Aldo Leopold Wilderness Research Institute

USDA Forest Service, Rocky Mountain Research Station

FY2022 Progress and Accomplishments Report

Chris Armatas, Kellie Carim, Teresa Hollingsworth, Lisa Holsinger, Danette Paige, Sean Parks, Lauren Redmore, Jason Taylor, Kathy Zeller, and postdoctoral contributors Kira Hefty, Eric Palm, and Erana Taylor

January 2023

Advancing Wilderness Stewardship Through Transformational Science

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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.

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.

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

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.

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

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

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Cover image: Stikine-LeConte Wilderness. Two brown bear tracks in tidal mudflat (Maria Burke). Courtesy photo by Wilderness Connect (https://wilderness.net/visit-wilderness/image-search-results.php#3774-Modal).

ALDO LEOPOLD
WILDERNESS RESEARCH INSTITUTE

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

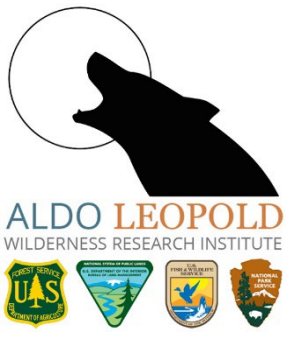
RMRS – Rocky Mountain Research Station

USDA – U.S. Department of Agriculture

USFS – USDA Forest Service

USGS – U.S. Geological Survey

WSR – Wild and Scenic Rivers



LEOPOLD INSTITUTE NEWS

Fiscal year 2022, like the last several years, was heavily influenced by COVID-19. During the first half of the year, we remained on maximum telework and then finally, returned to the office in early June. The transition back to the office went smoothly, and we have all adapted to a "hybrid" work environment where some people are in the office, while others are teleworking (across the Forest Service). The trials of COVID aside, the team made an impressive array of contributions to wilderness stewardship and, more broadly, conservation science. Our roughly 40 projects, along with publications, presentations, and manager engagements and other outreach efforts advanced or completed, are described below. Several scientists were formally recognized (through a variety of awards) for their recent contributions. Administratively, we completed development of our 2022–2032 science charter and strategic plan. The document, which is further described below, was signed in April of 2022. As described in the new charter, our updated mission statement is: *Advancing wilderness stewardship through transformational science*. Following a process late last FY to recruit the first R&D scientist focused on diversity, equity, and inclusion (DEI) in wilderness, this FY we onboarded said scientist and launched the nascent research program. Goals that inspired the DEI position included helping wilderness managers understand: recreational experiences, preferences, barriers, and incentives for underserved communities; "relevancy" of wilderness to all people, in the sense of both what does relevancy mean to different people, and also how we can increase relevancy; value and use of wilderness resources by diverse user groups; proposed and existing wilderness laws and policies, and if they advance equity and inclusion; and most importantly, how to improve access to wilderness for families of all backgrounds. We also laid the groundwork (including by engaging partners across NWPS agencies) to develop a science delivery strategy for the Institute. More work is forthcoming, but the process has launched. Below are a few specific items of note.

- **Chris Armatas** received an award from the Rocky Mountain Research Station that recognizes outstanding technology transfer of published scientific research.
- **Kellie Carim** received an award from the Rocky Mountain Research Station for the best Early Career Scientist Publication for her journal article, "Environmental DNA Sampling Informs Fish Eradication Efforts: Case Studies and Lessons Learned," published in the *North American Journal of Fisheries Management*.
- **Kira Hefty, Eric Palm,** and **Erana Taylor** joined the team as post-docs supporting wildlife, biodiversity, landscape connectivity, and climate change adaptation research.
- **Lisa Holsinger** received an Outstanding Science Support Award from the Rocky Mountain Research Station that recognizes a technical or professional employee who provides exceptional support to the research mission.
- **Sean Parks**, **Lauren Redmore**, and **Jason Taylor** had the opportunity to meet Undersecretary of Agriculture Homer Wilkes during his visit to Missoula in May 2022. During this time, the team shared our work on climate change and diversity, equity, and inclusion in wilderness, and learned more about how this work connects with priorities in Washington.
- **Lauren Redmore** joined ALWRI in December 2021. She is the first research social scientist dedicated to studying diversity, equity, and inclusion in wilderness and wildlands. She brings experiences from a wide array of contexts, including forestry, fisheries, human-wildlife conflict, parks management, and more, working with nonprofits and local, state, and federal governments in Sub-Saharan Africa and across the United States.
- **Jason Taylor** was nominated by the RMRS Station Director for a USFS Robert F. Lewis Pioneer and Science Award, in recognition of implementing new strategies to address emerging issues and promoting diversity and inclusion.

IN SUMMARY (TASKS AND PROJECTS)

Admin Tasks

ALWRI science charter
Develop a draft Science Delivery Plan
Implement an internal RFP for allocating DOI agency funds

Projects (by 2008 ALWRI Science Charter "Problem Areas" or PAs)

PA1: Recreation experiences and the impacts of recreation on wilderness

Visitor use management
Trends in recreation patterns and experiences
Wilderness use monitoring
Wilderness character monitoring support
Wild and scenic rivers user capacity
Recreation thresholds for wildlife

PA2: Relationships between people and wilderness lands and management

Application of Q-methodology for ALWRI Science planning
Social science in support of Comprehensive River Management Planning
Economic impacts of wilderness on gateway communities
Application and expansion of the social vulnerability protocol for management planning
Relevance, diversity, and inclusion in wilderness
Shared stewardship for wilderness management in Alaska
Examining wilderness values in Alaska
Understanding the history of Tribal lands in wilderness
Monitoring changes in Chinook salmon distributions across the Salmon River basin
Shared stewardship approaches for a high-use wilderness area
Collaborating with Yunnan University, China

PA3: Wildland fire and social and ecological values of fire

Lessons from wilderness fire
Ecosystem response to fire in wilderness
Contrasting historical and contemporary fire regimes
Paleo-ecological assessment of fire in wilderness
Pyrodiversity and aquatic biodiversity in wilderness
Benefits, costs, and challenges of prescribed fire in wilderness

PA4: Wilderness stewardship within larger ecological and social systems

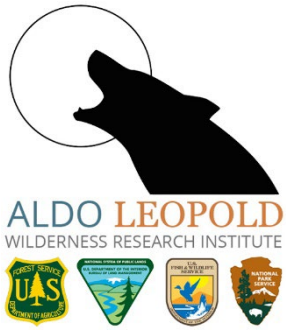
Protected area vulnerability through the lens of climate change connectivity
Evaluating a RAD decision-making framework to address climate change in wilderness
Effects of management, climate change, and disturbance on biodiversity and connectivity
Contributing to a Landscape Conservation Design for the Crown of the Continent Ecosystem
Connectivity assessment for the western United States
Multi-scale ecological connectivity across North America
Quantifying the contribution of wilderness to wildlife population genetics
eDNA monitoring of fish populations within and adjacent to wilderness
Genetic and life history diversity of bull trout in a wild and scenic river

External projects facilitated by Leopold Staff

Economic Benefits of Wilderness Working Group Report

Research to support management of the PCT scenic trail and related public lands

Future changes to wilderness areas and surrounding lands linked to land use and climate change



ADMINISTRATIVE TASKS

ALWRI Science Charter (Taylor and Hollingsworth) – Built on an extensive team effort and an exhaustive partner engagement and subsequent input (175 individual responses), and after working closely with the Acting Director for Landscape Restoration and Ecosystem Services Research (LR&ESR) to ensure timely engagement at WO R&D, ALWRI submitted its 2022–2032 science charter for formal review and approval. The charter was unanimously supported by the Interagency Wilderness Policy Council, was signed by WO R&D in April 2022, and will be formally engaged in FY23. Our broad stakeholder engagement, in building the charter, was identified by the Acting Director for LR&ESR as "…a potential model for how all R&D research charters should be developed."

ALWRI Science Delivery Plan (Taylor and Hollingsworth) – Dissemination of research findings is a critical part of the Leopold Institute's work. In FY22, we initiated development of a science delivery plan to complement and amplify outreach efforts of Institute scientists, and to serve as a deliberate, regular, and bidirectional bridge between scientists and managers. To support this effort, and led by ALWRI social scientists Armatas and Redmore, a series of interactive and confidential focus-group discussions on science communication were held with wilderness managers from the BLM, FWS, NPS, and USFS to identify how, when, where, and why science is used, or not used, by managers. In FY23, this effort will advance a survey to understand how to best deliver science to federal wilderness managers, and a living science delivery plan will be created and revisited as more information is learned.

Implement an internal request for proposals process for allocating DOI agency funds (Taylor and Hollingsworth) – In FY22, we implemented a new process for allocating Department of the Interior (BLM, FWS, and NPS) base-operations funds, which are transferred to the Institute on an annual basis. ALWRI scientists were provided an opportunity to respond to an internal request for proposals (RFP) to determine how those annual funds were distributed. The RFP asked that proposals address four criteria: nexus with wilderness stewardship, problem resolution, urgency/severity of need, and cost effectiveness.

PROJECTS

PA1: RECREATION EXPERIENCES AND THE IMPACTS OF RECREATION ON WILDERNESS

Visitor use management (Armatas) – In collaboration with university partners and NPS managers and planners at the national scale, ALWRI scientists continued to make progress toward providing NPS wilderness managers with a social science survey tailored to understanding visitor perceptions for the purpose of supporting wilderness stewardship planning. The study aims to develop a survey instrument that has 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. The initial pilot study, taking place in Everglades NP, is approaching data collection (pending OMB approval). A second pilot study has begun, with identification of an appropriate NPS unit ongoing. In addition, ALWRI scientists, in collaboration with RMRS and PNW researchers and NOAA scientists and practitioners, have developed a paper that will supplement the desired conditions guidebook, currently being developed by the Interagency Visitor Use Management Council. This contribution, which is currently under review, will directly support managers and planners across all land management agencies as they develop "desired conditions" in a variety of visitor use contexts.

Trends in recreation patterns and experiences (Armatas) – The Rattlesnake Wilderness in Lolo NF provides a unique opportunity to understand: (1) how conflict and crowding norm trends have shifted over a 30-year period in a designated wilderness; (2) how Limits of Acceptable Change Opportunity classes have shifted over a 30-year period; (3) visitor perceptions related to dams in wilderness; and (4) how mobile phone location data can be leveraged to support wilderness character monitoring. To address immediate wilderness visitor-use management needs, a small pilot project led by the Lolo NF and the City of Missoula, in collaboration with ALWRI scientists, is underway to understand and quantify visitor flows into, within, and out of the Rattlesnake Wilderness using an innovative combination of mobile phone location data and GPS data. Additionally, ALWRI scientists are leveraging existing archived datasets to understand how trends around conflict and crowding have shifted in this urban-proximate wilderness over the last 30 years.

Wilderness use monitoring (Armatas) – In collaboration with university partners and managers within federal land management agencies, ALWRI scientists provided science support for monitoring of elements critical to wilderness stewardship. This research project is nearly complete, with the finalization of reports pending comments from managers. The two projects include: (1) campsite data set compilation and analysis for the Frank Church River of No Return Wilderness; and (2) data set analysis and methodology consultation related to encounters in the Sequoia & Kings Canyon National Parks.

Wilderness character monitoring support (Carim) – Wilderness Character Monitoring is a standardized approach for all agencies that administer wilderness to monitor the condition of wilderness character across individual wilderness areas and as a whole agency. Data compilation and submission for Wilderness Character Monitoring occurs on a 5-year cycle. This monitoring approach has undergone one full 5-year cycle. ALWRI scientists engaged with wilderness managers across agencies to better understand research needs and opportunities associated with data generated during this first monitoring cycle. Through these conversations, it was determined that the primary need for agencies at this time are associated with support for data collection and data storage. There are currently no research needs identified.

Wild and scenic rivers user capacity (Armatas) – In cooperation with university partners and managers and planners at the national, regional, and forest level of the National Forest System, ALWRI scientists are developing a framework for completing the policy (legal and administrative) mandated “user capacity” determination for wild and scenic rivers. This project is based on an initial case study taking place on the recreation segment of the Salmon Wild and Scenic River. Data collection was completed in the fall of 2022, and data analysis and report write-up are ongoing.

Recreation thresholds for wildlife (Zeller) – Studies have associated non-consumptive outdoor recreation with negative effects on wildlife ranging from altered resource use and behavior patterns, to decreased survival, reproduction, and population sizes. However, these studies are rarely able to provide detailed data such as effect thresholds (e.g., type of recreation, number of recreators, and distance to trails) because of limited sample sizes. Therefore, managers lack the information they need to make multi-use recreation management decisions that would reduce negative effects on wildlife. This lack of information is especially acute today, due to the marked recent increase in recreation on public lands and wilderness areas. To address this knowledge gap, ALWRI scientists have initiated an audio playback experiment in the Bridger-Teton National Forest to quantify the behavioral effects of non-consumptive recreation on wildlife. Recordings of different recreation types (e.g., hiking, mountain

biking, running, and horseback riding), group sizes, and group dynamics (e.g., quiet vs. talkative) were used. Playback devices were paired with infrared sensors and remote cameras and placed on game trails. Wildlife triggered the sensor, causing the audio to be played while the camera records the animal's behavioral response.

PA2: Relationships between people and wilderness lands and management

Application of Q-methodology for ALWRI science planning (Hollingsworth, Armatas, J. Taylor) – In the past year, Institute leadership and scientists integrated a structured social science process into the planning process for ALWRI's new science charter. In FY22, we analyzed input from a diverse range of partners throughout the wilderness community regarding desired science priorities. That input was integrated into development of a new charter, and the process of engaging the wilderness community was articulated in two manuscripts, which are nearing submission.

Social science in support of Comprehensive River Management Planning (Armatas) – The Leopold Institute and the University of Missouri, School of Natural Resources, collaborated to gather visitor use and user information for the Eleven Point National Scenic River in Missouri to support their Comprehensive River Management Plan. This project was completed in FY22, with the finalization of a report that was delivered to managers.

Economic impacts of wilderness on gateway communities (Armatas) – In collaboration with the Conservation Economics Institute, ALWRI scientists completed a project that explored how wilderness, and the associated migration of people to areas nearby wilderness for outdoor amenities, leads to social and economic development in gateway communities. A manuscript was published in the journal *Land Use Policy* (see Hjerpe et al. 2022 in the **Publications** section below).

Application and expansion of the social vulnerability protocol for management planning (Armatas) – In three ways, ALWRI scientists focused on increased application and expansion of the established social vulnerability protocol (SVP) for engaging the public during large-scale planning processes. First, a web-based application of the SVP was finalized, with associated analysis and a report coproduced with managers; public input informed early stages of resilience planning at the project level for the Wallowa-Whitman NF. Second, progress continued on the integration of the SVP with another existing public participation tool, Human Ecology Mapping (HEM). This integration, in collaboration with a PNW research social scientist, has the goal to provide a spatially explicit understanding of how diverse publics are supported by public lands. The initial pilot of the integrated tool, called Mapping, Prioritization, and Public Participation (M3P), is nearly complete; the initial pilot is supporting a decision-making roundtable focused on planning for wildlife and recreation in Routt County, CO. A second pilot is being planned to support postfire restoration in California. Third, early preparation began on a manuscript that articulates the underpinning philosophy of the SVP.

Relevance, diversity, and inclusion in wilderness (Redmore, Armatas) – ALWRI scientists began multiple projects to examine differences in how diverse populations use, connect with, and understand wilderness.

DEI in BLM wilderness (Armatas): This project focuses on the concept of inclusion within two BLM managed wilderness areas in southern California. The project advanced with co-development of a survey instrument with unit managers; the survey is nearing submission to OMB.

Understanding relationships between underrepresented communities and Everglades NP (Armatas): ALWRI scientists, in collaboration with Everglades NP managers, are conducting a study focused on how underrepresented communities interact with, and view, Everglades NP and the agency more broadly. Interviews have been conducted with a broad range of community groups, and data analysis and write-up are ongoing.

Exploring African American Wilderness Heritage (Redmore): ALWRI scientists, in conjunction with collaborators at Clemson University are beginning a project that will help wilderness managers better understand key issues of relevancy and identify ways to better represent diverse histories in communications, outreach, and education. To date, key partnerships have been established, including with American Rivers, and wilderness managers from three different land management agencies, including FWS, NPS, and USFS. An initial scoping effort was conducted in the summer of 2022.

Maximizing retention of women in hunting and fishing (Redmore): ALWRI scientists, in collaboration with South Dakota State University began initial research to understand how to maximize participation of women in hunting and fishing. This work focuses on mentorship groups across the Mountain Prairie Region and seeks to conduct a program evaluation to understand aspects of programming that keep women returning to the sports. Additionally, this work will support an interactive map of women's groups across the region that can be used by participants and groups looking for partners and mentors, and will convene a community of practice for women's group leaders to offer them a space to come together and learn from each other's work.

Supporting a diversity, equity, and inclusion toolbox for wilderness (Redmore): ALWRI scientists, in close collaboration with Arthur Carhart National Wilderness Training Center staff, were asked to support the USFS Wilderness Information Management Steering Taskforce and the Wilderness Advisory Group to help them identify what wilderness managers might expect and need from a toolbox to support diversity, equity, and inclusion in wilderness. As part of Carhart's Emerging Professional's program, which seeks to connect early career professionals from across the land management agencies with wilderness-related opportunities, the team recruited 11 Forest Service Resource Assistants and trained them on how to run and transcribe notes from focus groups. Together, they ran five focus groups with representatives from various agencies and partners to identify what wilderness managers need from a toolbox, what a toolbox can and cannot address in terms of increasing diversity, equity, and inclusion, and what additional approaches might help increase diversity, equity, and inclusion in wilderness. Results were shared with various committees and task forces in a short write-up and in presentations.

Shared stewardship for wilderness management in Alaska (Redmore, Armatas, J. Taylor) – This empirical research aims to understand the intersections between the Alaska National Interest Lands Conservation Act (ANILCA) and the Wilderness Act, both of which are used to govern a significant percentage of land management decisions across the State of Alaska. Using a co-production approach with wilderness managers, ALWRI scientists have narrowed down the research to a comparative case study across two national parks. The study will develop an understanding of perspectives and meanings of uninhabited and inhabited wilderness for key wilderness partners, including federal, state, and Tribal representatives, and where overlap between the two perspectives and meanings can potentially be leveraged to develop collaborative approaches to wilderness management.

Examining wilderness values in Alaska (Redmore) – ALWRI scientists, in collaboration with Lake Superior State University, are in the process of examining how community members evoked wilderness

ideals during the 2019 Tongass National Forest Roadless Rule subsistence hearings in 18 different communities across Southeast Alaska. Qualitative transcripts from public hearings have been collected and will be analyzed for themes related to wilderness and support for various management options in the Tongass. This research is intended to reveal how residents value roadless rule designated areas for their wilderness ideals, which ideals are prioritized, and the role that wilderness plays for rural Alaska residents.

Understanding the history of Tribal lands in wilderness (Redmore) – In partnership with the Arthur Carhart National Wilderness Training Center, the Wild Foundation, and the USFS, ALWRI scientists have begun to examine the history of consideration for Tribal lands in federally designated wilderness prior to the passing of the Wilderness Act. This research seeks to understand the process of considering Tribal sovereignty in developing the Wilderness Act by federal lawmakers, and to identify which issues drove the ultimate exclusion of Tribal lands from the Wilderness Act that passed in 1964. This research is currently in development and may result in the development of a manuscript for the *International Journal of Wilderness.*

Monitoring changes in Chinook salmon distributions across the Salmon River basin (Carim) – This project focuses on monitoring changes in Chinook salmon distributions in response to reintroduction efforts by the Shoshone-Bannock Tribes in their homelands across the Salmon River basin. The work combines results of western science methods with traditional ecological knowledge to assist the Shoshone-Bannock Tribes with management of Chinook salmon. FY22 included analysis of eDNA samples collected by the Tribes to monitor Chinook salmon distributions, as well as continued conversations about next steps in expanding collaboration to reach the Shoshone-Bannock Tribe's larger goals for stewardship of Chinook salmon.

Shared stewardship approaches for a high-use wilderness area (Armatas, Redmore) – NWPS managers are seeking to improve wilderness outcomes through shared stewardship with neighboring agencies, community members, and interested parties. Shared stewardship of wilderness is still infrequent, although one wilderness area is making efforts toward this ideal to reduce visitor use conflicts. Alpine Lakes Wilderness is close to Seattle, highly visited (~100,000 visitors annually) by a diversity of people, and is located on Tribal lands held in trust by the federal government. A collaborative has been established to engage diverse partners to support visitor use management decisions; efforts are still at the early stages. ALWRI scientists have developed partnership with University of Washington researchers to better understand what shared stewardship looks like for Tribes and early efforts toward evaluating the collaborative have begun. This project seeks to advance the nascent practice of shared stewardship, blending adaptive monitoring and evaluation and transfer of results to a wider wilderness audience.

Collaborating with Yunnan University, China (Armatas) – ALWRI scientists are engaged in a scholarly exchange that aims to benefit the 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 is focused on contextualizing two studies around the impacts of environmental protection policies to rural, lakeside communities in China. An article is currently in review at Ecology and Society, and another manuscript is in preparation.

PA3: Wildland fire and social and ecological values of fire

Lessons from wilderness fire (Parks, Holsinger) – 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. ALWRI scientists are wrapping up a study covering the western United States comparing contemporary and historical fire severity and use results from the Gila Wilderness as a unique landscape from which lessons learned can help better manage land in and out of wilderness.

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 field data will be evaluated with appropriate statistics and will enable us to determine how fire history and bioclimatic characteristics influence postfire ecosystem trajectories, including the potential for enduring conversions to non-forest. ALWRI scientists partnered with University of Montana to recruit three graduate students (two master's and one PhD) to conduct this work. One of the master's students graduated in FY22, presented her work to the SBW managers, and is preparing a manuscript for publication. We continue to actively engage SBW personnel to gain insight and coordinate logistics.

Contrasting historical and contemporary fire regimes (Parks) – This project's goal is to contrast the contemporary fire severity at select sites (i.e., fire-scarred trees) to the historical inferred fire severity in Arizona and New Mexico. ALWRI scientists partnered with USGS and Western Colorado University to recruit a master's student who collected, analyzed, and interpreted field and satellite-derived fire severity data. Some of the historical data for this project were collected in wilderness. Field work was conducted in summer 2021 in the Saguaro Wilderness (Arizona); field work in the Gila Wilderness (New Mexico) was cancelled because of the 2021 Johnson Fire. The master's student graduated in FY22 and is preparing a manuscript for publication.

Paleo-ecological assessment of fire in wilderness (Hollingsworth, Parks) – The Leopold Institute partnered with Montana State University (MSU) to recruit a student (who is a Crow Tribal member) to conduct a paleo-ecological evaluation of fire in the Axolotl Lakes Wilderness Study Area (WSA), which is administered by the BLM. This study will provide a look back in time (over thousands of years) to quantify relative fire activity in the vicinity of the WSA. A sediment core was extracted from a lake immediately adjacent to the WSA in September 2022, and MSU collaborators believe the sample will cover about 10,000 years, an incredibly long record for the northern Rockies. Also, processing of the fire-scar samples and other samples (e.g., soil and tree cores) collected by Hollingsworth and Parks as a scoping mission was completed.

Pyrodiversity and aquatic biodiversity in wilderness (Carim, Parks, Hollingsworth) – ALWRI scientists are exploring approaches to quantifying pyrodiversity using designated wilderness (many with an extensive fire history) as the study areas. The Bob Marshall Wilderness Complex (BMWC) is some of the most intact wilderness in the contiguous United States, supports robust populations of otherwise imperiled aquatic species (e.g., bull trout), and has an active fire regime with little fire suppression. ALWRI scientists, in collaboration with University of Montana, will use environmental DNA and fire history of the BMWC to link two wilderness management objectives: biodiversity conservation and maintaining natural processes. A solicitation accepting applications for a graduate student to lead this work began in FY22. The selection of a graduate student and a first field season will occur in FY23.

Benefits, costs, and challenges of prescribed fire in wilderness (Parks) – One of the key tenets of the Wilderness Act is that wilderness is "untrammeled." However, the default strategy for most fires in wilderness remains suppression, which is clearly a form of trammeling. The consequences of fire exclusion are well documented, one of which being that forests are less resistant and resilient to the inevitable fire that cannot be suppressed. Therefore, in addition to trammeling, fire suppression also negatively impacts the "natural" character of wilderness because of the longer term and indirect consequence of altered vegetation and fire regimes. 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 may be considered trammeling, it is less commonly implemented within wilderness (though this varies among managing agencies). ALWRI scientists will begin to explore the benefits, costs, and challenges of implementing prescribed fire in wilderness. In FY22, our colleagues at Western Colorado University conducted a survey and interviews on this topic.

PA4: Wilderness stewardship within larger ecological and social systems

Protected area vulnerability through the lens of climate change connectivity (Parks, Holsinger, Zeller) – Protected areas serve as a refuge for plants and animals in a world increasingly modified by human activities. However, protected areas are not immune from the effects of climate change, and moreover, some protected areas are likely to be more vulnerable than others. ALWRI scientists are evaluating climate change vulnerability to protected areas across the globe. This work is published in a study titled "Efficacy of the Global Protected Area Network Is Threatened by Disappearing Climates and Potential Transboundary Range Shifts" (see Parks et al. 2022 in the **Publications** section below). ALWRI scientists are continuing this work to better understand if wilderness and other protected areas can serve as steppingstones for species undergoing climate-induced range shifts.

Evaluating a RAD decision-making framework to address climate change in wilderness (E. Taylor, Parks, Armatas, Carim, Hollingsworth, Redmore, J. Taylor, Zeller) – Climate change was not a consideration when the Wilderness Act was passed in 1964. Further, the Wilderness Act dictates that wilderness resources are maintained in their natural conditions. However, historical interpretations of these tenets may no longer be achievable due to climate change. The RAD (resist-accept-direct) decision framework provides a structure for describing potential effects of climate change and conservation decisions on public lands. This project will evaluate the RAD decision-making framework to address climate change impacts in wilderness. Over the course of 2022, foundational literature was reviewed and evaluated, interagency relations and partnerships were developed, solicitations for potential case study sites were issued and results considered, and a plan was formed for how we anticipate the project to play out in coming years. A GTR-type document also is under development to communicate the science produced by the RAD in Wilderness project.

Effects of management, climate change, and disturbance on biodiversity and connectivity (Hefty, Zeller) – ALWRI scientists, in cooperation with the Pacific Southwest Research Station, are 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 10 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. In FY22, we assessed how both alpha and beta diversity responded to management, climate change, and disturbance in this landscape. We and the larger team will also quantify the degree to which wilderness areas contribute to these 10 different pillars and future desired conditions.

Contributing to a Landscape Conservation Design for the Crown of the Continent Ecosystem (Palm, Zeller) – The Crown of the Continent covers nearly 18 million acres and is a patchwork of protected areas, Tribal lands, wilderness, 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, and ALWRI scientists is developing a Landscape Conservation Design for the entire ecosystem. We are conducting a multi-year study with the Manager's Partnership to incorporate connectivity into their Conservation Design. We have completed the ecological connectivity analysis and are embarking on modeling species-specific connectivity for multiple focal wildlife species throughout the ecosystem. The many wilderness areas in this ecosystem will be quantified in terms of their contribution to current and future wildlife connectivity.

Connectivity assessment for the western United States (Zeller) – Federal land management agencies are increasingly interested in how their lands fit into the greater ecological landscape context. For example, one of the goals of the BLM's National Landscape Conservation System is to identify already-established units that are important for conservation within the larger landscape context in terms of large-scale wildlife connectivity. There is also an interest in maintaining wildlife connectivity to other important habitat areas in the surrounding landscape. However, data to make these decisions are often lacking—especially at the large, cross-jurisdictional scales needed to understand broad landscape patterns of importance. ALWRI scientists are working with land managers from the BLM and other agencies to model wildlife connectivity across the western United States. Outputs will be used to identify wilderness and wilderness study areas that are important for maintaining wildlife, connectivity, and biodiversity.

Multi-scale ecological connectivity across North America (Zeller) – Multiple studies have modeled connectivity among wilderness and protected areas in North America. However, ecological processes and species do not tend to move solely among protected areas or necessarily have protected areas as their starting and known destination locations. By modeling connectivity without source and destination locations, connectivity can be more comprehensively quantified as can the contribution of wilderness and protected areas to providing connectivity for ecological processes and wildlife. In this project, led by The Wilderness Society, with input from the Leopold Institute and the University of British Columbia, we modeled connectivity at multiple spatial scales across North America. We published our results in Landscape Ecology (see Belote et al. 2022 in the **Publications** section below) and have posted seamless maps of connectivity across North America for download.

Quantifying the contribution of wilderness to wildlife population genetics (Zeller) – Landscape genetics can be used to determine landscape effects on genetic diversity and health of wildlife populations. ALWRI scientists are assessing the relationship between genetic diversity and protected areas across North America.

eDNA monitoring of fish populations within and adjacent to wilderness (Carim) – In collaboration with local, state, and federal partners, eDNA was used to determine the distributions of Pacific lamprey in watershed subbasins (8-digit HUCs) around the Puget Sound (Washington state) as well as the Tualatin

and Rogue River basins (Oregon). These samples were collected as part of a larger effort to describe the current distribution of Pacific lamprey across their historic range. In collaboration with the British Columbia Ministry of Natural Resources, Idaho Fish and Game, Colville Confederated Tribes, and Kootenai Tribe of Indians, eDNA samples were also collected to identify spawn timing and locations of burbot and subsequently protect spawning habitat for burbot in the Kootenai River. Finally, samples were collected to monitor for expansion of invasive northern pike at the leading edge of the invasion in Lake Roosevelt and to understand the source of invasive northern pike in this region. Because of the limited relevance to wilderness stewardship, the projects described here on burbot and northern pike have been handed over to the National Genomics Center for Wildlife and Fish Conservation. Research on Pacific lamprey is wide ranging and includes work in and adjacent to over two dozen wilderness areas, and will continue into FY23.

Genetic and life history diversity of bull trout in a wild and scenic river (Carim) – ALWRI scientists aim to better understand the genetic diversity, population structure, and population persistence of bull trout in the St. Joe Wild and Scenic River and connected tributaries. Genetic work will clarify the geographic scale of population function and, therefore, appropriate management units within the basin. Work will occur in collaboration with the Coeur d'Alene Tribe of Indians, Idaho Fish and Game, the University of Idaho, and the USDA Forest Service. In FY22, a proposal was funded by the USFWS to support genetic analysis of bull trout surveys in the St. Joe River basin. These funds were transferred to the Idaho Fish and Game genetics lab to process the samples. Samples were collected during the summer of FY22 and were submitted for processing. Genetic results are expected in winter of FY23.

EXTERNAL PROJECTS FACILITATED BY LEOPOLD STAFF

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. The working group's 10-chapter General Technical Report (*A Perpetual Flow of Benefits: Wilderness Economic Values in an Evolving, Multicultural Society*) was completed and submitted for publication in early FY21, and in FY22 was resubmitted for review and eventual publication.

Research to support management of the PCT scenic trail and related public lands (Armatas) – ALWRI scientists with colleagues from Applied Trails Research, LLC, continued to conduct a Pacific Crest National Scenic Trail (PCT) travel pattern analysis and a Yosemite travel pattern and wilderness study.

PCT travel pattern analysis: The PCT traverses 48 federally designated wilderness areas. The team continues to engage with managers of the Carson Pass Management Area in northern California (Eldorado and Stanislaus NFs) to review findings of the 2021 field work and plan for integration of trail counter data to further inform management of this unique and highly used area. Complementary wilderness management data collection and support continued with the USFS' PCT Administrator Lindsey Steinwachs for the Pasayten Wilderness in the Okanogan-Wenatchee NF in Washington State. The collaborative team also provided support and data analyses to the annual meetings of the Pacific Crest Trail - John Muir Trail land managers' meeting in March.

Yosemite travel pattern and wilderness study: Data analyses and wilderness management collaboration continued with researchers from ALWRI, Oregon State University, and Applied Trails Research. Data

analysis progressed, and the team worked with NPS managers to explore the state of overnight wilderness use in the park and associated wilderness character and natural resource conditions.

Future changes to wilderness areas and surrounding lands linked to land use and climate change (Parks) – Colleagues from the University of Idaho, with funding from ALWRI, have assessed current effects of land use and climate change to evaluate the future effects on wilderness areas and surrounding public lands of land use change and climate change projections. In addition, they evaluated the species occurring within specific wilderness areas and evaluated how species composition could be affected by future land use change and climate change projections. Lastly, they identified the wilderness areas most affected by future land use change, human population change, climate change projections, and changes in species composition. In FY22, a journal article from this previously funded work was published (see Aycrigg et al. 2021 in the **Publications** section below).

SERVICE AND TECHNOLOGY TRANSFER

Management/Stewardship Community Service

Chris Armatas served on the Interagency Visitor Use Management Council working group for desired conditions, as well as a working group on diverse and equitable public engagement, and served on the NPS Benefits of Wilderness working group.

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.

Sean Parks, in collaboration with University of Montana, continued to engage with managers of the Selway-Bitterroot Wilderness about ongoing projects involving postfire vegetation trajectories. Sean gave several presentations over the course of the year to managers, scientists, practitioners, and the general public. Sean also published two manager-focused science spotlights titled, *Climate Change Challenges Protected Area Efficacy* and *Examining Extreme Single-Day Fire Spread Events*.

Lauren Redmore served as a member of the National Parks Service Diversity and Inclusion committee. Additionally, she conducted an evaluation of Carhart's Wilderness Education, Outreach, and Interpretation training and helped inform future planning for trainings. In collaboration with Carhart, she supported efforts to create a program to connect agency early career recruits (e.g., Forest Service Resource Assistants) with opportunities to engage in wilderness research and delivery. This effort was catalyzed through focus group discussions to identify needs for a toolbox on diversity, equity, and inclusion, and has led to Carhart's development of an Emerging Professionals program, which is currently in progress.

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 served as a core contributor to developing the RMRS Climate Change Research Strategy (General Technical Report RMRS-GTR-435), served as a core member of the national planning team for the 2022 all FS-R&D virtual meeting, and hosted a public radio reporter conducting research about the management of wilderness areas on public lands in the West. He also served as a leadership coach for the FS Middle Leader Program.

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 represented at the USFS ScienceX webinar series on applying the resist-accept-direct (RAD) framework to wildlife habitat connectivity, and served as a panelist in a Wilderness Society webinar entitled, "Why did the black bear cross the road?"

Science Community Service

Chris Armatas served on the planning committee for the 2022 National Wilderness Workshop. He also 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, and began 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).

Kellie Carim continued to serve as an associated editor for the *North American Journal of Fisheries Management.* She served as a reviewer for articles submitted to Biological Invasions, Environmental DNA, Frontiers in Marine Science, Movement Ecology, and Transactions of the American Fisheries Society.

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 manuscripts for the journals *Society and Natural Resources* and the *International Journal of Wilderness* and guest lectured on qualitative data analysis at Clemson University.

Jason Taylor served as a member of the IUCN World Commission on Protected Areas, Wilderness, and Science of Management and Biodiversity, Specialist Groups. He also served as a peer reviewer for IUCN *WCPA Technical Note No. 10: Considerations of Remoteness to the Design and Protection of Wilderness Areas*.

Kathy Zeller continued to serve on a thesis committee for a graduate student at the University of Montana and is advising on that research. She also served as the treasurer for the Spatial Ecology and Telemetry Working Group of The Wildlife Society, and continued to serve as a member of the IUCN World Commission on Protected Areas, Connectivity Conservation Specialist Group.

Conference and Meeting Presentations

Chris Armatas (1) presented results from campsite monitoring work to the Frank Church Board of Directors; (2) gave an invited presentation on a public engagement approach to understanding human-nature relationships at the ACES (a community on ecosystem services) conference; and, (3) co-presented about wilderness management in a time of rapid change during the National Wilderness Stewardship Alliance webinar series.

Further, Chris presented during a Wild and Scenic Rivers Community of Practice meeting (Team RAPIDS) on how social science can be integrated into river planning.

Kellie Carim presented research on (1) landscape distributions of Pacific lamprey at the Pacific Lamprey Conservation Initiative's Lamprey Information Exchange; (2) taxonomy of freshwater lamprey in western North America at the American Fisheries Society (both Oregon Chapter and National meetings); (3) the role of wilderness and life history diversity in bull trout persistence at the *Salvelinus confluentus* Curiosity Society Meeting; and (4) conservation of culturally important fish species across broad landscapes at the University of Minnesota Conservation Sciences Seminar Series

Sean Parks (1) presented his team's work on climate connectivity within the global protected area network at the Wildlife Society annual meeting; (2) gave an invited presentation at the Association for Fire Ecology annual meeting titled *Wilderness for Fire Science: How Protected Areas Help Scientists Better Understand Fire Regimes;* and (3) participated in a webinar science series organized by the Forest Service and World Wood Day about changing fire regimes in the western United States.

Lauren Redmore co-organized a session on affinity groups to increase representation in the outdoors for the International Association of Society and Natural Resources 2022 virtual conference on diversity, equity, and inclusion. During this session, she presented on her work on women's hunting and fishing groups and helped lead a discussion around affinity groups in the outdoors. She also shared two of her research projects during an invited poster session with the Undersecretary of Agriculture in Missoula, MT. Lauren additionally gave an invited seminar and an invited presentation on diversity, equity, and inclusion in wilderness to the University of Montana Department of Society and Conservation and the annual Bob Marshall Wilderness Complex managers' meeting.

Jason Taylor presented overviews of the Institute for a variety of audiences, including as part of the Arthur Carhart National Wilderness Training Center, National Wilderness Leadership Training, the Interagency National Wilderness Skills Institute, and the USFS Wilderness & Wild and Scenic Rivers Program Managers Meeting.

Kathy Zeller presented at two scientific meetings. She first presented on multi-species responses to forest management, disturbance, and climate in the Sierra Nevada Mountains at the annual Wildlife Society Conference. Then, at the North American Annual Meeting of the International Association of Landscape Ecology, she presented on mountain lion gene flow and landscape genetics.

Publications

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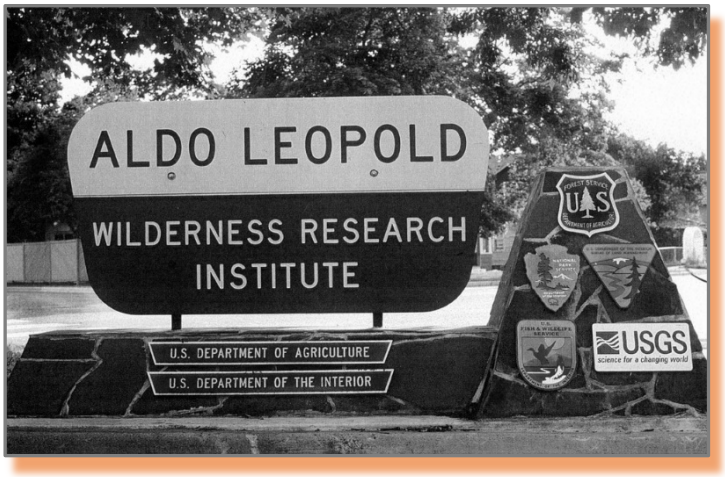
The Aldo Leopold Wilderness Research Institute, part of USDA Forest Service Rocky Mountain Research Station, is an interagency, national research facility located on campus at the University of Montana. Our mission is "advancing wilderness stewardship through transformational science."



The Leopold Institute is the only federal research group in the United States dedicated to development and dissemination of knowledge needed to steward the 111-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.

The Institute's impact is national and international in scope.

In addition to being administered by the RMRS, the Leopold Institute's work is responsive to an Interagency Wilderness Policy Council and the Institute serves as a member of the Interagency Wilderness Steering Committee. These collaborations help to ensure that our work is relevant to NWPS managers.

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