWest) (links to RPA2)** (Zeller) – Federal land management agencies are increasingly interested in how their lands fit into the greater ecological landscape context. However, little information exists at large landscape scales to evaluate this and develop shared strategies across agencies and jurisdictions. Therefore, seamless analyses of wildlife habitat and connectivity are needed across large areas. Habitat and connectivity for wildlife are also shifting rapidly due to the dynamic nature of landscapes, landscape disturbance, and a changing climate. Lack of knowledge about future

conditions can lead to uncertainties regarding management investments and the long-term success of these investments on wildlife populations and communities. To meet these challenges, we worked with the BLM, NFS, state agencies, and other partners toward developing a seamless, online decision-making tool of past and current habitat and functional connectivity for multiple wildlife species in the western US. By taking a seamless approach and creating wall-to-wall outputs across the west, regardless of jurisdictional boundaries, we will be able to provide ecologically meaningful information relevant to partners, including federal agencies, wilderness and wildlife managers, non-profit organizations, tribes, private landowners and industrial companies. We are initially developing the tool with pronghorn and will work to expand to other species once the analytical framework and user-interface are established.

**RPA1-4 Quantifying the contribution of wilderness to genetic viability of wildlife populations** (Zeller, Carim) – Wilderness and other similarly protected areas are relatively free from direct human disturbance, and as such, tend to be more ecologically intact than other areas. However, recent studies have shown that there is not a large degree of overlap between species of conservation concern and highly protected areas. Because genetic diversity is one of the foundations of healthy wildlife populations, we are examining the link between wilderness areas and other protected areas and genetic diversity. Toward this end, we advanced modeling genetic diversity of hundreds of species across North America as a function of protected areas, protected area status (i.e. IUCN status 1a/b, 2, etc.), connectivity, and other factors.

**RPA1-5 Assessing aquatic community assemblages in wilderness areas and adjacent waterbodies with development of a multi-species eDNA panel (links to RPA3)** (Carim) – Accessing wilderness is often difficult and resource intensive. As a result, methods that maximize efficiency and information gathering are important when surveying wilderness areas. This project focuses on 1) optimization of laboratory methods to reduce time, costs, and resources to assess species diversity in eDNA samples, and 2) applying this method to understand aquatic species assemblages in and adjacent to Mt. Baker and Stephen Mather Wilderness Areas, and North Cascades National Park, (i.e., the Nooksack River basin). In FY23, laboratory analysis of eDNA samples as completed, and results of species distributions were communicated to state and federal managers and local Native American Tribes.

**RPA1-6 The role of wilderness and wild and scenic rivers in promoting persistence of genetic and life federally threatened bull trout (links to RPA2,5)** (Carim) – Bull trout are native to western North America and are considered an aquatic “umbrella species” that require cold, clean, and connected rivers systems for persistence. Given these habitat requirements, wilderness waters and free-flowing wild and scenic rivers often support the healthiest remaining bull trout populations and may be the only locations where this species will persist under future climate scenarios. This work will focus on understanding where and how wilderness and wild and scenic rivers promote genetic and life history diversity of bull trout, leading to populations persistence. This project focuses on using wilderness as a benchmark to categorize bull trout persistence under the “best case” scenario. This work also combines information on bull trout occupancy models and climate projections to identify other wilderness areas that may provide refuge for bull trout into the future, and to inform stewardship of this species in wilderness areas where persistence is less certain. Bull trout are culturally important to many Ingenious peoples of the northern Rocky Mountains and are listed as threatened under the Endangered Species Act. As a result, any work on this species will involve diverse partnerships with an emphasis on co-stewardship. In FY23, we supported collaborators in preparing a research proposal to study lake-dwelling bull trout populations that primarily occur in headwater wilderness areas. Additionally, genetic samples were collected to further describe genetic diversity of bull trout in the St. Joe Wild and Scenic River (the last extant population in the Coeur d’Alene River basin).

**RPA1-7 Pyrodiversity and aquatic species distribution in wilderness (links to RPA2)** (Carim, Hollingsworth, Parks) – This project will use eDNA methods to assess the influence of landscape variables (particularly wildfire) in the Bob Marshall Wilderness on distributions of several cold-water species, with an emphasis on bull trout (highly mobile with large home ranges), tailed frogs (cold water specialist, but less mobile with prolonged juvenile life stage), and sculpin (limited mobility and small home ranges, and easily influenced by habitat fragmentation). This project is being conducted in collaboration with a graduate student in the University of Montana Wildlife Biology Program. In FY23, eDNA samples were collected at over 80 locations in the Bob Marshall Wilderness and were assessed for the presence of the above-mentioned aquatic species.

**RPA1-8 Current and projected distribution, of lamprey species in wilderness and wild and scenic rivers (links to RPA2)** (Carim) – Lampreys are an ancient lineage of fish that, unlike trout and salmon, prefer larger river systems, shallower sloped streams, and relatively warmer water temperatures. Some species (such as Pacific lamprey) are culturally significant to Indigenous peoples of the Columbia River basin. For many lamprey species, the larger information gaps lie in simply understanding their current distributions. This project uses eDNA methods to determine distributions of anadromous Pacific lamprey (*Entosphenus tridentatus*) and freshwater lamprey in the genus *Lampetra* across Oregon, Washington, and Idaho and will explore where wilderness and wild and scenic rivers may support these taxa. The scope of this work overlaps with over 40 wilderness areas and nearly 20 wild and scenic rivers. In FY23, existing eDNA samples, collected across many subbasins (overlapping with portions of 30 wilderness and 26 Wild and Scenic Rivers), were analyzed to determine presence of *Lampetra*.

**RPA 1-9 Species diversity of freshwater lamprey in western North America and relevance to wild and scenic river Outstanding Remarkable Values (links to RPA3)** (Carim) – The taxonomy of freshwater lampreys native to western North America is not well understood. Previous species designations for many lampreys were based on life history traits (e.g., resident vs migratory), however these designations are not supported by genetic information. This project uses robust genetic analyses to demonstrate this point and provide insights into management units for different lamprey species based on life history. This is relevant as all lamprey species native to the western United States are species of conservation concern and understanding taxonomic classification and identifying management units are the first steps in protecting these species. This study has already revealed the presence of unique lineages of freshwater lamprey in twelve designated wild and scenic rivers, many of which have “fisheries” listed as an Outstandingly Remarkable Value.

**RPA1-10 Local adaptation of westslope cutthroat trout to wilderness and similarly protected areas (links to RPA2,3)** (Carim) – Westslope cutthroat trout were once wide-ranging across the western United States, but hybridization with nonnative species and habitat fragmentation have isolated many of the remaining populations in headwater areas, often in designated wilderness. Given the small home ranges and tendency for natal homing, it’s believed that westslope cutthroat trout experience high levels of local adaptation. Understanding this is important as populations from wilderness are often used as source populations for reintroduction efforts outside of wilderness. This work is also important as westslope cutthroat trout are commonly stocked in wilderness lakes for recreational fishing opportunities. A publication outlining this work is in preparation and will be submitted to Evolutionary Applications for consideration in the species issue on genetic rescue.

**RPA1-12 Connectivity across the sagebrush biome (links to RPA2)** (Zeller) – The sagebrush biome is facing several threats including human development and habitat modification, invasive species, conifer expansion, and altered fire regimes. From 2001 – 2020 an average of 1.3 million acres of sagebrush habitat has been degraded. A recent interagency publication, *A Sagebrush Conservation Design to*

*Proactively Restore America's Sagebrush Biome*, developed a spatially explicit model to identify sagebrush integrity and threats to sagebrush habitat that can be used to identify conservation and management actions to stem the loss of sagebrush. The next step in this work is to identify connectivity of sagebrush and sagebrush obligate species, like the greater sage grouse. We are working to develop a connectivity model to identify the 'backbone' of sagebrush core areas that have high levels of connectivity across the biome and are developing a new range-wide landscape genetic connectivity model for sage grouse. Both products will identify the importance of wilderness and other protected lands for connectivity and where management actions might be conducted to maintain or restore connectivity across the biome.

## **RPA2: CLIMATE CHANGE AND DISTURBANCE: IMPROVE KNOWLEDGE ABOUT THE IMPACTS AND CONSEQUENCES OF CLIMATE CHANGE AND CLIMATE-DISTURBANCE INTERACTIONS, INCLUDING WILDLAND FIRE, RELEVANT TO WILDERNESS STEWARDSHIP**

**RPA2-1 Climate connectivity assessment of the global protected area network (links to RPA1)** (Parks, Zeller) – Through the lens of climate analogs, we quantified, for each protected area across the globe, several metrics of vulnerability to species undergoing climate-induced range shifts. The overall objective was to better understand if protected areas can serve as steppingstones for species undergoing climate-induced range shifts. A paper was published in *Global Change Biology*, titled 'Protected areas not likely to serve as steppingstones for species undergoing climate-induced range shifts' (<https://www.fs.usda.gov/research/treesearch/65894>).

**RPA2-2 Altered fire regimes across North America** (Parks) – We continued work with an international group of colleagues on the Powell Center proposal titled 'Synthesis of the new North American tree-ring fire-scar network: using past and present fire-climate relationships to improve projections of future wild'. Our group currently has four papers that we are aiming to submit in FY24: 1) A multi-century perspective reveals a pervasive fire deficit across most of North America, 2) The geography of historical fire-climate relationships in North America, 3) Scaling fire regimes: quantification of the fire-area relationship in western North America, and 4) A gridded data set of historical fire activity for North America.

**RPA2-3 Ecosystem response to fire in wilderness** (Parks) – The overarching objective of this study is to evaluate the ecosystem response to fire across a broad bioclimatic and fire history gradient in the Selway-Bitterroot Wilderness (SBW). The study will enable us to determine how fire history and bioclimatic characteristics influence post-fire ecosystem trajectories, including the potential for enduring conversions to non-forest. Leopold scientists partnered with University of Montana to recruit three graduate students (one master's and two PhD) to conduct this work. We actively engaged SBW personnel to gain insight, coordinate logistics, and share results. To date, one paper has been published in *Forest Ecology and Management*, titled 'Mesic mixed-conifer forests are resilient to both historical high-severity fire and contemporary reburns in the US Northern Rocky Mountains' (<https://www.fs.usda.gov/research/treesearch/66442>). Somewhat related: we also published a paper in *Fire Ecology*, titled 'The scientific value of fire in wilderness' (<https://www.fs.usda.gov/research/treesearch/66215>).

**RPA2-4 A comparison of fire severity under contemporary and historical time periods, with lessons learned from wilderness** (Parks) – Some case studies have shown that contemporary fires are burning more severely compared to a historical time period. This has important implications for the long-term

persistence of forest ecosystems. We conducted a study covering the western US comparing contemporary and historical fire severity in and out of wilderness; we also highlighted the Gila Wilderness as case study from which lessons learned can help better manage land in and out of wilderness. We published a paper in Forest Ecology and Management, titled 'Contemporary fires are more severe compared to the historical reference period for western US dry conifer forests' (<https://www.fs.usda.gov/research/treesearch/66351>).

**RPA2-5 Does pyrodiversity beget biodiversity? (links to RPA1)** (Parks) – Pyrodiversity is defined as spatio-temporal variability in fire patterns. It has been theorized that pyrodiversity results in higher biodiversity, yet this has not been extensively tested. This project uses designated wilderness areas, many with extensive fire history, as study areas to help quantify pyrodiversity, define “best practices” in measuring pyrodiversity, and in linking to characteristics of biodiversity. We partnered with University of Montana to recruit a graduate student (master’s) to conduct this work.

**RPA2-6 A complex assessment of fire history and Indigenous management and use: A wilderness study area case study (links to RPA5)** (Hollingsworth, Parks, Armatas) – Wilderness areas frequently have historical, cultural, and spiritual significance to Indigenous people and Tribes. The US government has a long history of taking control of and managing lands that were traditionally managed by Tribes, and many of the landscapes we deem as “natural” and “pristine” are in fact a legacy of Indigenous management practices, including fire and fuels management. Quantifying short and long-term fire history while acknowledging Indigenous land use and considering these practices, in an area with a complex landscape history, **may support** collaborative management strategies with tribes in wilderness and other federally managed areas. In FY23, we supported a Crow graduate student at Montana State University to conduct this work. As a first step to quantify long-term fire history in the area, the student collected a lake sediment core at Axolotl Wilderness Study Area in the Gravelly Mountain Range in Southwest Montana, a region identified as communal hunting grounds for the Crow people.

**RPA2-7 Effects of management, climate change, and disturbance on wildlife biodiversity (links to RPA1,2)** (Zeller, Hefty) – This work, in cooperation with the Pacific Southwest Research Station, is part of a larger effort to quantify socio-ecological resiliency in the forested landscapes of the Lake Tahoe region of the Sierra Nevada Mountains. Three forest management and two climate scenarios are being assessed with ten different pillars of resiliency for this area: biodiversity conservation, forest resilience, fire dynamics, carbon sequestration, wetland integrity, air quality, water security, fire-adapted communities, economic diversity, and social and cultural well-being. We are assessing the biodiversity conservation pillar by modeling habitat suitability and connectivity for over 100 terrestrial wildlife species in the region across all climate and forest management scenarios. We summarized alpha and beta diversity and identified the importance of protected areas, including wilderness, for biodiversity conservation across the study area. We modeled how biodiversity and diversity-stability relationships on this landscape responded to management, climate change, and disturbance. [A manuscript on shifting patterns of species richness](#) was published and a publication on response of patterns of beta diversity and diversity-stability relationships has been submitted for publication.

### **RPA3: STEWARDSHIP EFFECTIVENESS: EXAMINE THE EFFECTS AND EFFECTIVENESS OF WILDERNESS STEWARDSHIP DECISIONS, INCLUDING THE POTENTIAL FOR AND EFFECTS OF MANAGEMENT INTERVENTIONS**

**RPA3-1 Wildlife responses to recreation noise: Developing a critical understanding for a growing concern** (Zeller) – In recent years, many wilderness and other land managers have seen an unprecedented increase in the number of visitors recreating on public lands. With more people hiking, biking, and using off-road vehicles, there is an urgent need to understand these recreation effects on wildlife – particularly through the lens of auditory cues. Using auditory stimuli to study reactions of wildlife may reveal more information than using only visual stimuli since wildlife often hear humans before seeing us. How human noise affects wildlife is only just beginning to be understood, but the evidence is building that human noise can be pervasive — even in natural and wilderness areas — and can cause a reaction similar to how prey would respond to a predator, increasing vigilance and stress, reducing amount of time feeding, and/or fleeing an area. These altered behaviors can reduce an animal’s time finding food and might have negative effects on populations. Using novel technologies, we experimentally exposed mammal and bird species to recreation sounds in their natural habitats in the Bridger-Teton National Forest in Wyoming to 1) assess mammal behavioral and stress responses to recreation sounds, 2) estimate changes in mammal and bird use of areas, and 3) quantify changes in diversity. A manuscript sharing our findings will be published in early FY24.

**RPA3-3 Quantifying brown bear response to bear viewing sites** (Zeller) – Katmai National Park, a popular destination for viewing brown bears, has seen a tenfold increase in visitation between 1998 and 2015. Because human presence is known to alter bear spatial and temporal use of areas, managers need information on the effects of visitation on bears in the park. Understanding if, when, and under what circumstances bears respond to human visitation can help ensure proper management of the park and its resources. A long-term, time-lapse camera dataset that captures human and bear visitation has been developed by park employees and other researchers. Initial analyses have been performed on the data through the year 2018. Newly acquired data since 2018 and new analytical methods will be employed to reanalyze the data to determine if there is an effect of visitors on brown bear presence, spatial use, and behavior at viewing sites in the park. No work was done on this project in FY23; we are still awaiting arrival of data to be analyzed.

**RPA3-4 Developing a monitoring protocol for a wild and scenic river recreation ORV (Outstanding Remarkable Value)** (Rushing, Armatas) – ALWRI scientists are working with managers of Fossil Creek WSR to create a monitoring survey, and subsequently a protocol, for their required assessment of how each outstandingly remarkable value changes over time. To align with the protect and enhance mandate of WSRs, Fossil Creek needs to monitor the change in visitor experience (referred to as satisfaction in their management plan) every five years. We are creating the pilot survey, as well as the associated approach to administration of the survey and analysis of the data. The unit plans to carry the approach forward, with their own resources, in subsequent monitoring periods. While Fossil Creek is the test site, the broader monitoring approach (to be published in a GTR), will serve the broader WSR and VUM communities. In FY23 ALWRI scientists compiled all necessary materials for a generic information collection and submitted them to the Forest Service Social Science Coordinator. There has been no feedback from the Social Science Coordinator and the package has not been sent to the Office of Management and Budget.

**RPA3-5 Benefits, costs, and challenges of prescribed fire in wilderness (links to RPA2)** (Parks, Boerigter) – Prescribed fire is commonly used outside of wilderness to make forests more resistant and resilient to wildfire. Yet, because prescribed fire is a management action and is sometimes considered inconsistent with the Wilderness Act (trammeling), it is less-commonly implemented within wilderness (though this varies among managing agencies). ALWRI scientists are continuing to articulate the benefits, costs, challenges, and barriers of implementing prescribed fire in wilderness. In partnership with ALWRI,

Western Colorado University hosted a workshop on the topic and produced a synthesis report, titled [‘Prescribed fire and U.S. wilderness areas: barriers and opportunities for wilderness and fire management in a time of change’](#). We also produced [a StoryMap](#) summarizing the synthesis paper. Work on this topic continues.

**RPA3-6 Ecological benefits and impacts of fish stocking in wilderness (links to RPA1,2)** (Carim) – Fish stocking in wilderness is common across the western United States. The effects of this activity impacts on ecosystems through the spread of nonnative species and introduction of fish into historically fishless areas. However, supplementation and reintroduction of native species in wilderness may serve a role for protection of native species that are suffering declines outside of wilderness areas. This project reviews the ecological impacts and benefits of fish stocking in wilderness. A University of Montana graduate student seminar based on this topic is scheduled for Spring 2024

**RPA3-7 to 3-10 Evaluating a RAD decision-making framework to address climate change in wilderness (links to RPA1,2)** – (Hefty, Rushing, E. Taylor, Parks, J. Taylor, Armatas, Carim, Hollingsworth, Redmore, Zeller) – Climate change and associated disturbances are accelerating the trajectory and magnitude of environmental changes. The resist, accept, direct (RAD) framework provides a decision-making space for managers, partners, and researchers to decide if they need to respond to and/or prepare for uncertainty in future environmental conditions. Given the unique qualities of federally designated wilderness, it is currently unclear how management interventions may be applied to either resist or direct environmental change, or if interventions are appropriate. Nevertheless, wilderness character is and will continue to be affected by climate change. The RAD in Wilderness project has engaged interagency managers, partners, and scientists in evaluating a RAD decision-making framework for use in wilderness. Socio-ecological research proposals for four case studies, one per each wilderness-administering agency, have been completed and accepted by project partners. Case studies cover a wide range of socio-ecological challenges associated with climate change to cover a diverse range of research questions relevant to evaluating RAD for use within wilderness. Training workshops for case study participants are currently in development to deliver science results for each case study and use those results to support RAD climate adaptation planning, highlighting integration of a Futures Wheel as a tool to evaluate RAD decisions in wilderness. In-person workshops will take place in FY2024 after completion of quantitative analyses and will be a combination of science delivery and a source of data collection.

**RPA3-7 Isle Royale (NPS) - Evaluating a RAD decision-making framework to address climate change in wilderness** (Hefty, Rushing, E. Taylor, Parks, J. Taylor, Armatas, Carim, Hollingsworth, Redmore, Zeller)

Climate change is exacerbating existing disturbance impacts to forested vegetation communities on Isle Royale. Whether or not to intervene to resist changes to current vegetation composition and structure, accept changing conditions, or direct change to a new climatically compatible vegetation community will have wide-ranging implications for important wildlife and visitor use experience. In June of 2023, we completed a site visit to Isle Royale to meet project partners, network with NPS staff and affiliates, complete interviews, and refine research questions and methodology for our quantitative biological analysis. In winter 2023, we hired a research fellow through ORISE who will help set up and run our biological modeling. We are currently gathering and developing model input that addresses managers’ concerns, including down-scaled climate change projections, wildfire, beetle damage, and moose browse.

**RPA3-8 Black Ridge Canyons Wilderness (BLM) - Evaluating a RAD decision-making framework to address climate change in wilderness** (Hefty, Rushing, E. Taylor, Parks, J. Taylor, Armatas, Carim, Hollingsworth, Redmore, Zeller)

In the Black Ridge Canyons Wilderness in southwestern Colorado, climate change is contributing to reduced hydroperiods in ephemeral canyon streams. Loss of stream and pool habitat threatens native frog species, including the northern leopard frog, and may exacerbate competitive pressure from non-native invasive bullfrogs. Managers are currently collecting data on native and invasive frog presence, but data to detect trends in habitat quality are sparse, hindering the ability of managers to make defensible, climate change adaptation decisions for species conservation efforts. The ability to make defensible management decisions is dependent on sound data and monitoring strategies. This is particularly true in wilderness where management interventions are highly scrutinized. Nevertheless, the time required to collect and analyze pertinent datasets to support decisions often falls behind the pace at which decisions need to be made. There is a need to assess how current datasets and theory may be leveraged and how managers can optimize data collection to meet capacity limitations and make rapid, defensible decisions in the face of climate change. In August 2023, we completed a site visit to the wilderness area to meet project partners and learn more about the study system and the challenges with species vulnerable to climate change within the context of wilderness. We completed interviews with BLM staff and affiliates through the fall and winter to better understand partner limitations and capacity. We also gathered a team of subject-matter and local experts to design a set of likely future ecological scenarios for native herps in the wilderness that will help inform R-A-D alternative strategies for our management partners.

**RPA3-9 Whitebark pine, range-wide wilderness assessment (USFS) - Evaluating a RAD decision-making framework to address climate change in wilderness** (Hefty, Rushing, E. Taylor, Parks, J. Taylor, Armatas, Carim, Hollingsworth, Redmore, Zeller)

Considered a keystone species, loss of whitebark pine has important implications for upper subalpine forest communities and indigenous cultural practices. Identifying climate refugia and important source populations of connectivity for whitebark pine will be crucial for preserving cultural heritage and ecosystem function in these sensitive montane systems. Since the recent federal listing of whitebark pine as a threatened species, there has been an expressed need for range-wide, transboundary consistency in modeling and restoration efforts so that data informing management actions, within or outside wilderness, are robust and defensible. The whitebark pine case study will encompass the range of whitebark pine on USFS lands, with special consideration given to the role of wilderness in promoting whitebark pine conservation into the future. We gathered a group of USFS wilderness managers and researchers to evaluate R-A-D alternatives for whitebark pine with respect to range-wide conservation. Range-wide data to predict current and project future distribution of whitebark pine was successfully acquired and initial quantitative analyses have begun.

**RPA3-10 Sonoran pronghorn in Cabeza Prieta and Kofa NWR (FWS) - Evaluating a RAD decision-making framework to address climate change in wilderness** (Hefty, Rushing, E. Taylor, Parks, J. Taylor, Armatas, Carim, Hollingsworth, Redmore, Zeller)

Changes in precipitation patterns are changing vegetation communities in the desert southwest. Loss of surface water and reduction in forage will likely impact recovery efforts for the federally endangered Sonoran pronghorn within its historical range. Furthermore, pronghorn habitat extends into designated wilderness, making efforts to improve, expand, or preserve pronghorn habitat uniquely challenging. Recovery efforts have primarily focused on improving habitat conditions outside wilderness and explicitly within the bounds of the historical range of the species. It is unknown how current management strategies or alternative strategies that incorporate wilderness or expand beyond the



historical range of Sonoran pronghorn may promote or detract from landscape connectivity in different climate futures. We plan to evaluate use of the RAD (resist-accept-direct) framework to describe a multi-perspective decision space regarding Sonoran pronghorn recovery efforts within and outside designated wilderness in southern Arizona. In May of 2023, we completed a site visit to meet project partners, tour Sonoran pronghorn recovery areas and infrastructure, and refine research questions. We have completed interviews with project partners and participated in quarter-annual Sonoran pronghorn recovery team meetings to future develop partnerships for our project. We requested and successfully acquired data to develop species distribution and connectivity analyses for pronghorn that will guide discussion surrounding R-A-D management alternatives.

#### **RPA4: RELEVANCE AND INCLUSIVITY: EXPAND OUR UNDERSTANDING OF WILDERNESS RELEVANCE, EXPERIENCES, INCLUSIVITY, AND USE AMID SOCIAL-ECOLOGICAL CHANGE**

**RPA4-1 Developing a system-level survey to support visitor use management and wilderness stewardship planning in wilderness areas** (Armatas, Rushing) – In collaboration with university partners and NPS managers and planners, this project aims to provide social science support for visitor use management within wilderness areas inside NPS units. Specifically, the project has a quantitative element, which constitutes a survey instrument that can be applied in multiple NPS units over time, with slight variations depending on the context. As such, the survey instrument will have a programmatic section, which will cover issues likely relevant across units, as well as a site-specific section focused on addressing planning challenges of the selected study site. In FY23, the quantitative element neared completion in the Everglades NP, where a survey was implemented, and analysis completed and presented to managers at the Park. Additionally, a second pilot of the approach began and was advanced at North Cascades NP. This project also has a qualitative element (for the Everglades study only), which included qualitative interviews with organizations representing underrepresented communities to understand barriers and perspectives related to visiting Everglades NP and, more broadly, general relationships between underrepresented communities and the NPS. The qualitative project is near completion, with one article published in International Journal of Wilderness and another submitted.

**RPA4-2 Understanding trends in recreation and visitor use** (Armatas) – A collaboration between UM, the USFS, and the City of Missoula, this project focuses on better understanding visitor perceptions and travel patterns in the Rattlesnake Wilderness and National Recreation Area and nearby city open space. The project is multifaceted, and includes an understanding of current visitor perceptions, as well as a change in perceptions (by doing a trends analysis on data collected in the early 1990s). This project neared completion in FY23, with the submission of three journal articles and the submission of a data archive.

**RPA4-3 Developing a framework for user capacity determination for wild and scenic rivers** (Armatas) – In cooperation with university partners and managers and planners at the national, regional, and forest level of the National Forest System, this research aims to provide a framework for completing the policy (legal and administrative) mandated ‘user capacity’ determination for wild and scenic rivers. This project provides an initial case study on the ‘recreational’ segment of the Main Salmon River and an example for the WSR management and planning community at large, while also meeting the immediate needs of the Salmon-Challis NF, who administers the Wild and Scenic Salmon River in Idaho. The user capacity work, while using a WSR as a case study, is an applicable idea, with both limitations and strengths, to broader wilderness management needs – namely, visitor use management to preserve the primary recreation wilderness quality of solitude, unconfined, or primitive recreation. After two seasons of data collection

challenges, this study neared completion in FY23, with the development of a draft report, a presentation to managers, and an intention to stay involved in future river planning efforts on the Salmon River.

**RPA4-4 Wilderness Condition Monitoring science support** (Armatas) – This project, in collaboration with university partners and Federal land managers, provides science support for monitoring of elements critical to wilderness stewardship. This research currently includes two projects: (1) campsite data set compilation and analysis for the Frank Church River of No Return Wilderness; (2) data set analysis and methodology consultation related to encounters in the Sequoia & Kings Canyon NPs (SEKI). This project neared completion in FY23, with the finalization of the report for the Frank Church managers, and the near finalization of the SEKI report.

**RPA4-5 Understanding natural resource governance and stewardship in China** (Armatas) – ALWRI scientists collaborated on scholarly exchanges that can benefit stewardship and protection of our Earth's wildlands. China, in this specific case, is endowed with a significant portion of the Earth's wild places, and understanding the challenges they face, the approaches taken to stewardship, and the differences between governance systems can provide insights that may lead to more sustainable stewardship of wildlands. This specific collaboration focused on contextualizing two studies around the impacts of environmental protection policies to rural, lakeside communities in China. An article for [the first case study was published in Ecology and Society](#), and another manuscript progressed toward submission.

**RPA4-6 Understanding relevance, diversity and inclusion in California desert wilderness** (Armatas, Rushing) – This project aims to advance our understanding of issues related to DEI and relevance of wilderness, for both basic and applied science needs. This case study includes interviews with wilderness managers, representatives from local partner organizations, and Coachella Valley recreationists in Southern California. In FY23, we transitioned the project from a quantitative approach to a qualitative approach, including the revision of the study plan and completion of most of the data collection.

**RPA4-7 Exploring African American wilderness heritage to increase wilderness relevancy and access** (Redmore) – This project seeks to advance an understanding of how wilderness is relevant to African American communities in Lowcountry, South Carolina. The goal of this project is to help improve wilderness education, outreach, and interpretation, and will ultimately link issues around Black land loss with access to public lands and wilderness across three land management agencies (USFS, USFWS, NPS). This work is in collaboration with co-PIs Aby Sene-Harper at Clemson and Janae Davis from American Rivers. ALWRI collaborators worked to collate pre-existing oral histories of local residents and collected primary oral histories with federal managers to understand the roles of federal agencies in facilitating access and relevancy for African Americans with federal public lands. In addition, relationships were built with local non-profits to develop collaborative working partnerships on the ground and to ensure that this project is additive to the wider landscape of actionable conservation work on-the-ground.

**RPA4-8 Examining women's hunting and fishing groups to advance understanding of role of affinity groups in improving wilderness access for underserved communities** (Redmore) – Working with faculty at South Dakota State University and two masters students, this project grew a body of research aimed at better understanding how women access outdoor spaces through sports like hunting and fishing. Specifically, this project **worked** to identify the range of women's-specific programs and events and evaluate what makes for effective programming to recruit and retain women in hunting and fishing. We produced an on-line interactive social systems map of identified groups. In FY23, ALWRI researchers and collaborators recruited two masters students and collected data for three manuscripts. Additionally, this

project was able to host two communities of practice events for group leaders, including one three-day in-person event in Brookings, SD, and one virtual half-day event.

**RPA4-9 Empowering underrepresented groups in wilderness** (Redmore, Rushing, Carim) – RPA 1-7 includes a social science component that will be conducted in collaboration with outdoors interest-groups and non-profits focused on increasing diversity in and accessibility to wilderness experiences. This project aims to examine how citizen science opportunities can support more diverse opportunities for wilderness stewardship (beyond trail and weed management), as well as empower underrepresented community members to see themselves in wilderness.

**RPA4-10 Leading a “Wilderness for a diverse America” special issue** (Redmore) – The International Journal of Wilderness (IJW) has been the main forum for science communication with the wilderness community for many years, but there has never been an issue focused on issues of diversity, equity, and inclusion in wilderness. [The December 2023 Special Issue of IJW on “Wilderness for a Diverse America”](#) includes 11 contributions, ranging from issues of accessibility, wilderness interpretation, meanings of wilderness character, as well as two international perspectives of wilderness, and can be accessed at [www.ijw.org](http://www.ijw.org).

#### **RPA5: SHARED STEWARDSHIP: IMPROVE OUR UNDERSTANDING OF CO-PRODUCTION APPROACHES AND ABILITIES TO HARMONIZE MULTIPLE KNOWLEDGE SYSTEMS TOWARDS MORE INCLUSIVE WILDERNESS STEWARDSHIP**

**RPA5-1 Evaluating decision making and knowledge engagement toward more effective science delivery** (Redmore, Armatas, Helmy, Hollingsworth, Rushing, J. Taylor) – ALWRI is currently undergoing an effort to improve science communication and delivery with the wilderness community (AT-2). From data collected in FY22 through virtual white boards, ALWRI researchers have analyzed data and drafted a manuscript synthesizing findings around barriers and facilitators to the integration of science into wilderness management. The manuscript will be submitted for review in FY24. This project aims to support that effort through the development and deployment of a national-scale survey to better understand wilderness managers’ science communication needs and preferences.

**RPA5-2 Shared stewardship for wilderness management in Alaska (links to RPA4)** (Redmore, Armatas, J. Taylor) – This project is broadly focused on understanding what makes wilderness management in Alaska different from the lower-48, particularly as it relates to the Alaska National Interest Lands Conservation Act (ANILCA). The research aims to understand “why wilderness”, as well as challenges and opportunities to adopting an “inhabited wilderness” management approach to wilderness in Alaska. ALWRI staff and scientists worked closely with staff from Wrangell-St. Elias and Denali NPs, as well as an Alaska Native community non-profit executive director, to co-produce the research questions and approach. They spent two weeks in Alaska conducting fieldwork alongside staff from Wrangell-St. Elias and Denali NPs. The team collected several interviews with NPS staff and laid the groundwork for additional interviews in FY24. In addition, they received funding from Alaska NPS, allowing for the creation of a partnership with The Wilderness Society to fund photo-documentation of the impacts of climate change on Alaska Native communities and wilderness, an agreement that will be put in place in FY24.

**RPA5-3 Advancing the Social Vulnerability Protocol: Expansion of scientific foundations and development of the M3P tool** (Armatas) – In two ways, this project focuses on nurturing the already established social vulnerability protocol for engaging the public during large-scale planning processes. First, this project aims to expand the scientific foundation of the protocol through further publication of related work and applications. Second, in collaboration with a research social scientist at the PNW

research station, this project aims to continue the development of the Mapping, Prioritization, and Public Participation (M3P) tool, which includes the integration of two existing public engagement approaches (i.e., the Social Vulnerability Protocol and Human Ecology Mapping (HEM)). In FY23, a pilot project using the M3P tool was implemented on the Mendocino NF within the context of post-fire restoration. Further, an article is near submission describing the scientific foundations of the social vulnerability protocol.

**RPA5-4 Exploring the relationship between federal land managers and non-governmental partners: A study focused on national trail partnerships (links to RPA4)** (Armatas) – ALWRI scientists provided a research perspective for this project focused on understanding indicators of success for trail partnerships. This work was led by a PhD candidate at Virginia Tech, with support flowing from both the USFS and NPS. In FY23, a collaborative workshop was held in Virginia with project partners to complete the initial report for this project.

**RPA5-5 Developing and evaluating an approach to shared stewardship in high-use wilderness areas (links to RPA4)** (Armatas, Redmore) – A collaborative group, including USFS managers and planners, ALWRI scientists, NGOs, and tribal communities are among the entities participating in the Alpine Lakes Collaborative (ALC); a shared stewardship group focused on planning the future of a high use wilderness area outside of Seattle. The ALC is an effort toward shared stewardship in wilderness and is currently being stood up by a diversity of partners. As a part of this effort, it is critical to understand challenges and opportunities to shared and equitable stewardship, and to identify how transferable this approach might be to other wilderness areas. In FY23, we advanced large components of this project including multiple case studies to advance understanding of collaborative arrangements between tribal entities and federal land managers (with the University of Washington – Dr. Begay), and an evaluation of the ALC to understand what works (and what does not) for an on-the-ground collaborative, shared stewardship effort.

**RPA5-6 A synthesis in support of public engagement for developing desired conditions for visitor use management (link to RPA 4)** (Armatas) – This project involves the development of a paper that will supplement the desired conditions guidebook, currently being developed by the Interagency Visitor Use Management Council (IVUMC). The paper was finished in late FY23 and is now published on the IVUMC website.

**RPA5-7 Coproduction of knowledge with the Shoshone-Bannock Tribes on Chinook salmon restoration (links to RPA 1,2)** (Carim) – The homelands of the Shoshone-Bannock Tribes and treaty rights to co-management covers several wilderness areas in central Idaho, including the Frank Church River of No Return and the Sawtooth Wilderness Areas. Expanding this work has implications for improving co-stewardship of wilderness areas with tribal partners as well as improved understanding of methods for reintroduction and supplementation to sustain culturally significant fish species in these areas. This project uses eDNA sampling to monitor changes in Chinook salmon distributions in response to reintroduction efforts by the Shoshone-Bannock Tribes in their homelands across the Salmon River basin. This work is built upon seven years of relationship building with the Shoshone-Bannock Tribes. Samples collected in fall of 2020 marks the first sampling event likely to detect changes in salmon distributions in response to adult salmon reintroduction work. We facilitated a connection between Tribal members and biologists at IDFG, to establish a relationship and communicate the tribe's management priorities for Chinook.

**RPA5-8 Coproduction of ALWRI science plan, delivery, and application** (Armatas, Hollingsworth, J. Taylor) – With the successful application of a structured social science process in support of ALWRI's

science planning, ALWRI staff advanced a manuscript focused on our innovative, co-production process that drove development of our [2022 Science Charter](#).

**RPA5-9 Shared stewardship and monitoring of bull trout in a wild and scenic river (links to RPA1)**

(Carim) – The Wild and Scenic North Fork Malheur River is home to the last strong hold of bull trout in the Malheur River basin, which includes the Strawberry Mountain and Monument Rock Wilderness Areas. This master’s project will apply eDNA methods to assess the distribution and abundance of bull trout in the North Fork Malheur Wild and Scenic River and will require through communication and collaboration with diverse partners at the USFS, FWS, OR Dept. of Fish and Wildlife, and Burns Paiute-Tribe. In 2023, eDNA samples were collected in the North Fork Malheur River Wild and Scenic River, as well as Monument Rock Wilderness Area to determine the distribution of bull trout and several other native fish.

**RPA5-10 A comparative case study to identify opportunities and challenges to strengthen Federal-Tribal shared stewardship of Wild and Scenic Rivers (WSR) (Redmore, Rushing, Carim)**

– The goal of this project is to advance an understanding of Federal-Tribal Wild and Scenic River shared stewardship planning and practice, with a focus on how WSRs are accounting for and integrating Tribal treaty rights, Indigenous Traditional Ecological Knowledge, and Tribal values and worldviews. Using a comparative case study approach of shared stewardship between WSR staff and Tribes across three rivers in the continental US, we will examine available literature and supplement with interviews of key federal managers and Tribal and non-Tribal partners to identify opportunities and challenges to implementing and improving Federal-Tribal shared stewardship. In FY23 we developed a study plan and had it approved by members of the Interagency Wild and Scenic River Coordinating Council Tribal Relations Task Team.

**EXTERNAL PROJECTS FACILITATED BY LEOPOLD STAFF**

**Ext –1 Economic Benefits of Wilderness Working Group Report (J. Taylor)** – The Wilderness Economics Working Group, initially convened by the Leopold Institute in 2014, included scientists from the BLM, FWS, NPS, and USGS within the U.S. Department of the Interior, the Forest Service within the U.S. Department of Agriculture, several universities, and private industry. After many years of effort, the working group’s General Technical Report ([A perpetual flow of benefits: wilderness economic values in an evolving, multicultural society](#)) was completed and published in FY23.

**Ext –2 Powell North American Fire History Working Group (Parks)** – The Powell North American Fire History Working Group was funded by the John Wesley Powell Center for Analysis and Synthesis (USGS) to evaluate fire-climate relationships using the North American tree-ring fire-scar network ([link](#)). The working group includes 15 agency and university scientists from the US, Canada, and Switzerland; Parks is one of four PIs. In FY23, the group held an in-person meeting in Fort Collins and otherwise made good progress on several components of the project. We expect that several papers will be published in FY24 and beyond.

## SERVICE AND TECHNOLOGY TRANSFER

### *Management/Stewardship Community Service*

**Chris Armatas** served on the planning committee for the National Wilderness Workshop. Specifically, Chris co-organized a track focused on co-management of lands between the federal government and Tribal communities, and served as co-advisor to the Indigenous Student Planning committee. He also served on the Interagency Visitor Use Management Council working group for desired conditions, and began service on the science advisory committee for the National Visitor Use Monitoring Program.

**Clare Boerigter** produced a StoryMap for the Prescribed Fire in Wilderness Synthesis Paper (<https://tinyurl.com/wildernessandfire>).

**Kellie Carim** served on the Interagency Wild and Scenic Rivers Coordinating Council (IWSRCC) as a liaison representing ongoing research at the ALWRI. She also served on the IWSRCC Tribal Task Team, a subcommittee working to improve and expand engagement with Native American Tribes in wild and scenic rivers management. As part of this work, Kellie and Lauren Redmore traveled with the Wolf Wild and Scenic River located on the Menominee Reservation in Wisconsin in April of 2023. Here, they learned of the cultural and subsistence value of Lake Sturgeon to the Menominee people and the loss of this fish from historic spawning and subsistence fishing grounds on the Wolf Wild and Scenic River. Kellie also participated in a formal structured decision-making group to help score management activities for protecting and increasing Arctic grayling in Red Rocks Lakes Wilderness with a focus on effects on wilderness character and biota.

From July – November of 2023, Kellie Carim served in a detail for the USDA Forest Service Washington Office, Research & Development, as the National Program Lead for Watershed and Aquatic Ecology Research. In this position, she served as a liaison communicating among scientists across Forest Service research stations and elevating the relevance and importance of the agency's research products at a national level. Major accomplishments during her detail included a condensed summary of all watershed and aquatic ecology research in the agency, highlighting major research themes and recent accomplishments. This national publication is being used to communicate the value of Forest Service research both within the agency, as well as to policy makers in Washington D.C. This synopsis also provides the foundation for the watershed and aquatic ecology 5-year strategic research plan that will be completed in FY24.

**Sean Parks**, in collaboration with University of Montana, continued to engage with managers of the Selway-Bitterroot Wilderness about ongoing projects involving post-fire vegetation trajectories. Sean gave several presentations over the course of the year at trainings (Carhart, NAFRI) and to managers, scientists, and practitioners. Sean also contributed to three manager-focused science spotlights titled, *Will protected areas serve as steppingstones under climate change?*, *Contemporary wildfires are more severe compared to the historical reference period in western U.S. dry conifer forests*, and *Fire refugia in a fire-prone world*. Sean also presented at and helped organize the Selway-Bitterroot Wilderness and Frank Church – River of No Return Wilderness fire science workshop.

**Lauren Redmore** participated in a three-week social-ecological watershed assessment with the Forest Service International Programs in southern Madagascar where she presented her findings and key recommendations to the US Ambassador to Madagascar. She also served on the IWSRCC Tribal Task Team, supporting integration of social science into Federal-Tribal relations around Wild and Scenic

Rivers. In addition, she provided social science expertise to other Forest Service staff members, including those conducting work in sub-Saharan Africa as well as in the Pacific Northwest. Finally, she presented the results of a series of focus groups on a diversity, equity, and inclusion toolbox, conducted in collaboration with Carhart, to leadership across the Interagency Wilderness Stewardship Committee. Redmore, L. & Zavaleta Cheek, J. (2022). Women in the outdoors: Persistent challenges to increasing retention of a growing segment of America's hunting and fishing recruits. Presentation to USDA Forest Service Pacific Northwest social science meeting, virtual.

**Jaclyn Rushing** served as a member of the IWSRCC Tribal Relations Committee, a subcommittee working to improve and expand engagement with Native American Tribes in wild and scenic rivers management. Jaclyn also served in an interagency group lead by Carhart staff to develop interagency wilderness messages. Jaclyn was invited to present about ALWRI science and evaluating science in wilderness at the Northern Rockies Wilderness Skills Institute at the Powell Ranger Station in May.

**Jason Taylor** served as a member of the Interagency Wilderness Steering Committee. He also continued agency-level outreach and engagement activities across the NWPS. He participated in monthly wilderness regional program manager meetings across multiple agencies; contributed to the NPS National Wilderness Leadership Council; and facilitated quarterly, bureau-level program updates with IWSC and Policy Council representatives. Jason also served as a member of the IUCN World Commission on Protected Areas, Wilderness Specialist Group. He also served on the planning committee for the National Wilderness Workshop and was invited to serve as a member of the World Wilderness Congress Executive Committee, which is planning WILD12 for 2024.

**Kathy Zeller** served on the leadership and technical teams of the Crown Managers Partnership, a multi-jurisdictional group of federal, state, provincial, Tribal, and First Nation agency managers in Alberta, British Columbia, and Montana. Kathy also presented her research to managers at a Carhart training. Zeller, Kathy. 2023. Isolation Consequences: [Researchers discover Olympic Peninsula cougars are becoming more isolated based on genetic evidence. Science You Can Use \(in 5 Minutes\)](#), July 2023. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 2 p. (Problem 1, 2, 3)

**Lauren Redmore, Jaclyn Rushing, and Kellie Carim** contributed to the Bob Marshall Wilderness Foundation's Fall 2023 Newsletter. This newsletter highlighted the ecological and social science work to describe the response of aquatic species to fire in the Bob Marshall Wilderness while empowering underrepresented groups through citizen science opportunities. (See projects RPA1-7 and RPA4-9 above.)

### **Science Community Service**

**Chris Armatas** served on the Editorial Board of the *International Journal of Wilderness*, served on multiple graduate student committees, gave two different guest lectures at the University of Montana, one lecture at the University of Washington, continued service as a member of the standing committee on transportation needs of national parks and public lands (a unit of the National Academies of Science, Engineering, and Medicine), began service as a technical committee member and science advisor for a pilot project aimed at developing a new nationwide survey focused on outdoor recreation (i.e., a reboot of the National Survey on Recreation and the Environment (NSRE)), and peer-reviewed five journal articles.

**Kellie Carim** continued to serve as an associated editor for the *North American Journal of Fisheries Management* and as a reviewer for *North American Journal of Fisheries Management* and *Aquatic Conservation*. She served on graduate committees at University of Montana and Oregon State University and gave lectures at University of Montana.

**Sean Parks** continued to serve as a committee member for students at University of Montana and Utah State University.

**Lauren Redmore** continued to serve on the Society for Conservation Biology's Disciplinary Inclusion Task Force as a member of the institutional history team. She peer-reviewed three manuscripts for the journals *Society and Natural Resources* and the *Journal of Outdoor Recreation and Tourism*. In addition, she guest lectured at the University of Montana and South Dakota State University on topics ranging from methodologies in social science as well as on her research and findings. She also is serving as a committee member for three masters students at South Dakota State University.

**Jaclyn Fox Rushing** served in a RMRS community of practice focused on sharing science with diverse communities. She gave three guest lectures at the University of Montana and Northern Arizona University, and served as a career panelist for classes at North Carolina State University and University of Montana. Jaclyn continued service as a reviewer for *Journal of Leisure Research, Society and Natural Resources*, and *Leisure Sciences*.

**Kathy Zeller** continued to serve on thesis committees and advise on research for graduate students at the University of Montana. She also was on the editorial board for the journal *Landscape Ecology*, and reviewed articles for multiple other scientific journals. Kathy continued to serve as a member of the IUCN World Commission on Protected Areas, Connectivity Conservation Specialist Group.

### **Conference and Meeting Presentations**

**Chris Armatas** presented on a developing public engagement tool called "Mapping, Prioritization, and Public Participation" (M3P) during: (1) the 2022 virtual gathering of the International Association for Society and Natural Resources; and (2) the Rocky Mountain Research Station, Missoula Fire Sciences Lab Seminar Series. In addition, he presented on the topic of public participation during the Wildfire Adaptation and Qualitative data learning series put on by the Fire Adapted Communities Learning Network. Chris also presented on the ongoing evaluation of the Alpine Lakes Collaborative during: (1) the National Training for the Authur Carhart National Wilderness Training Center; and (2) the joint monthly meeting of the Wilderness, Wild and Scenic Rivers program and the Recreation, Heritage, and Volunteer Resources. Lastly, Chris presented on public participation for multi-objective forest management to the State Meeting of Montana's Society of American Foresters.

**Kellie Carim** presented research on landscape distributions of Pacific lamprey at the Pacific Lamprey Conservation Initiative's Lamprey Information Exchange in Vancouver, WA in December of 2022.

**Sean Parks** (1) presented his team's work on climate connectivity within the global protected area network at the Species on the Move conference and to the USFWS Southwest Climate Change Webinar Series; (2) presented and moderated a talk at the National Wilderness Workshop titled *Igniting the conversation about prescribed fire in wilderness*; (3) presented at the Association for Fire Ecology conference titled *A multi-century perspective reveals a pervasive fire deficit across most of North America*; and (4) served as a co-author on >15 presentations at various scientific conferences.



**Lauren Redmore** presented her research on co-management at the 2023 National Wilderness Workshop in Missoula, MT. In addition, she presented a poster on the Alpine Lakes Collaborative at the 2022 Affiliated Tribes of Northwest Indians Climate Summit in Airway Heights, WA. Additionally, alongside Chris Armatas and Jason Taylor, she shared about ALWRI's work extensively with federal managers across Alaska.

**Jaclyn Fox Rushing** presented on a panel about applying RAD in federal public lands at the International Association of Society and Natural Resources 2023 conference. She also presented an overview of the Institute at the 2023 Northern Rockies Wilderness Skills Institute.

**Kathy Zeller** presented on two of her research projects at the Forest Service Region 1 Biologists meeting. She also presented her connectivity research to managers, scientists, and practitioners at the Corridors, Connectivity, and Crossings conference.

## *Publications and Science Delivery Products*

**Armatas, C.A.**, L.K. Cervený, K. Quiócho, J.J. Sánchez, K.M. Leong, C.J. Gaither, G. Bottitta, D.R. Williams, D. Schwarzmann. 2023. [Embracing the public participation process for developing desired conditions: building relationships for actionable knowledge](#). Interagency Visitor Use Management Council: Denver, CO. (Problem 5)

Barry, T., T. Christensen, C. Behe, C. Coon, J.M. Culp, S. Fletcher, M. Gill, W. Goedkoop, R. Hindrum, C. Jacobson, K.F. Lárusson, J. Lento, M. Marissink, D. Mclennan, C. Price, M. Rönkä, M. Svoboda, I. Thaulow, **J. Taylor**, N.M. Schmidt, S. Wegeberg, and R. Smith. 2023. [Development of a multi-scale monitoring programme: approaches for the Arctic and lessons learnt from the Circumpolar Biodiversity Monitoring Programme](#) (CBMP) 2002-2022. *Frontiers in Conservation Science*, section Global Biodiversity Threats 4:1220521. <https://doi.org/10.3389/fcosc.2023.1220521>

**Carim, K. J.**; Larson, D. C.; Helstab, J. M.; Young, M. K.; Docker, M. F. 2023. [A revised taxonomy and estimate of species diversity for western North American Lampetra](#). *Environmental Biology of Fishes*. 106: 817-836. <https://doi.org/10.1007/s10641-023-01397-y> (Problem 1, 2, 3, 5)

Center for Public Lands, Western Colorado University; **Aldo Leopold Wilderness Research Institute**, Rocky Mountain Research Station, USDA Forest Service. 2023. [Prescribed fire and U.S. wilderness areas: barriers and opportunities for wilderness and fire management in a time of change](#).

DeVan, M.R., J.F. Johnstone, M.C. Mack, **T.N. Hollingsworth**, and D.L. Taylor (2023). Host identity affects the response of mycorrhizal fungal communities to increasing fire severity in Alaskan boreal forests. *Fungal Ecology* 62:101222 <https://doi.org/10.1016/j.funeco.2022.101222>

Dilts, T. E.; **Zeller, K. A.**; Cushman, S. A.; Larrucea, E. S.; Crowell, M. M.; Byer, N. W.; Shoemaker, K. T.; Matocq, M. D. 2023. [Pygmy rabbit habitat network reveals threats and opportunities for management and conservation](#). *Landscape Ecology*. <https://doi.org/10.1007/s10980-023-01672-4>. (Problem 1)

Ditmer, M. A.; Wittemyer, G.; **Zeller, K. A.**; Breck, S. W.; Fletcher, R. J., Jr.; Crook, K. R. 2023. [Predicting dispersal and conflict risk for wolf recolonization in Colorado](#). *Journal of Applied Ecology*. <https://doi.org/10.1111/1365-2664.14504>. (Problem 1)

Flores, D., **Redmore, L.**, & **Rushing, J.** (2023). Diversity, equity, and inclusion and engagement in outdoor recreation – a way forward. [Presentation to USDA Science You Can Use, Webinar](#).

Hoecker, T. J., **Parks, S. A.**, Krosby, M.; Dobroeski, S. Z. 2023. [Widespread exposure to altered fire regimes under 2° C warming is projected to transform conifer forests of the western United States](#). *Communications Earth and Environment*. <https://doi.org/10.1038/s43247-023-00954-8%20> (Problem 2)

Holmes, Thomas P., ed. 2022. [A perpetual flow of benefits: wilderness economic values in an evolving, multicultural society](#). Gen. Tech. Rep. WO-101. Washington, DC: U.S. Department of Agriculture Forest Service, Washington Office. 196 p. <https://doi.org/10.2737/WO-GTR-101>.

Jaffe, M. R.; Kreider, M. R.; Affleck, D. L. R.; Higuera, P. E.; Seielstad, C. A.; **Parks, S. A.**; Larson, Andrew J. 2023. [Mesic mixed-conifer forests are resilient to both historical high-severity fire and contemporary reburns in the US Northern Rocky Mountains](#). *Forest Ecology and Management*. 545: 121283. <https://doi.org/10.1016/j.foreco.2023.121283>. (Problem 2)

Kreider, M. R.; Jaffe, M. R.; Berkey, J. K.; **Parks, S. A.**; Larson, Andrew J. 2023. [The scientific value of fire in wilderness](https://doi.org/10.1186/s42408-023-00195-2). *Fire Ecology*. 19: 36. <https://doi.org/10.1186/s42408-023-00195-2>. (Problem 2)

**Palm, E. C.**; Landguth, E. L.; Holden, Z. A.; Day, C. C.; Lamb, C. T.; Frame, P. F.; Morehouse, A. T.; Mowat, Garth; Proctor, M. F.; Sawaya, M. A.; Stenhouse, G.; Whittington, J.; **Zeller, K. A.** 2023. [Corridor-based approach with spatial cross-validation reveals scale-dependent effects of geographic distance, human footprint and canopy cover on grizzly bear genetic connectivity](https://doi.org/10.1111/mec.17098). *Molecular Ecology*. <https://doi.org/10.1111/mec.17098>. (Problem 1)

**Parks, S. A.**; **Holsinger, L. M.**; Abatzoglou, J. T.; Littlefield, C. E.; **Zeller, K. A.** 2023. [Protected areas not likely to serve as steppingstones for species undergoing climate-induced range shifts](https://doi.org/10.1111/gcb.16629). *Global Change Biology*. 29: 2681-2696. <https://doi.org/10.1111/gcb.16629> (Problem 1, 2)

**Parks, S. A.**; **Holsinger, L. M.**; Abatzoglou, J. T.; Littlefield, C. E.; **Zeller, K. A.** 2023. [Response to concerns raised about the likelihood of protected areas serving as steppingstones for species responding to climate change](https://doi.org/10.1111/gcb.16940). *Global Change Biology*. <https://doi.org/10.1111/gcb.16940>. (Problem 1, 2)

**Parks, S. A.**; **Holsinger, L. M.**; Blankenship, Kori; Dillon, Gregory K.; Goeking, Sara A.; Swaty, Randy. 2023. [Contemporary wildfires are more severe compared to the historical reference period in western US dry conifer forests](https://doi.org/10.1016/j.foreco.2023.121232). *Forest Ecology and Management*. 544: 121232. <https://doi.org/10.1016/j.foreco.2023.121232>. (Problem 2)

Peng, L., L. He, M. Shen, M. Zhao, and **C.A. Armatas**. 2023. [Understanding stakeholder perceptions of environmental justice: A study of tourism in the Erhai Lake Basin, Yunnan Province, China](https://doi.org/10.5751/ES-14424-280401). *Ecology and Society* 28(4):1. <https://doi.org/10.5751/ES-14424-280401>. (Problem 3)

**Redmore, L.**; Katholo, I.; Sene-Harper, A.; Songhurst, A.; McCulloch, G.; Stronza, A.. 2023. [The village, the elephant, and the state: Land access and vulnerability in rural Botswana](https://doi.org/10.1007/s10745-023-00390-4). *Human Ecology*. 32(2-3): 105. <https://doi.org/10.1007/s10745-023-00390-4>. (Problem 1)

Rodman, K. C.; Davis, K. T.; **Parks, S. A.**; Chapman, T. B.; Coop, J. D.; Iniguez, J. M.; Roccaforte, J. P.; Sanchez Meador, A. J.; Springer, J. D.; Stevens-Rumann, C. S.; Stoddard, M. T.; Waltz, A. E. M.; Wasserman, Tzeidle N. 2023. [Refuge-yeah or refuge-nah? Predicting locations of forest resistance and recruitment in a fiery world](https://doi.org/10.1111/gcb.16939). *Global Change Biology*. <https://doi.org/10.1111/gcb.16939>. (Problem 2)

**Taylor, J.J.**, **T.N. Hollingsworth**, **C.A. Armatas**, **K.J. Carim**, **K.L. Hefty**, **O. Helmy**, **L.M. Holsinger**, **D. Paige**, **S.A. Parks**, **L.E. Redmore**, **J.F. Rushing**, **E.J. Taylor**, and **K.A. Zeller**. 2023. [The Future of Wilderness Research: A 10-Year Wilderness Science Strategic Plan for the Aldo Leopold Wilderness Research Institute](https://doi.org/10.1007/s10745-023-00390-4). *International Journal of Wilderness* 29(1), 46-71.

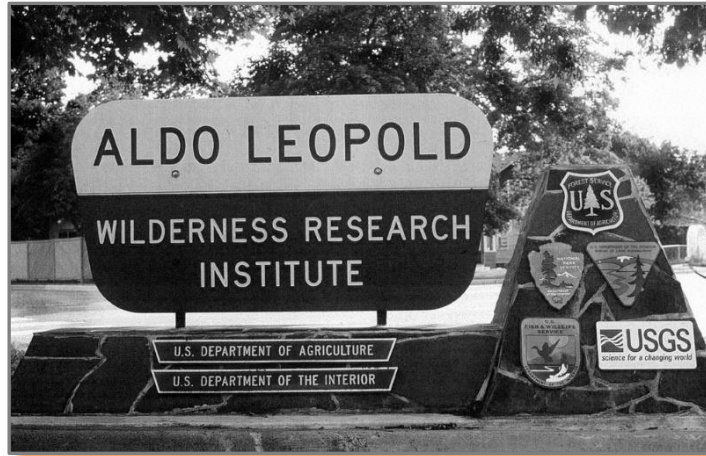
Thomsen, J. M., W. L. Rice, **J. Rushing**, and **C.A. Armatas**. 2023. [U.S. Wilderness Research in the 21<sup>st</sup> Century: A Scoping Review of Wilderness Visitor Use Management Research from 2000 to 2020](https://doi.org/10.1080/00222216.2022.2142870). *Journal of Leisure Research* 54(1): 3-25. <https://doi.org/10.1080/00222216.2022.2142870>. (Problems 1 and 4)

Wultsch, C.; **Zeller, K. A.**; Welfelt, L. S.; Beausoleil, R. A. 2023. [Genetic diversity, gene flow, and source-sink dynamics of cougars in the Pacific Northwest](https://doi.org/10.1007/s10592-023-01532-3). *Conservation Genetics*. <https://doi.org/10.1007/s10592-023-01532-3>. (Problem 1)

**Zeller, K. A.;** Wulsch, C.; Welfelt, L. S.; Beausoleil, R. A.; Landguth, E. L. 2023. [Accounting for sex-specific differences in gene flow and functional connectivity for cougars and implications for management](https://doi.org/10.1007/s10980-022-01556-z). *Landscape Ecology*. 38: 223-237. <https://doi.org/10.1007/s10980-022-01556-z>. (Problem 1, 2, 3)

Zhu, X., D Chen, M. Kogure, E. Hoy, L. Berner, A. Breen, A. Chatterjee, S. Davidson, G. Frost, **T. Hollingsworth**, G. Iwahana, R. Jandt, A. Kade, T. Loboda, M. Macander, M. Mack, C. Miller, E. Miller, S. Natali, M. Reynolds, A. Rocha, S. Tsuyuzaki, C. Tweedie, D. Walker, M. Williams, X. Xu, Y. Zhang, N. French, and S. Goetz. (2023). [A synthesized field survey database of vegetation and active layer properties for the Alaskan tundra \(1972–2020\)](https://doi.org/10.5194/essd-2023-222), *Earth Syst. Sci. Data Discuss.* [preprint], <https://doi.org/10.5194/essd-2023-222>.

The Aldo Leopold Wilderness Research Institute, part of USDA Forest Service Rocky Mountain Research Station, is an interagency, national research facility located on campus at the University of Montana. Our mission is "advancing wilderness stewardship through transformational science."



The Leopold Institute is the only federal research group in the United States dedicated to development and dissemination of knowledge needed to steward the nearly 112-million-acre National Wilderness Preservation System, all 800+ units managed by two Departments and four agencies, from Puerto Rico to Alaska. We have a long history of conducting and sharing science in support of the NWPS, as well as collaborating with management, Tribal, academic, non-governmental organizations, community, and other partners within the United States and internationally.

ALWRI recognizes that wilderness means different things to different people. Our research, research application, and knowledge-sharing programs honor and acknowledge the breadth of these meanings.

