

Aldo Leopold Wilderness Research Institute

FY2019 Accomplishments and FY2020 Program of Work



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October 2019

Leopold Institute News

As we start a new programming year, the Leopold Institute gratefully acknowledges the many partnerships that facilitate our science in support of the National Wilderness Preservation System. We had an incredibly productive year in FY2019. In FY2020 we look forward to welcoming a new Director, Research Biologist, and Research Social Scientist – and we are excited to represent our work at the 11th World Wilderness Congress.

- Director **Susan Fox** retired in July 2019, after seven years at the Leopold Institute and more than 30 years with the Forest Service. We thank Susan for her leadership and wish her many adventures in the Pacific Northwest!
- Deputy Director **Beth Hahn** is serving as the Acting Director through November 2019, after which she will transfer full-time to the USFS International Programs staff.
- Senior Social Scientist **Alan Watson** is leading the science program at the 11th World Wilderness Congress. Alan hosted international scholars **Dr. Li Peng** from the University of Yunnan in Kunming, China and PhD Candidate **Sini Kantola** from the University of Oulu and the Natural Resource Institute of Finland.
- Research Ecologist **Carol Miller** submitted her research portfolio for panel review and was promoted. The panel commended Carol for her “high caliber and excellent work in wildfire and wilderness sciences,” and noted that her “publications and technology transfer efforts...have informed land management decisions locally, regionally, nationally, and internationally.”
- Research Ecologist **Sean Parks** was selected to receive a Presidential Early Career Award for Scientists and Engineers, the highest honor bestowed by the United States Government to outstanding scientists and engineers who are beginning their independent research careers and who show exceptional promise for leadership in science and technology.
- Ecologist **Lisa Holsinger** continued her leadership in training other researchers on the use and application of Google Earth Engine satellite imagery and geospatial datasets.
- Oak Ridge Institute for Science and Education Fellow **Chris Armatas** successfully defended his dissertation *Pragmatist Ecological Economics: Focusing on Human-Nature Relationships and Social-Ecological Systems*.
- Program Administrator **Danette Paige** overhauled Leopold Institute financial tracking.
- University of Montana work study students **Carrera Harmon**, **Stormy Hack**, and **Kenley Fields** contributed to a variety of Leopold Institute programming.



FY2019-FY2020 Leopold Institute Projects

Wilderness Economics Working Group (WEWG) – Leopold working group to facilitate research collaboration among federal agencies and university and NGO partners on the economic and social dimensions of current and emerging issues confronting American wilderness areas and to develop better communication with the American public and land managers about this important topic. The overall goal of WEWG is to assess the current status of, and trends in, the economic values and ecosystem service benefits provided by wilderness lands. In FY2020, the 10-chapter General Technical Report showcasing this working group’s findings will be published.

Ecological and social resilience of fire-prone landscapes – Leopold scientists and collaborators engaged



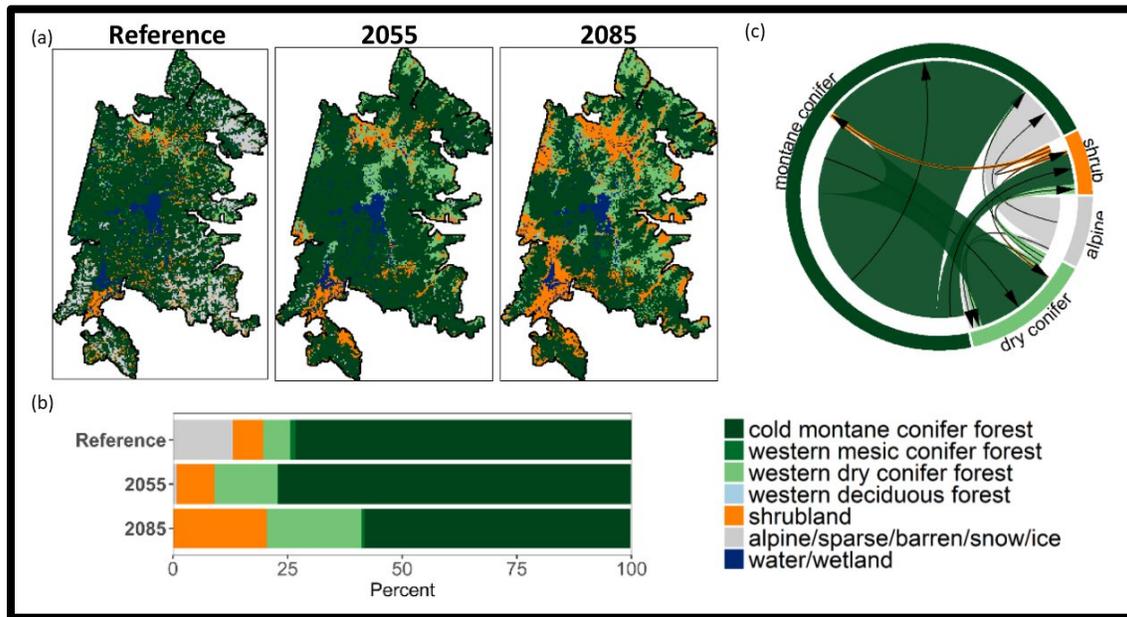
with federal land managers to evaluate resilience in their landscapes, as an integrated social-ecological system. During workshops, participants considered the likelihood that the current system is (not) resilient to wildfire, the elements that need to be resilient to wildfire to enable the system to persist (or adapt successfully), and which human actions are needed to promote resilience to wildfire. Workshop outcomes included the identification

of actions, approaches, and/or behaviors that can enhance social-ecological resilience, as well as key constraints and limitations to enhancing social-ecological resilience.

Fire as a landscape process, including “fire refugia” – Investigations include the effect of unburned fire refugia patch size on tree seedling abundance using a model developed from field observations, and the role of seed sources within fire refugia in fostering tree regeneration in severely burned patches, thus conferring resilience to dry mixed-conifer forests following high severity fire. This portfolio of work conducted by Leopold scientists and collaborators also includes quantifying the risk of fire-facilitated transition to non-forest in the western US, as well as the properties of western North American forests that reinforce landscape resilience, such as the importance of dynamically shifting patchworks of forests and non-forests. Field observations span a wide environmental gradient within mixed-conifer forests with sites in the Pacific Northwest (West Cascades, Blue Mountains), interior West (central Idaho), southern Rockies (Colorado) and the Southwest (Arizona and New Mexico).

Fire risk assessment for wilderness – Spatial risk analysis tools are increasingly used for fire management and planning. Leopold scientists have been working to adapt these tools for the wilderness context where natural fire benefits the resource. One study, to be completed in FY2020, is investigating whether fuels management can be designed at landscape scales across multiple jurisdictions and land designations to simultaneously enhance both protection of human communities and wilderness resource management objectives. Landscapes being studied include the Sierra Nevada (portions of the Sierra, Sequoia, Inyo, and Stanislaus NFs, and Sequoia-Kings Canyon and Yosemite NPs) and northern New Mexico (a mix of USFS, DOI, private ownership, and human communities such as Los Alamos, Taos, and Santa Fe).

Wilderness in the context of larger ecological and social systems – Climate change poses a serious threat to biodiversity and unprecedented challenges to the preservation and protection of natural landscapes. We evaluated how climate change might affect vegetation in 22 of the largest and most iconic protected area complexes across North America. Key findings: 1) the majority of protected areas examined may experience substantial vegetation changes by the end of the 21st century; 2) anticipated trends towards vegetation associated with warmer or drier climates, with cascading ecological responses for the flora and fauna; 3) fine-scale maps of future vegetation are presented to help envision the future challenges for native vegetation and the species dependent upon such resources; and, 4) these maps may aid in building conservation strategies and climate adaptation measures to conserve biodiversity across North American protected areas.

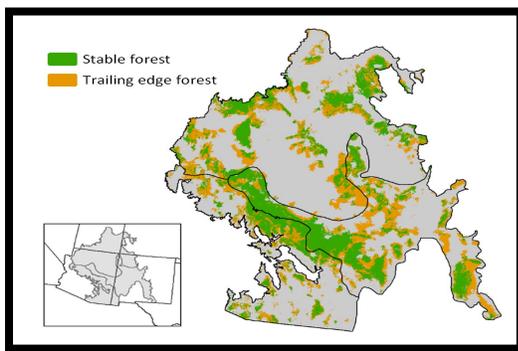


Potential vegetation changed in Yellowstone NP and surrounding protected areas.

The effect of suppression on natural fire regimes – Wilderness and other protected areas are often used as natural benchmarks for evaluating human impacts. Leopold scientists, along with collaborators, compared fire activity inside and outside of protected areas for US and Canada as a way of evaluating human impacts on natural fire regimes. Using area burned between 1984 and 2014 for 11 ecoregions in Canada and the United States, we built and compared statistical models of fire likelihood and a set of 11 key anthropogenic, climatic, and physical variables. Climatic variables were usually of foremost importance in explaining fire activity inside and outside PAs, with anthropogenic variables being the second most important predictors, even inside PAs. While the individual contributions of anthropogenic variables indicate that fire activity decreased as a function of increasing human footprint, the anthropogenic effects were often substantially greater than those of physical features and were comparable to or even greater than climatic effects in some densely developed ecoregions, both outside and within PAs. This assessment of human-altered fire activity could serve as an indicator of human pressure in PAs; however, further analysis will be needed to understand specific interactions among fire, human pressures, and the environmental conditions at the scale of PAs.

Lessons from wilderness fire – The practice of allowing naturally ignited fires to burn began over 40 years ago in a handful of wilderness areas and national parks. This ongoing experiment is providing valuable lessons for managers of other areas who seek alternative strategies to aggressive fire suppression but may lack the experience. The large wilderness areas in the Northern Rockies region have been leaders in this practice. During FY2020, Leopold collaborators will complete a comprehensive review of modern wilderness fire science and lessons learned in the northern Rockies since 1970 when fire management began to adopt the practice of allowing naturally ignited fires to burn. The synthesis will be published as a General Technical Report and will serve as the definitive and comprehensive information on wilderness fire history and management in the Northern Rockies. The study draws on a combination of information sources including agency fire history records, geospatial fire atlases, published literature, historical and contemporary photos, and interviews with key informant managers.

Quantifying the risk of fire-facilitated transition to non-forest in California and the Southwest – Forests are an incredibly important resource across the globe, yet they are threatened by climate change



through stressors such as drought, insect outbreaks, and wildfire. Trailing edge forests—those areas expected to experience range contractions under a changing climate—are of particular concern because of the potential for abrupt conversion to non-forest. However, due to plant-climate disequilibrium, broad-scale forest die-off and range contraction in trailing edge forests are unlikely to occur over short timeframes (<~25–50 yr) without a disturbance catalyst (e.g., wildfire). This underscores that explicit attention to both climate and disturbance is necessary to understand how the distribution of forests

will respond to climate change. As such, we first identify the expected location of trailing edge forests in the intermountain western United States by mid-21st century. We then identify those trailing edge forests that have a high probability of stand-replacing fire and consider such sites to have an elevated risk of fire-facilitated transition to non-forest. Our findings suggest the potential for transformed landscapes in the intermountain western United States that will affect ecosystem services such as watershed integrity, wildlife habitat, wood production, and recreation.

Methodological advances in satellite-derived fire severity indices – Satellite-derived spectral indices such as the relativized burn ratio allow fire severity maps to be produced in a relatively straightforward manner across multiple fires and broad spatial extents. These indices often have strong relationships with field-based measurements of fire severity, thereby justifying their widespread use in management and science. In this study, we built a Random Forest model describing a field-based measure of fire severity, the composite burn index (CBI), as a function of multiple spectral indices, a variable representing spatial variability in climate, and latitude. The model we produced allows for the direct mapping of CBI, which is more interpretable compared to spectral indices. Moreover, because the model and all spectral explanatory variables were produced in Google Earth Engine, predicting and mapping of CBI can realistically be undertaken on hundreds to thousands of fires. We provide all necessary code to execute the model and produce maps of CBI in Earth Engine. This study and its products will be extremely useful to managers and scientists in North America who wish to map fire effects over large landscapes or regions. This project was a multi-agency international collaboration, including scientists and practitioners from USFWS, NPS, USGS, Parks Canada, Canadian Forest Service, and universities in the US, Canada, and Australia. Most of the field data for this project were collected in protected areas, including wilderness.

Influence of annual climate variation on area burned in India – Wildland fire is an understudied yet highly important disturbance agent on the Indian subcontinent. In particular, there is uncertainty regarding the degree to which annual climate variation influences inter-annual variability in fire activity. In this study, we evaluate wildland fire at two complementary spatial scales (including a protected area) in the southern portion of the Western Ghats mountain range in India. Although not the only factor influencing area burned, episodes of drought could be exerting an increasingly significant effect on wildfire activity in the Western Ghats.

Local indigenous knowledge and ecological restoration – Grassland, forest and riparian ecosystems on mixed-ownership federal lands adjacent to the Crow Reservation: developing a protective shield for sustainability of the environment and culture from the impacts of climate-related disturbance. The emphasis of this project was to understand how to incorporate local indigenous knowledge into restoration associated with climate-change induced disturbance to protect sustainability in mixed-ownership lands, with a focus on the Upper Missouri River basin. Areas of study included the Bighorn Canyon National Recreation Area (NPS and Crow), the Crow Reservation, the Pryor Mountains Wild Horse Range (NPS, BLM, FS); Bighorn National Forest, Shoshone National Forest; Custer Gallatin National Forest. Substantial Wilderness and Wilderness Study Area acreage is central to restoration in these areas.



Visiting Chinese graduate student and Tanzania scholar float the Flathead Wild and Scenic River with Forest Service river rangers on a trip hosted by the Leopold Institute and funded by the Office of International Programs and the Intermountain Region.

Social science to support Eleven Point National Scenic River management planning – The Leopold Institute and the School of Natural Resources at the University of Missouri are collaborating to gather visitor use and user information for the Eleven Point National Scenic River in Missouri to support the Comprehensive River Management Plan. Study design includes a survey that explores knowledge and perceptions related to management of the Irish Wilderness, which is adjacent to the Eleven Point River.

Social vulnerability assessment to support management planning – This social vulnerability protocol provides a step-by-step manual for engaging the public about ecosystem services tradeoffs and the drivers of change considered influential to the continued provision of important ecosystem services. This protocol provides a rigorous social science approach for implementation, alongside common public engagement practices such as listening sessions, open houses, and focus groups. This protocol was completed in support of Forest Plan revision in USFS Region 3.



Modeling travel behavior in wilderness – In this project, we revisited a modeling process that simulates visitor travel and campsite occupancy levels within travel zones in the Boundary Waters Canoe Area Wilderness. Using a computer-based, OMB-approved, survey, nearly 12,000 visitor itineraries were voluntarily contributed to build a sample of real itineraries.

Wilderness data archival products – Collaboration between the University of Montana and the Leopold Institute; FY19 accomplishments included the continued archival of social science products developed within and outside of the Leopold Institute, as well as providing archival support and consultation to others within the Federal government interested in archiving scientific products in perpetuity.



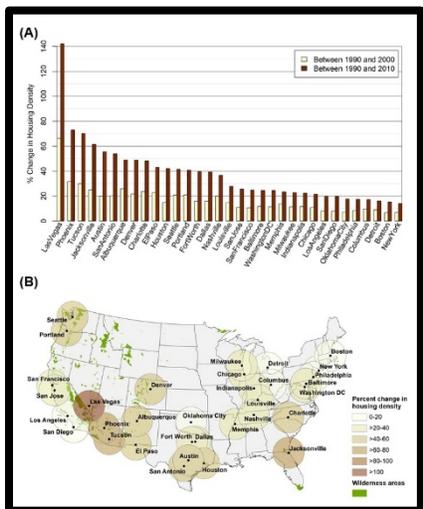
Social science to support Flathead Wild and Scenic River management planning – Social vulnerability of outstandingly remarkable values for the Flathead Wild and Scenic River System, to support the development of a Comprehensive River Management Plan. In particular, the study plan addresses the complexity of establishing user capacity—a requirement for all comprehensive river management plans—as well as describing baseline and current conditions and uses, identifying desired conditions for river values and classifications, and identifying the kinds of use that the river corridor can accommodate. The social vulnerability approach developed by the Leopold Institute generally aims to engage people (both natural resource ‘experts’ and the general public) with a fun, thought-provoking exercise where benefits and opportunities provided by nature are prioritized in a structured way that illustrates the relationships

identifiable between people and the resource, and then additional input is obtained with regard to how important elements of these relationships may be influenced by relevant ‘drivers of change’. Drivers of change are those factors (e.g., climate change impacts, management actions, facilities, user density, land-use change, visitor behavior) that could negatively or positively influence the ability of a person to realize those benefits important to them. The result is an individual relationship between the person and the natural resource of interest. All individual relationships are then statistically analyzed to yield a

limited number of typified viewpoints, or ‘archetypes’, that can convey the broad range of opinions about the topic to the decision-maker and the general public in a tractable way.

Recreation and the Preservation of Wilderness Character – Wilderness managers seek ways to preserve outstanding opportunities for a primitive and unconfined type of recreation. Measuring and monitoring a number of indicators for unconfined recreation will help, as will an understanding of which setting attributes best contribute to unconfined experiences. While a parsimonious number of indicators is desirable, the use of a single measure isn’t likely to fully capture the full aspects and nuances of what it means to be unconfined. To improve our understanding of this, a 20-item quantitative research instrument was developed and administered through a trailhead survey to help us understand what is important to feeling unconfined while in the Selway-Bitterroot Wilderness area. This scale was found to be valid and reliable and included four principal components that were labeled: Free Choice, Untethering from Responsibility, Making Own Plans, and Exploring.

Synthesis of ecological economics and social-ecological systems research – Synthesized knowledge and theoretical understanding of research within the field of ecological economics and social-ecological systems research. The contributions of this work include: a full literature review of pragmatist philosophy and an articulation of its central tenets; a pairing of this philosophy with the field of ecological economics, a field that continues to struggle to find an identity as a conservation social science; recommended focus on human-nature relationships as a central question; a recommendation to more clearly articulate the strengths and weaknesses of different qualitative and quantitative methods for the purpose of improved interdisciplinary and transdisciplinary research; and, an articulation of the myriad benefits provided by adopting a social-ecological systems lens for engaging in conservation social science in the face of complex environmental problems.



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

– In this study, we are analyzing existing spatial data to evaluate the effects of future land use change, human population changes, and climate change projections on wilderness areas and surrounding public lands. Project outcomes include identifying which wilderness areas are most effected by future land use change, human population change, climate change projections, and changes in species composition.

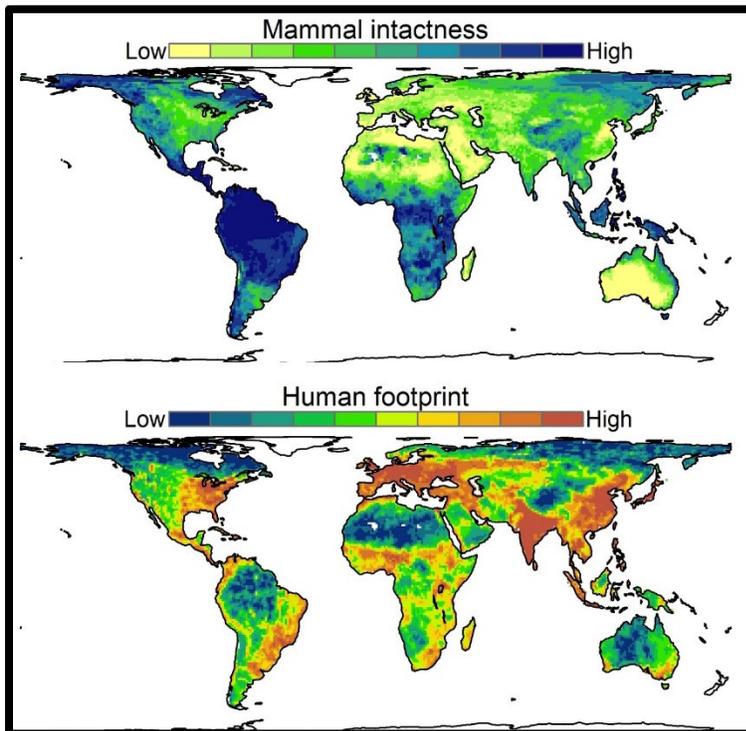
Pacific Crest Trail Wilderness Camping Sustainability – This study is conducting research to investigate camping impacts in high-use areas along the Pacific Crest Trail (PCT) with the purpose of developing more sustainable camping “Best Management Practice” guidance for agency, PCT Association, and volunteer staff. Through collaborations with representatives of the PCT management community we collectively identified various representative high-use PCT segments for applied research and management support. This work is seeking to: 1) Measure and characterize the camping impact management problems common to high-use zones; 2) Improve our ability to evaluate the sustainability

of existing campsites and potential new campsites through both ground-based and GIS analyses; and, 3) Evaluate and recommend improved science-based camping management strategies and actions.

An assessment of vulnerable wildlife, their habitats, and protected areas in the United States –

Protected areas are the foundations of most regional, national, and global efforts to sustain natural ecological processes and conserve biodiversity. However, the success of protected areas in achieving conservation goals depends partly on how well ecological and biological diversity is represented in a network of designated lands. In this study, we are investigating the overlap between suitable habitat for wildlife species of conservation concern and the location of protected areas.

Global wilderness and mammalian diversity - Maps of the human footprint allow ecologists to identify the wildest lands on the planet, track their decline, and prioritize wildland conservation efforts. Other



research efforts have mapped biological intactness and identified conservation priorities to protect biodiversity. However, little research has used historical references to evaluate intactness of species composition globally. Using a dataset estimating historical and current distributions of mammals, we asked whether the wildest places on earth support the most intact mammal communities. Contrary to our expectation, we show that the global human footprint is not strongly correlated with mammal species intactness. We reveal surprising situations where the human footprint and mammal intactness were both high and where the human footprint and mammal intactness were both low. Our results may be used to

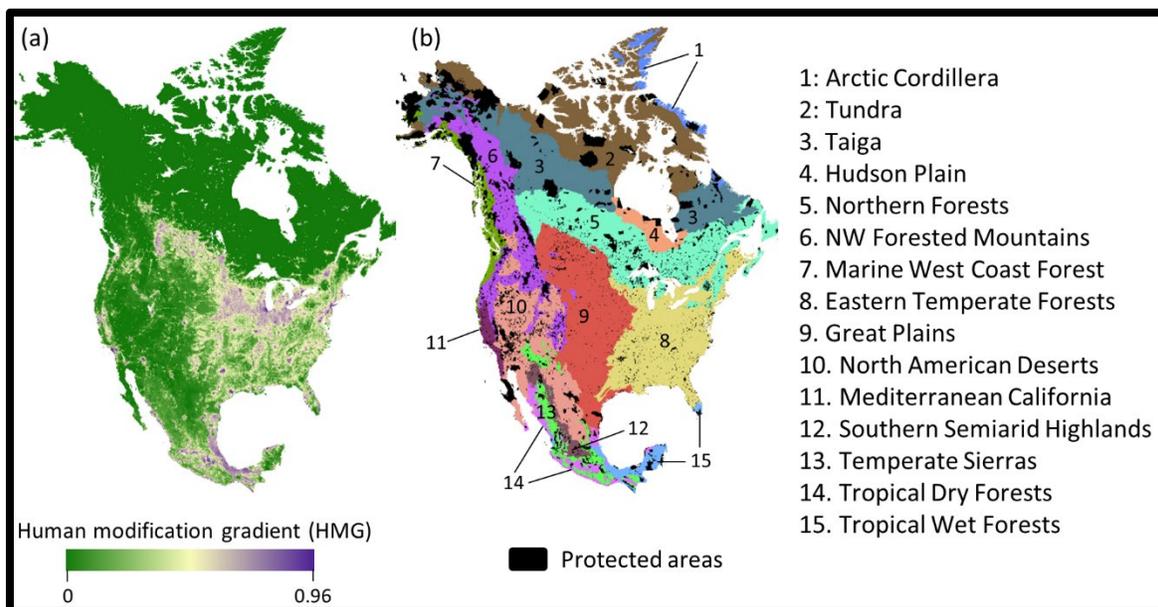
enhance maps and estimates of global wilderness areas by identifying wild and intact regions, while also prioritizing conservation of intact but human-modified landscapes.

Short- vs. long-term consequences of climate change on fire regime in the northern Rocky Mountains –

In a recently initiated study, we intend to clarify and quantify how fire regimes may respond to climate change. We hypothesize that the short-term consequences of climate change on fire regimes will be different, and sometimes sharply contrast, with the long-term effects. More specifically, initial analyses show that area burned and fire severity both increase in hot and dry years; under climate change, we might therefore expect that area burned and fire severity will increase. However, we consider this a shorter-term effect that is also a reflection of existing fuels and vegetation types. Over longer timeframes (several decades), we expect that fuel loads and vegetation types will change as the climate warms, and these changes may also influence fire regimes in a manner that could contrast with the short-term consequences. Stay tuned as this project develops.

Relationships between fire, soil properties, and hydrological function – A new pilot study in FY2020 will examine whether and how the wilderness fire program in the Bob Marshall Wilderness Complex has altered soil properties and hydrological function. Findings will help to quantify the long term consequences of managing fire as a natural process.

Evaluating the impact of human land uses on climate change connectivity across North America and the ability of protected areas to encompass important climate change corridors. Climate connectivity, the ability of a landscape to promote or hinder the movement of organisms in response to a changing climate, is contingent on multiple factors including the resistance they experience along such routes. However, evaluations of climate connectivity rarely consider human land uses that may alter movement routes or increase resistance to movement. Here, we evaluate climate connectivity across North America considering both climate change and human land uses. We also delineate potential movement routes and evaluate whether the protected area network supports movement corridors better than non-protected lands. We found that that climate connectivity decreased across the continent when incorporating human land uses and that ~96% of movement routes in North America must contend with human land uses to some degree as they shift in response to climate change. We also found that protected areas do not represent climate corridors better than non-protected lands across the continent. Overall, our study indicates that previous evaluations of climate connectivity underestimate climate change exposure because they do not account for human impacts over much of the North American continent. *This work is in progress and should be completed in FY2020.*



Identifying corridors into and out of protected areas under climate change – In a recently initiated study, we intend to identify potential corridors, or movement routes, among wilderness areas while incorporating climate change and human land uses. A unique facet of this study is that we will only evaluate connectivity between protected areas with analogous climates; most studies to date have evaluated connectivity among protected areas without considering climatic similarity. This study is in its initial phases and we hope to make substantial progress this year.

Technology Transfer and Science Community Service

- Editor and Peer Reviewer Contributions
 - Alan Watson serves as the Executive Editor of the International Journal of Wilderness.
 - Carol Miller served as a peer reviewer for a research grade panel evaluation for a GS-12 Research Ecologist.
 - Carol Miller provided a review for renewal of one of the 15 USFS Fire Science Exchanges.
 - Carol Miller served as Associate Editor for two manuscripts submitted to the journal Fire Ecology.
 - Chris Armatas served as a peer reviewer for the journal Ecological Economics and the International Journal of Wilderness.
 - Alan Watson reviewed Fulbright applications for Russian candidates for appointments in the US, and for US scholars to serve in Senior Specialists appointments.
 - Sean Parks served as a peer reviewer for four journal articles and provided an informal “friendly review” for a colleague’s book chapter.
- Science Advisory Roles
 - Chris Armatas reviewed a study plan for the application of a published social vulnerability protocol by Oregon State Air Quality Division within the context of sustainable materials management.
 - Alan Watson serves as a science advisor to the Interagency Wild & Scenic River Coordinating Council.
 - Sean Parks and Alan Watson have served on the USFS Chief’s Wilderness Advisory Group.
- Conference Leadership
 - 11th World Wilderness Congress: Alan Watson is a member of the Executive Committee, and is chairing the science and stewardship symposium at WILD11; Chris Armatas is supporting organizational efforts.
 - Alan Watson served on the planning committee for the Wilderness Management Workshop in Bend, Oregon, and coordinated the poster session.
 - Carol Miller co-organized a 2.5 day workshop in April 2019 on the ecological and social resilience of fire-prone landscapes.
 - Sean Parks co-organized a special session at the Landscape Ecology Annual Meeting (April, 2019; Fort Collins, CO) titled *Wildfire-driven forest conversion in western North American landscapes: emerging science and implications for resilience and adaptation*.
 - Sean Parks co-organized a special sessions at the North American Forest Ecology Workshop (June, 2019; Flagstaff, AZ) titled *Forest fire severity patterns and trends: implications for ecosystem trajectories in North America*.
- Presentations
 - Carol Miller delivered two invited presentations at a 2019 Northern Rockies Fire Science Network workshop on Wilderness Fire, as well as participating in the field trip and contributing to the design of the workshop.
 - Alan Watson and Chris Armatas presented *River research across time. Wild, Scenic, and Beyond!* at the River Management Society symposium.
 - Alan Watson delivered four Wilderness and Wild & Scenic River science lectures at the University of Montana.

- Alan Watson presented a lecture on the wild river science agenda and ongoing science projects on the Flathead and Mark Twain National Forests to the Interagency Wild & Scenic Rivers Coordinating Council.
- Alan Watson delivered a presentation on the role of science in wilderness management at the R2/R3 Wilderness academy.
- Chris Armatas presented *Integrating social science into federal natural resource planning: A public engagement approach* at the Rocky Mountain Research Station, Forestry Sciences Lab.
- Sean Parks delivered a presentation at a symposium titled “Climate change and the ecology of Sierra Nevada forests” at UC Merced. The presentation was titled *Potential consequences of a warming climate on protected area conservation capacity, vegetation, and fire regimes in the Sierra Nevada*.
- Sean Parks delivered three presentations at various venues titled *Cloud-based computing provides new opportunities for regional-to-continental modelling of fire effects*.
- Sean Parks delivered a presentation at the Landscape Ecology Annual Meeting titled *Living on the edge: trailing edge forests at risk of fire-facilitated conversion to non-forest*.
- Sean Parks delivered a webinar titled *Modelling and mapping the potential for high-severity fire in the western US*. Webinar hosted by the Southwest Fire Science Consortium. Intended audience included managers, practitioners, and scientists.
- International Visitors and Collaborations
 - Alan Watson hosted a scientist from China for 6 months to share information on river restoration and protection
 - Alan Watson hosted a Fulbright Scholar from Finland for 6 months to share information on methodology related to public participation GIS applications.
 - Alan Watson served the US State Department as a Fulbright Senior Environmental Specialist to China for 6 weeks
 - Alan Watson cooperated with a Russian Academy of Sciences scientist on a large scale assessment of wilderness ecosystems in Russia for publication in the International Journal of Wilderness.
 - Carol Miller and Sean Parks continue to actively collaborate with their Canadian Forest Service counterparts.

Publications

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