

Accomplishments Report | FY2016-2017

In this report, we highlight research conducted and the tools and products developed for wilderness managers and partners. This work would not be possible without support from a number of programs and offices. We gratefully acknowledge support from....

National Park Service

Visitor & Resource Protection Directorate, Wilderness Stewardship Division
Park Planning & Special Studies
Black Canyon of the Gunnison National Park

US Fish & Wildlife Service

National Wildlife Refuge System, National Wilderness Program
Natural Resource Program Center

Bureau of Land Management

National Conservation Lands System, National Wilderness Program
California State Office

Forest Service

National Forest System, Wilderness and Wild & Scenic Rivers
Research & Development
National Fire Plan
Office of Sustainability and Climate Change
Natural Resource Economics Research Center
Office of International Programs
Colville National Forest Collaborative Forest Landscape Restoration Program

Joint Fire Science Program



Celebrations

Sean Parks wins the 2017 Forest Service Early Career Scientist Award

We are proud to announce that Leopold research ecologist Sean Parks was recognized for his accomplishments conducting high-impact relevant and applicable scientific studies with the potential to advance ecological and fire sciences. Sean's research focuses around three main topics. The first is the self-regulating process of wildfire - that burned areas often limit the spread and size of subsequent fire and can act as effective fuel-breaks. The second is changing fire regimes, and the degree to which climate and/or past management are responsible for changes in expected fire activity across the western United States. His third area of research is in landscape connectivity through space and time, which examines the rate at which species must migrate to keep pace with a warming climate. Congratulations Sean!

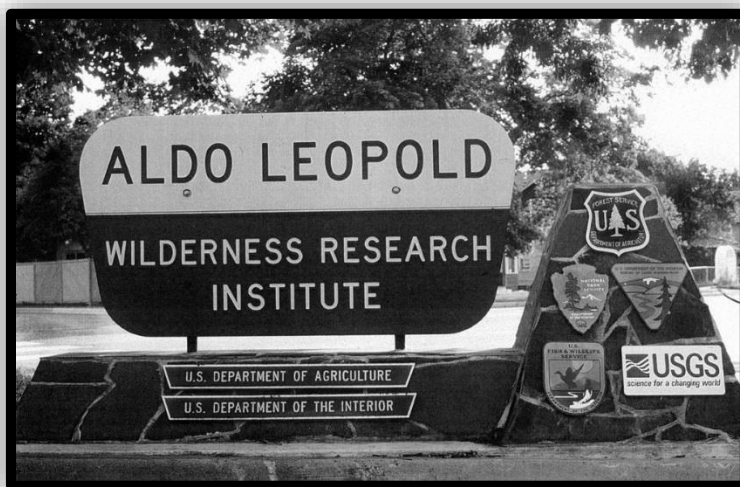


Sean Parks receiving award from Deputy Chief's Rodriguez-Franco and Lago.

https://www.fs.fed.us/rmrs/people/sean_parks

25th anniversary of the Leopold Institute

On August 21, 2018, the Leopold Institute will celebrate our 25th anniversary. We are planning several events, to be held locally in Missoula, at the National Wilderness Workshop in Gunnison, Colorado, and in Washington, DC. Stay tuned and help us celebrate!



New Resources for Managers

Wilderness Science Movies

We have produced three short movies showcasing the important relationship between wilderness science and wilderness stewardship. These movies focus on three topics: recreation, fire, and climate change. In 2018, we will produce an overview film on wilderness science.

<http://leopold.wilderness.net/resources-for-managers/movies/default.php>



Restoration Toolbox on Wilderness Connect

Leopold staff led the development of the new Ecological Intervention and Site Restoration Toolbox. The toolbox contains agency-specific guidance on ecological interventions, as well as a tool for determining if a proposed intervention has addressed all the questions and issues to allow staff to more readily evaluate the proposed action in a Minimum Requirements Analysis.

<http://www.wilderness.net/restoration>

Initial feedback has been positive: ***“The Toolbox is like a dream come true. Thank everyone involved for their hard work. What an invaluable tool.”*** - Kenneth S. Cline, Professor of Environmental Law & Policy, College of the Atlantic

Ecological Intervention and Site Restoration Toolbox

This toolbox contains material pertaining to large-scale interventions and small-scale site restoration in wilderness. In addition to the resources provided here, you may also be able to obtain advice and recommendations through discussion on [Wilderness Connect](#). Date of last update: 12/26/17.

[EXPAND ALL](#) | [COLLAPSE ALL](#)

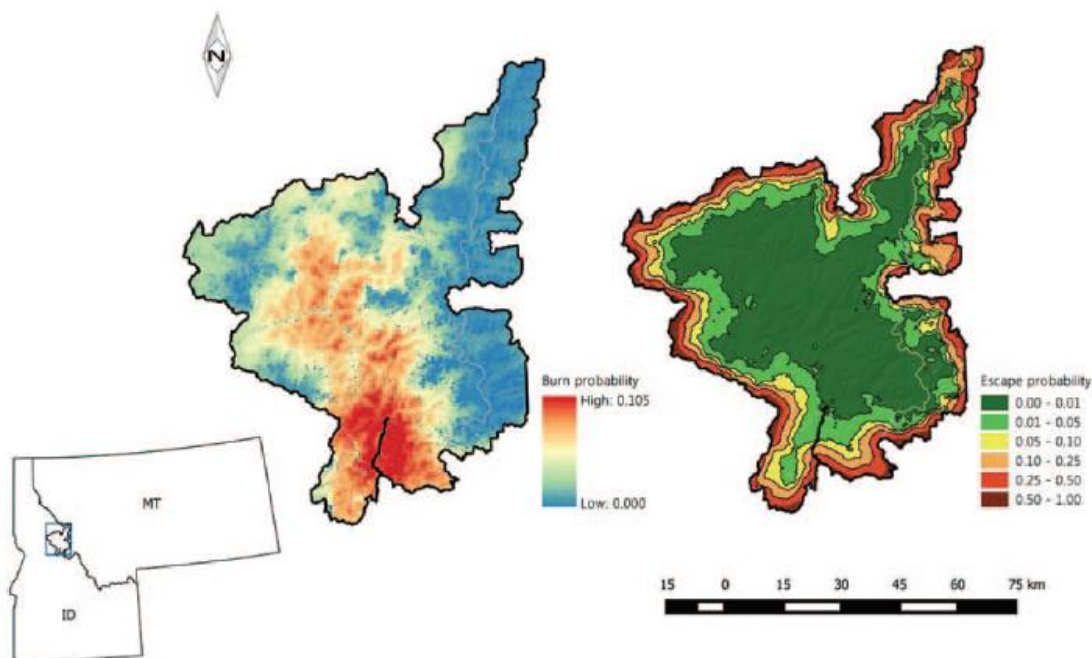


Fire

Progress in Wilderness Fire Science: Embracing Complexity

Carol Miller, Gregory H. Aplet. *Journal of Forestry* 114:373-383.

Wilderness has played an invaluable role in the development of wildland fire science. Since Agee's review of the subject 15 years ago, tremendous progress has been made in the development of models and data, in understanding the complexity of wildland fire as a landscape process, and in appreciating the social factors that influence the use of wilderness fire. Regardless of all we have learned, though, the reality is that fire remains an extraordinarily complex process with variable effects that create essential heterogeneity in ecosystems. Whereas some may view this variability as a management impediment, for others it provides a path forward. As research has shown, embracing fire in all its complexity and expanding its use can help reduce fuels, restore resilient landscapes, and contain costs. Wilderness fire science will continue to play an important role in understanding opportunities for using fire, its role in ecosystems, its risks and benefits, and influence of risk perception on decision-making.



Fire behavior modeling tools can be adapted for spatial risk assessments and decision support for wilderness fires; these maps were developed for the Selway-Bitterroot Wilderness.



Fire

Wildland Fire limits Subsequent Fire Occurrence

Sean A. Parks, Carol Miller, Lisa M. Holsinger, L. Scott Baggett, Benjamin J. Bird. *International Journal of Wildland Fire* 25: 182–190.

Several aspects of wildland fire are moderated by site- and landscape-level vegetation changes caused by previous fire, thereby creating a dynamic where one fire exerts a regulatory control on subsequent fire. For example, wildland fire has been shown to regulate the size and severity of subsequent fire. However, wildland fire has the potential to influence other properties of subsequent fire. One of those properties – the extent to which a previous wildland fire inhibits new fires from igniting and spreading within its perimeter – is the focus of our study. In four large wilderness study areas in the western United States (US), we evaluated whether or not wildland fire regulated the ignition and spread (hereafter occurrence) of subsequent fire. Results clearly indicate that wildland fire indeed regulates subsequent occurrence of fires $\$ 20$ ha in all study areas. We also evaluated the longevity of the regulating effect and found that wildland fire limits subsequent fire occurrence for nine years in the warm/dry study area in the south-western US and over 20 years in the cooler/wetter study areas in the northern Rocky Mountains. Our findings expand upon our understanding of the regulating capacity of wildland fire and the importance of wildland fire in creating and maintaining resilience to future fire events.

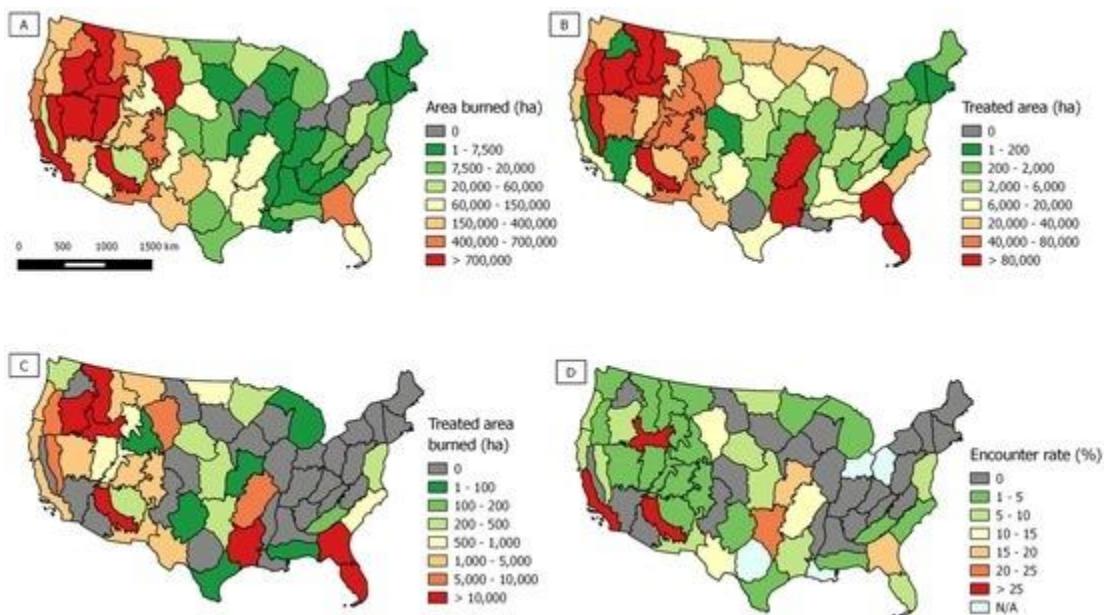


Fire

Beyond Fuel Treatment Effectiveness: Characterizing Interactions between Fire and Treatments in the U.S.

Kevin Barnett, Sean A. Parks, Carol Miller, Helen T. Naughton. *Forests* 7:237.

In the United States, fuel reduction treatments are a standard land management tool to restore the structure and composition of forests that have been degraded by past management. Although treatments can have multiple purposes, their principal objective is to create landscape conditions where wildland fire can be safely managed to help achieve long-term land management goals. One critique is that fuel treatment benefits are unlikely to transpire due to the low probability that treated areas will be burned by a subsequent fire within a treatment's lifespan, but little quantitative information exists to corroborate this argument. We summarized the frequency, extent, and geographic variation of fire and fuel treatment interactions on federal lands within the conterminous United States (CONUS). We also assessed how the encounters between fuel treatments and fires varied with treatment size, treatment age, and number of times treated. Overall, 6.8% of treatment units evaluated were encountered by a subsequent fire during the study period, though this rate varied among ecoregions across the CONUS. Larger treatment units were more likely to be encountered by a fire, and treatment units were most frequently burned within one year of the most recent treatment, the latter of which is likely because of ongoing maintenance of existing treatments. Our results highlight the need to identify and prioritize additional opportunities to reduce fuel loading and fire risk on the millions of hectares of federal lands in the CONUS that are in need of restoration.



Distribution of (A) area burned; (B) treated area; (C) treated area burned; and (D) the encounter rate between fuel treatments and fires on federal lands, summarized for each of 67 ecoregions across the CONUS.



Fire

Participatory Geographic Information Systems as an Organizational Platform for the Integration of Traditional and Scientific Knowledge in Contemporary Fire and Fuels Management

Brooke Baldauf McBride, Fernando Sanchez-Trigueros, Stephen J. Carver, **Alan E. Watson**, Linda Moon Stumpff, Roian Matt, William T. Borrie. *Journal of Forestry* 115:43-50.

Traditional knowledge about fire and its effects held by indigenous people, who are connected to specific landscapes, holds promise for informing contemporary fire and fuels management strategies and augmenting knowledge and information derived from western science. In practice, however, inadequate means to organize and communicate this traditional knowledge with scientists and managers can limit its consideration in decisions, requiring novel approaches to interdisciplinary and cross-cultural communication and collaboration. We propose that Participatory Geographic Information Systems (PGIS) is one platform for the assemblage and communication of traditional knowledge vital to fire and fuels management, while preserving linkages to broader cultural contexts. We provide summaries of four preliminary case studies in the Intermountain West of North America to illustrate different potential applications of a PGIS tool in this context and describe some remaining challenges.

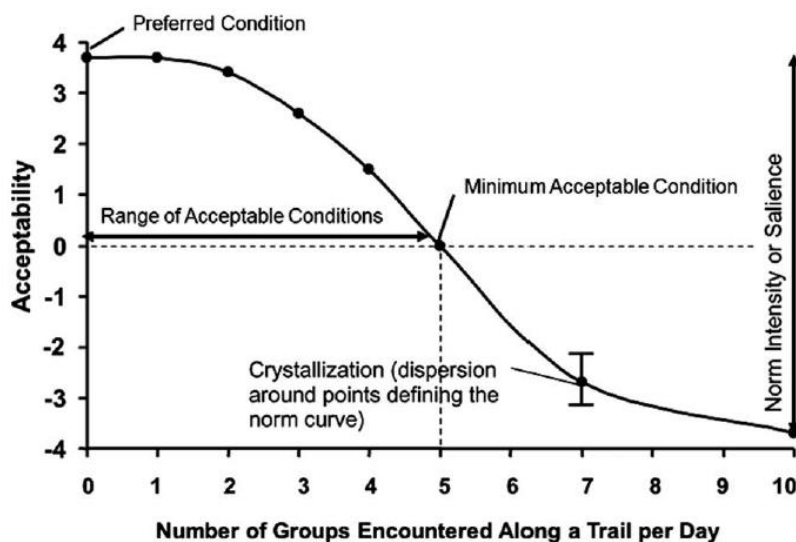


Human Dimensions

The Evolution of Wilderness Social Science and Future Research to Protect Experiences, Resources, and Societal Benefits

Alan E. Watson, H. Ken Cordell, Robert Manning, Steven Martin. *Journal of Forestry* 114: 329–338.

The historic Wilderness Act celebrated its 50th anniversary in 2014, and wilderness social science shared a similar legacy. As paradoxical as it might seem, humans are an important part of wilderness, helping to define the very concept and representing an important component of wilderness use and management. Much of the past five decades of wilderness-related social science has focused on recreational use, documenting the impacts of recreation on wilderness resources and the quality of the wilderness experience, exploring application of the concept of recreational carrying capacity to wilderness, and developing planning and management frameworks for balancing the inherent tension between wilderness use and protecting the quality of wilderness resources and the experience of visiting wilderness. The Limits of Acceptable Change and related planning frameworks, including formulation of recreation-related indicators and standards, continues to help guide wilderness management today. Other programs of social science research have developed protocols for measuring and monitoring wilderness recreation, defined the root causes of conflict among wilderness users and identified management approaches to minimize this conflict, explored the appropriate and acceptable use of fees for wilderness use, and identified a growing suite of wilderness values. All of these programs of research and others that could not be included in this review article have helped guide wilderness management and policy. However, social science research has evolved as a function of changes in both wilderness and society. This evolution continues through a focus on public attitudes toward adaptation to climate change, public attitudes toward restoration in wilderness to correct past human intervention, appropriate use of technology in wilderness, and issues related to the relevance of wilderness in light of changes in society and use of public lands. This article tells the story of these changes in issues and the relationship between wilderness and the American people.



Hypothetical social norm curve for the acceptability of a range of wilderness

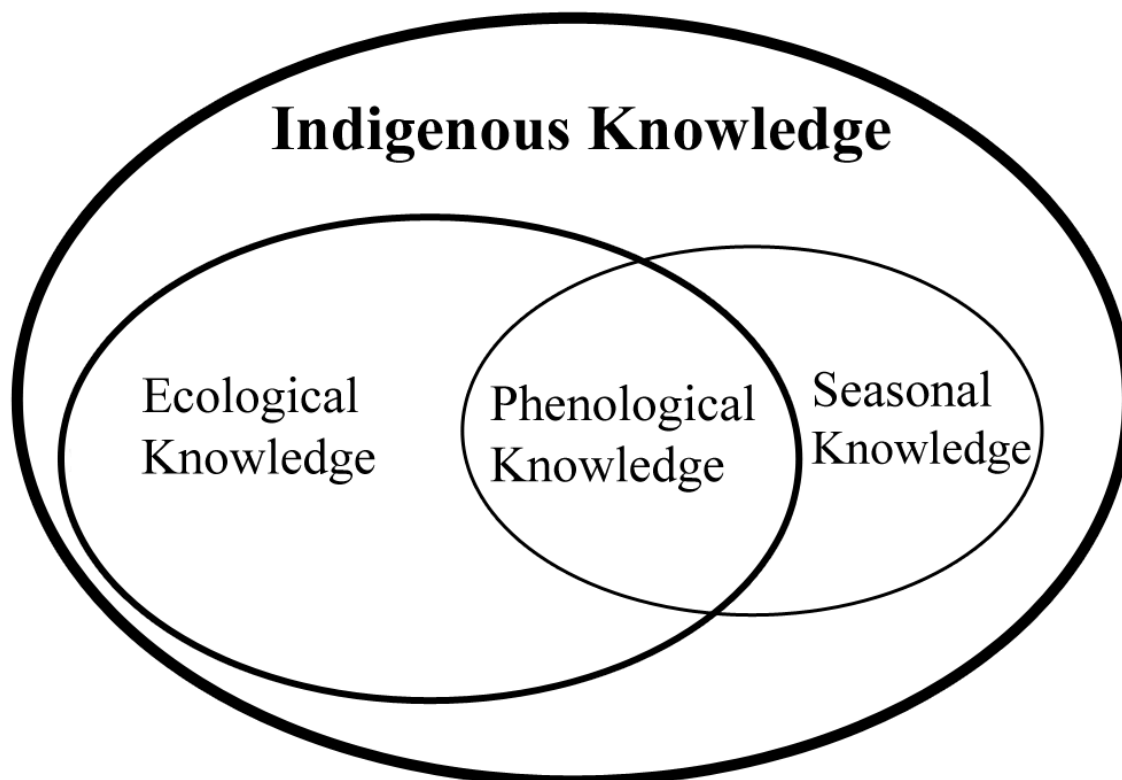


Human Dimensions

Opportunities to Utilize Traditional Phenological Knowledge to Support Adaptive Management of Social-ecological Systems Vulnerable to Changes in Climate and Fire Regimes

Christopher A. Armatas, Tyron J. Venn, Brooke B. McBride, Alan E. Watson, Steve J. Carver. *Ecology and Society* 21:16.

The field of adaptive management has been embraced by researchers and managers in the United States as an approach to improve natural resource stewardship in the face of uncertainty and complex environmental problems. Integrating multiple knowledge sources and feedback mechanisms is an important step in this approach. Our objective is to contribute to the limited literature that describes the benefits of better integrating indigenous knowledge (IK) with other sources of knowledge in making adaptive-management decisions. Specifically, we advocate the integration of traditional phenological knowledge (TPK), a subset of IK, and highlight opportunities for this knowledge to support policy and practice of adaptive management with reference to policy and practice of adapting to uncharacteristic fire regimes and climate change in the western United States.



The relationship between Indigenous knowledge and its subsets



Wilderness Character

Mapping Wilderness Character in Denali National Park and Preserve

Rob Burrows, **James Tricker**, Dan Abbe, **Peter Landres**, Jon Paynter, David Schirokauer, Philip Hooge
National Park Service Report NPS/DENA/NRR-2016/1223. Fort Collins, CO: U.S. Department of the Interior.

The recent development of an interagency strategy to monitor wilderness character allows on-the-ground managers and decision-makers to assess whether stewardship actions for an individual wilderness are fulfilling the legislative mandate to "preserve wilderness character." By using credible data that are consistently collected, one can assess how wilderness character changes over time and evaluate how stewardship actions affect trends in wilderness character. As most of these data depict spatial or geographic features in wilderness, a Geographic Information System (GIS) -based approach was developed to identify the state of wilderness character for the designated and eligible wilderness in Denali National Park and Preserve.



Wilderness Character

Mapping Threats to Wilderness in Saguaro National Park Wilderness

James Tricker, B. MacEwen, Ray O'Neil, R., Peter Landres. Report on File.

The Wilderness Act of 1964 (Public Law 88-577) established the National Wilderness Preservation System (NWPS) “for the protection of these areas, [and] the preservation of their wilderness character” (Section 2(a)). In congressional testimony clarifying the intent of wilderness designation, Howard Zahniser (1962) said, “The purpose of the Wilderness Act is to preserve the wilderness character of the areas to be included in the wilderness system, not to establish any particular use”; legal scholars (Rohlf and Honnold 1988; McCloskey 1999) subsequently confirmed that preserving wilderness character is the Act’s primary legal mandate. Furthermore, the policies of all four wilderness managing agencies state that they are to preserve wilderness character in all areas designated as wilderness. Wilderness character is an inherent part of a wilderness, and varies across the landscape just as elevation, vegetation, and other landscape features vary from one place to the next. Maps that depict how wilderness attributes vary across the landscape from least to most wild have been produced at a variety of scales: globally (Sanderson et al. 2002), continentally (Carver 2010), nationally (Aplet et al. 2000), and locally (Carver et al. 2008). Adding to this body of work, a recent study for the Death Valley Wilderness (Tricker et al. 2012; Carver et al. 2013) has provided a spatially explicit description of impacts to wilderness character for all lands falling within a particular National Park Service (NPS) wilderness. This approach has been strongly supported by the NPS, and further studies have been conducted for wildernesses within Olympic, Denali, Sequoia and Kings Canyon, and now Saguaro National Park (SAGU).

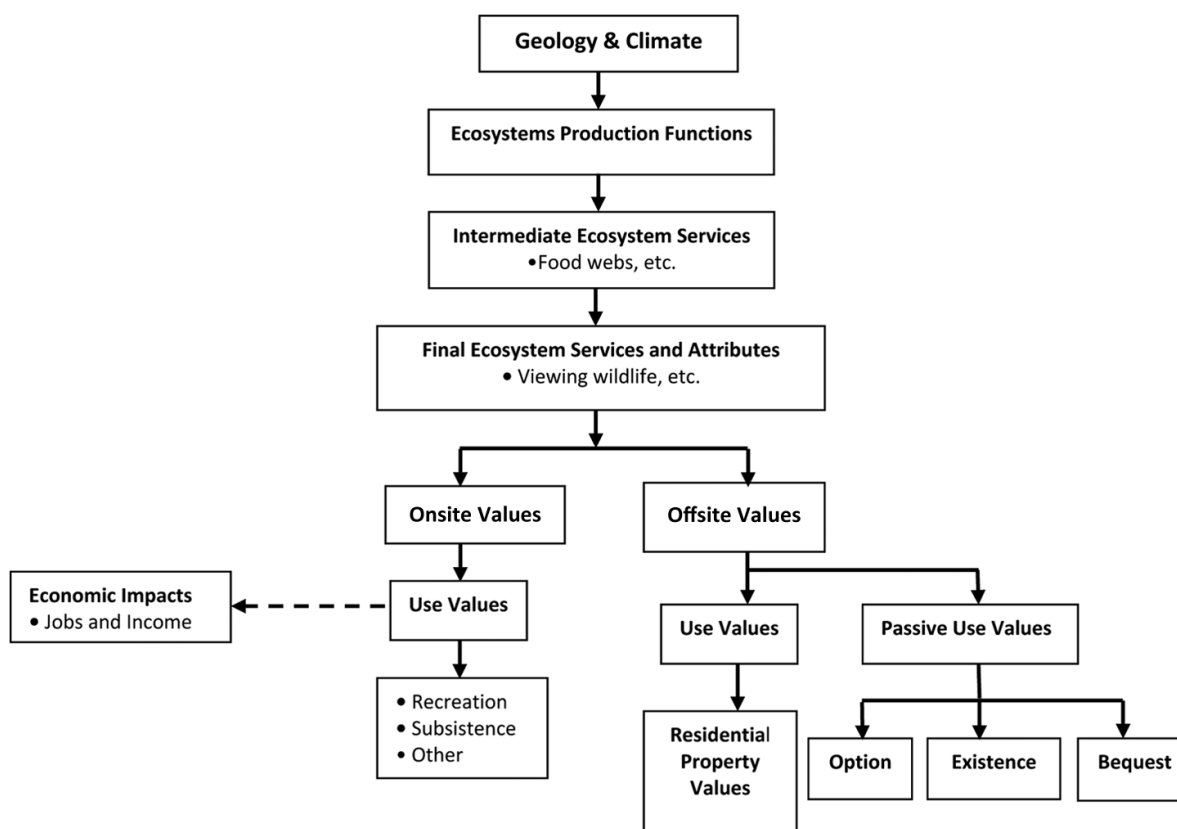


Economics

A Synthesis of the Economic Values of Wilderness

Thomas P. Holmes, J.M. Bowker, Jeffrey Englin, Evan Hjerpe, John B. Loomis, Spencer Phillips, Robert Richardson. *Journal of Forestry* 114: 320-328.

Early applications of wilderness economic research demonstrated that the values of natural amenities and commodities produced from natural areas could be measured in commensurate terms. To the surprise of many, the economic values of wilderness protection often exceeded the potential commercial values that might result from resource extraction. Here, the concepts and tools used in the economic analysis of wilderness are described, and the wilderness economic literature is reviewed with a focus on understanding trends in use, value, and economic impacts. Although our review suggests that each of these factors is trending upward, variations in research methods plus large gaps in the literature limit understanding of long-run trends. However, as new data on wilderness use, visitor origins, and spatially referenced features of landscapes are becoming increasingly available, more robust economic analysis of both onsite and offsite wilderness economic values and impacts is now becoming possible and are important to pursue.



Wilderness economic values and impacts



Recreation

A Review and Synthesis of Recreation Ecology Research Findings on Visitor Impacts to Wilderness and Protected Natural Areas

Jeffrey L. Marion, Yu-Fai Leung, Holly Eagleston, Kaitlin Burroughs. *Journal of Forestry* 114:352-362.

The 50th anniversary of the US Wilderness Act of 1964 presents a worthy opportunity to review our collective knowledge on how recreation visitation affects wilderness and protected natural area resources. Studies of recreation impacts, examined within the *recreation ecology* field of study, have spanned 80 years and generated more than 1,200 citations. This article examines the recreation ecology literature most relevant to wilderness and backcountry, with a focus on visitor impacts to vegetation, soil, wildlife, and water resources. We also review relationships with influential factors, such as the amount of use, visitor behavior, and vegetation type. An understanding of these impacts and their relationships with influential factors is necessary for land managers seeking to identify acceptable limits of impact or selecting management actions that will effectively avoid or minimize resource impacts.



Recreation

A Review and Synthesis of Recreation Ecology Research Supporting Carrying Capacity and Visitor Use Management Decisionmaking

Jeffrey L. Marion. *Journal of Forestry* 114:339-351.

Resource and experiential impacts associated with visitation to wilderness and other similar backcountry settings have long been addressed by land managers under the context of “carrying capacity” decisionmaking. Determining a maximum level of allowable use, below which high-quality resource and experiential conditions would be sustained, was an early focus in the 1960s and 1970s. However, decades of recreation ecology research have shown that the severity and areal extent of visitor impact problems are influenced by an interrelated array of use-related, environmental, and managerial factors. This complexity, with similar findings from social science research, prompted scientists and managers to develop more comprehensive carrying capacity frameworks, including a new Visitor Use Management framework. These frameworks rely on a diverse array of management strategies and actions, often termed a “management toolbox,” for resolving visitor impact problems. This article reviews the most recent and relevant recreation ecology studies that have been applied in wildland settings to avoid or minimize resource impacts. The key findings and their management implications are highlighted to support the professional management of common trail, recreation site, and wildlife impact problems. These studies illustrate the need to select from a more diverse array of impact management strategies and actions based on an evaluation of problems to identify the most influential factors that can be manipulated.



Stewardship

Manipulating the Wild: a Survey of Restoration and Management Interventions in U.S. Wilderness

Lucy Lieberman, Beth Hahn, Peter Landres. *Restoration Ecology* in press.

Landscape scale restoration is a common management intervention used around the world to combat ecological degradation. For wilderness managers in the United States, the decision to intervene is complicated by the Wilderness Act's legal mandate to preserve wilderness character and demonstrate managerial restraint (16 U.S.C. § 1131–1136). We assessed the frequency and type of management interventions, specifically actions to manage ecosystems that have occurred in the National Wilderness Preservation System between 2011 and 2015, including the specific type of intervention, the methods used, the project proponent, and the factors that influenced the decision to act. We sent an online survey to staff members at 527 wilderness units from four federal agencies that manage wilderness and found that management interventions occurred in 37% of wildernesses sampled ($n = 210$). The greatest frequency of interventions occurred in the National Park Service (75%), and the three most common interventions were vegetation treatments (46%), wildfire (35%), and wildlife restoration projects (18%). Our findings point to a need for greater transparency about information on management interventions. We recommend creating an interagency database to track information on management interventions in wilderness to better understand which actions are occurring and why; such a database could help inform wilderness stewardship decisions while demonstrating best practices for ecological restorations implemented within the constraints of the Wilderness Act.

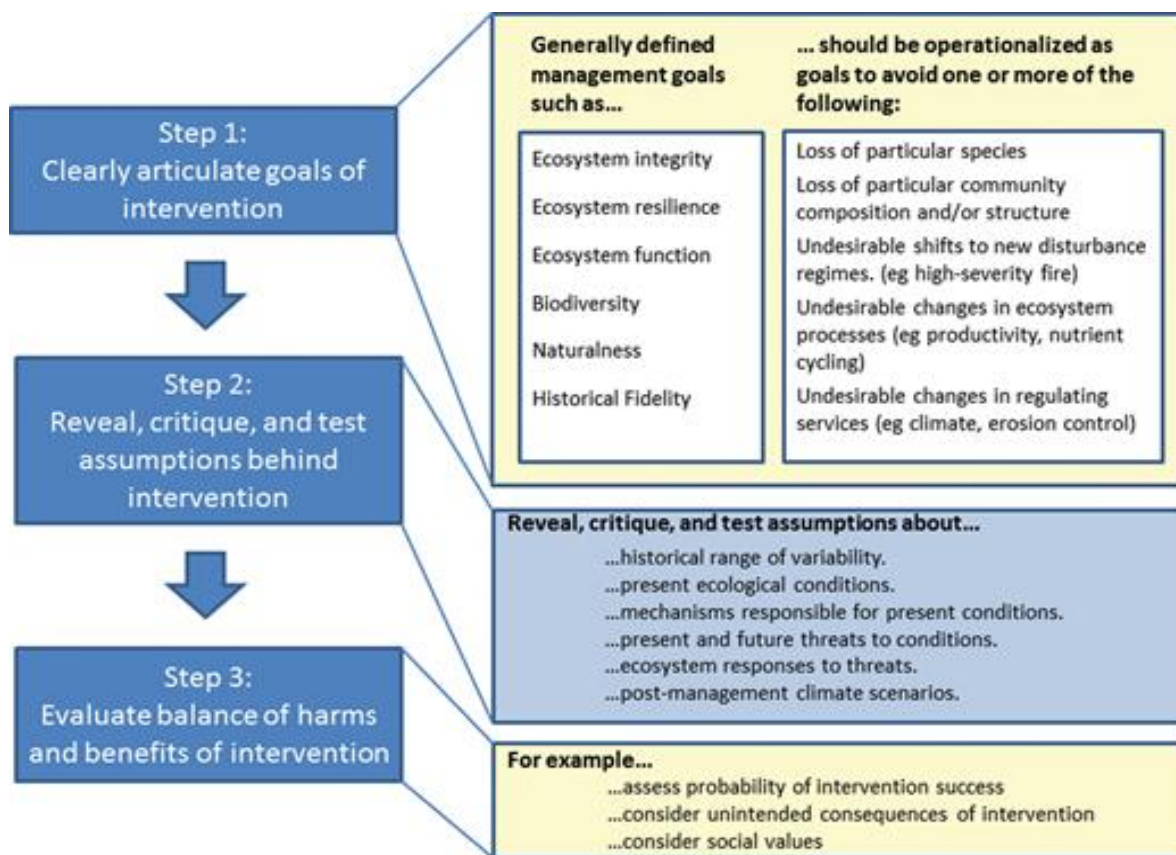


Stewardship

Wilderness in the 21st century: A framework for testing assumptions about ecological intervention in wilderness using a case study of fire ecology in the Rocky Mountains

Cameron E. Naficy, Eric G. Keeling, **Peter Landres**, Paul F. Hessburg, Thomas T. Veblen, Anna Sala. *Journal of Forestry* 114:384-395.

Changes in the climate and in key ecological processes are prompting increased debate about ecological restoration and other interventions in wilderness. The prospect of intervention in wilderness raises legal, scientific, and values-based questions about the appropriateness of possible actions. In this article, we focus on the role of science to elucidate the potential need for intervention. We review the meaning of “untrammled” from the 1964 Wilderness Act to aid our understanding of the legal context for potential interventions in wilderness. We explore the tension between restraint and active intervention in managing wilderness and introduce a framework for testing ecological assumptions when evaluating restoration proposals. We illustrate use of the framework in the restoration of fire regimes and fuel conditions in ponderosa pine and mixed-conifer forests of the US Rocky Mountains. Even in this relatively well-studied example, we find that the assumptions underlying proposed interventions in wilderness need to be critically evaluated and tested before new, more intensive management paradigms are embraced.



Stewardship

A Mental Model of Science Informed by Public Lands Managers: Increasing the Chances for Management Based on Science

Alan E. Watson, Christopher A. Armatas. *Journal of Contemporary Management* 8:1-17.

Some federal public lands have been legally protected as “wilderness areas” since 1964 in the US. A federal science program evolved first in response to a novel public lands management concept, and subsequently in response to new issues that emerged both as society changed and more knowledge about social and ecological values of wilderness accumulated. Wilderness science needs have largely been defined by government and cooperating academic scientists through identification of researchable questions which, historically, have centered on science disciplines, wilderness attributes, or threats to these attributes. Analysis of a survey of 368 federal wilderness managers demonstrates how management can inform science. From over 1200 responses, a mental map of research needs, prioritized by the purpose of the research, led to proposal of 5 major strategic science planning dimensions: (1) basic research to understand effects of various threats; (2) integrated research on “big” emerging issues that lend themselves to larger than wilderness issues; (3) applied research to evaluate stewardship effectiveness; (4) applied research to support stewardship tool development and; (5) applied research to support inventory and monitoring. A strategic science plan that identifies targets according to this mental model will increase likelihood of science being used to guide management.



Stewardship

Wilderness Stewardship in America Today and What We Can Do to Improve It

Ken Cordell, Chris Barns, David Brownlie, Tom Carlson, Chad Dawson, William Koch, Garry Oye, Chris Ryan.
Journal of Forestry 114:292-297.

The authors of this article are recently retired wilderness professionals from universities or federal agencies. We were asked to share our observations about how wilderness stewardship is being managed in America today. We based our observations on our many years of combined professional wilderness career experience as managers, trainers, scientists, educators, and other careers. Combined, the authors have worked 308 years generally in natural resources and 236 years in wilderness specifically. All of us have had challenging management or research duties related to wilderness stewardship. For this article, wilderness refers specifically to the National Wilderness Preservation System (NWPS). We as coauthors were invited to share our thoughts about wilderness management today because it was thought that our group would have some unique insights. With the years of experience in various positions in the federal agencies and affiliated universities, we hope that our combined experience lends credibility to our assessing the status of the NWPS. In the process of conceptualizing this article, a number of wilderness stewardship challenges were identified. Some examples of these challenges are briefly listed below. Of those identified by the coauthors, we selected five that we thought are the most significant overarching challenges. These five are subsequently described and our expert opinions on potential ways to address them are offered.



Stewardship

Boundary Waters Canoe Area Wilderness – A Long History of Management Guided by Science

David Cole. *Journal of Forestry* 114:363-364.

The Boundary Waters Canoe Area Wilderness (BWCAW) in northern Minnesota is one of the most iconic and cherished wilderness areas in the United States. One of the original wilderness areas established in 1964, the BWCAW protects a glaciated landscape of about 1,175 lakes, connected by several hundred miles of streams. Located adjacent to Canada's Quetico Provincial Park (also managed as wilderness), the two areas form a transboundary wilderness of about 2 million acres. Among the most heavily used wilderness areas in the United States (Cole 1996), most travel is by canoe, although motorized boating is allowed on a few lakes, and some hiking occurs. One of the unique things about the BWCAW—and something few people are aware of—is that more pioneering wilderness science has been conducted there than anywhere else in the United States. The purpose of this case study is to describe the role the BWCAW played in the early development of wilderness science and to show how some of the science conducted there has contributed to good wilderness stewardship.



Stewardship

Evaluating Effectiveness of IUCN Protected Area Management Category 1b Sites

Sarah A. Casson, Vance G. Martin, **Alan Watson**, Angie Stringer, Cyril F. Kormos. In *Wilderness Protected Areas: Management Guidelines for IUCN Category 1b Protected Areas*, IUCN.

Wilderness decision makers should evaluate the ability of a wilderness protected area to conserve the site's wilderness attributes and values. It is crucial to know if a site can meet its ecological and social objectives. Wilderness decision makers should use best-practices tools and robust monitoring frameworks to evaluate whether the full range of wilderness attributes are being protected. To understand and protect wilderness areas, managers need to be able to measure what they are trying to conserve. Evaluating the ecological and social effectiveness of wilderness areas allows wilderness decision makers to better facilitate appropriate, targeted management action at both local and national levels to improve efficiency and effectiveness of conservation action (including future site designation). Evaluation of wilderness areas' effectiveness provides opportunities to learn from and respond to conservation successes, failures or inadequacies.



Wildlife

Where the Wild Things Are: A Research Agenda for Studying the Wildlife-Wilderness Relationship

Michael K. Schwartz, **Beth A. Hahn**, **Blake R. Hossack**. *Journal of Forestry* 114: 311-319.

We explore the connection between US designated wilderness areas and wildlife with the goal of establishing a research agenda for better understanding this complex relationship. Our research agenda has two components. The first part of our agenda considers, “wildlife for wilderness,” considering the impact of wildlife on wilderness character. Whereas studies show that wildlife is important in both the perception and actual enhancement of wilderness character, the context and particulars of this relationship have not been evaluated. For instance, is knowing that a rare, native species is present in a wilderness area enough to increase perceptions of naturalness or does the public need to observe the species or its sign (e.g., tracks) for this benefit? The second part of our research agenda, “wilderness for wildlife,” considers the types of research needed to understand the impact of wilderness areas on wildlife and biodiversity conservation. Several studies show the effect of one area being designated wilderness on one wildlife species. Yet, there has been no research that examines how the networks of wilderness areas in the National Wilderness Preservation System (NWPS) are used by a species or a community of species. Furthermore, we found no studies that focused on how the NWPS affects ecological or trophic interactions among species. We hope that by providing a research agenda, we can spur multiple lines of research on the important topic of wildlife and wilderness.

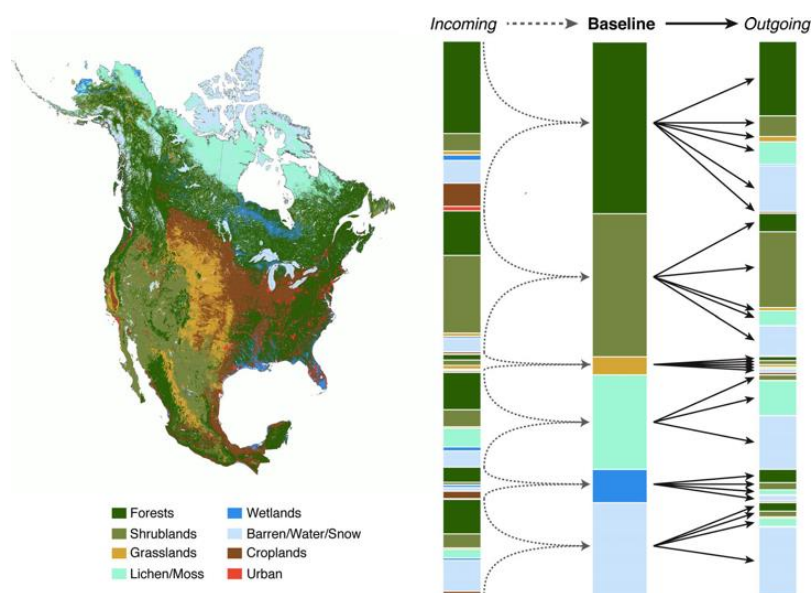


Climate Change

Potential Relocation of Climatic Environments Suggests High Rates of Climate Displacement within the North American Protection Network

Enric Batllori, Marc-André Parisien, **Sean A. Parks**, Max A. Moritz, **Carol Miller**. *Global Change Biology* 23:3219-3230.

Ongoing climate change may undermine the effectiveness of protected area networks in preserving the set of biotic components and ecological processes they harbor, thereby jeopardizing their conservation capacity into the future. Metrics of climate change, particularly rates and spatial patterns of climatic alteration, can help assess potential threats. Here, we perform a continent-wide climate change vulnerability assessment whereby we compare the baseline climate of the protected area network in North America (Canada, United States, México—NAM) to the projected end-of-century climate (2071–2100). We estimated the projected pace at which climatic conditions may redistribute across NAM (i.e., climate velocity), and identified future nearest climate analogs to quantify patterns of climate relocation within, among, and outside protected areas. Our analysis suggests that the conservation capacity of the NAM protection network is likely to be severely compromised by a changing climate. The majority of protected areas (~80%) might be exposed to high rates of climate displacement that could promote important shifts in species abundance or distribution. A small fraction of protected areas (<10%) could be critical for future conservation plans, as they will host climates that represent analogs of conditions currently characterizing almost a fifth of the protected areas across NAM. However, the majority of nearest climatic analogs for protected areas are in nonprotected locations. Therefore, unprotected landscapes could pose additional threats, beyond climate forcing itself, as sensitive biota may have to migrate farther than what is prescribed by the climate velocity to reach a protected area destination. To mitigate future threats to the conservation capacity of the NAM protected area network, conservation plans will need to capitalize on opportunities provided by the existing availability of natural land-cover types outside the current network of NAM protected areas.



Current land cover distribution, with projections of where incoming and outgoing land-cover types may occur.

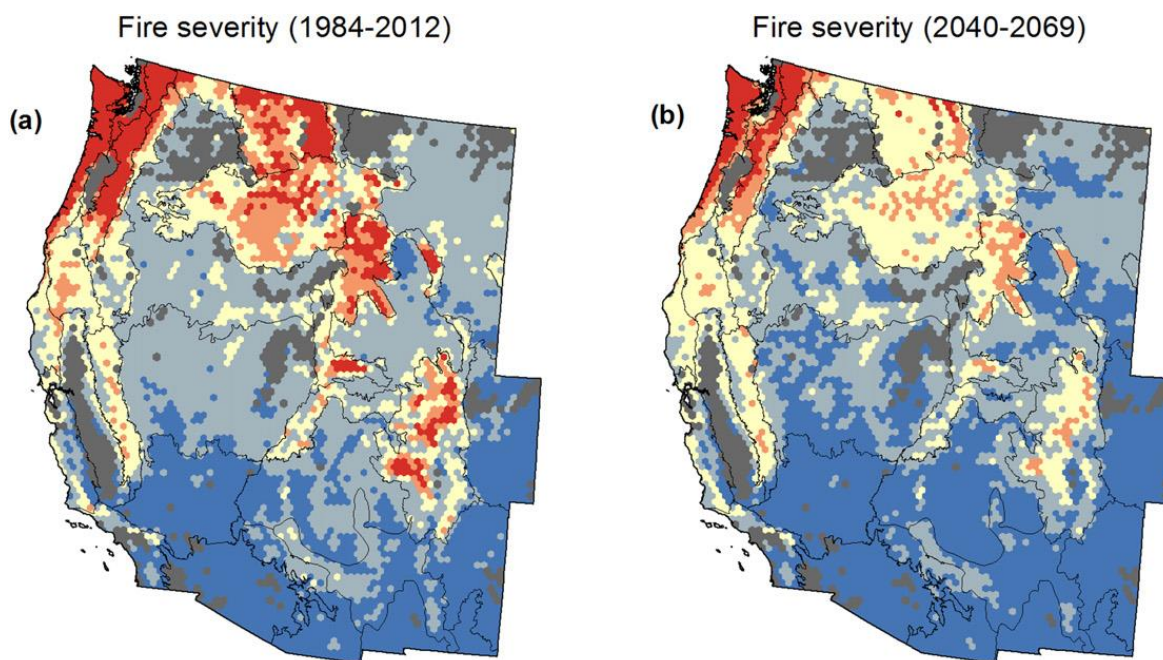


Climate Change

How will Climate Change Affect Wildland Fire Severity in the Western US?

Sean A. Parks, Carol Miller, John T Abatzoglou, Lisa M. Holsinger, Marc-André Parisien, Solomon Z. Dobrowski. Environmental Research Letters 11:035002.

Fire regime characteristics in North America are expected to change over the next several decades as a result of anthropogenic climate change. Although some fire regime characteristics (e.g., area burned and fire season length) are relatively well-studied in the context of a changing climate, fire severity has received less attention. In this study, we used observed data from 1984 to 2012 for the western United States (US) to build a statistical model of fire severity as a function of climate. We then applied this model to several ($n = 20$) climate change projections representing mid-century (2040–2069) conditions under the RCP 8.5 scenario. Model predictions suggest widespread reduction in fire severity for large portions of the western US. However, our model implicitly incorporates climate-induced changes in vegetation type, fuel load, and fire frequency. As such, our predictions are best interpreted as a potential reduction in fire severity, a potential that may not be realized due human-induced disequilibrium between plant communities and climate. Consequently, to realize the reductions in fire severity predicted in this study, land managers in the western US could facilitate the transition of plant communities towards a state of equilibrium with the emerging climate through means such as active restoration treatments (e.g., mechanical thinning and prescribed fire) and passive restoration strategies like managed natural fire (under suitable weather conditions). Resisting changes in vegetation composition and fuel load via activities such as aggressive fire suppression will amplify disequilibrium conditions and will likely result in increased fire severity in future decades because fuel loads will increase as the climate warms and fire danger becomes more extreme. The results of our study provide insights to the pros and cons of resisting or facilitating change in vegetation composition and fuel load in the context of a changing climate.



Predicted fire severity under observed (a) and projected mid-century (b) climate conditions



Climate Change

Evaluating future success of whitebark pine ecosystem restoration under climate change using simulation modeling

Robert E. Keane, **Lisa M. Holsinger**, Mary F. Mahalovich, Diana F. Tomback. *Restoration Ecology* 25:220-233.

Major declines of whitebark pine forests throughout western North America from the combined effects of mountain pine beetle (*Dendroctonus ponderosae*) outbreaks, fire exclusion policies, and the exotic disease white pine blister rust (WPBR) have spurred many restoration actions. However, projected future warming and drying may further exacerbate the species' decline and possibly compromise long-term success of today's restoration activities. We evaluated successes of restoration treatments under future climate using a comprehensive landscape simulation experiment. The spatially explicit, ecological process model FireBGCv2 was used to simulate whitebark pine populations on two U.S. Northern Rocky Mountain landscapes over 95 years under two climate, three restoration, and two fire management scenarios. Major findings were that (1) whitebark pine can remain on some high mountain landscapes in a future climate albeit at lower basal areas (50% decrease), (2) restoration efforts, such as thinning and prescribed burning, are vital to ensure future whitebark pine forests, and (3) climate change impacts on whitebark pine vary by local setting. Whitebark pine restoration efforts will mostly be successful in the future but only if future populations are somewhat resistant to WPBR. Results were used to develop general guidelines that address climate change impacts for planning, designing, implementing, and evaluating fine-scale restoration activities.

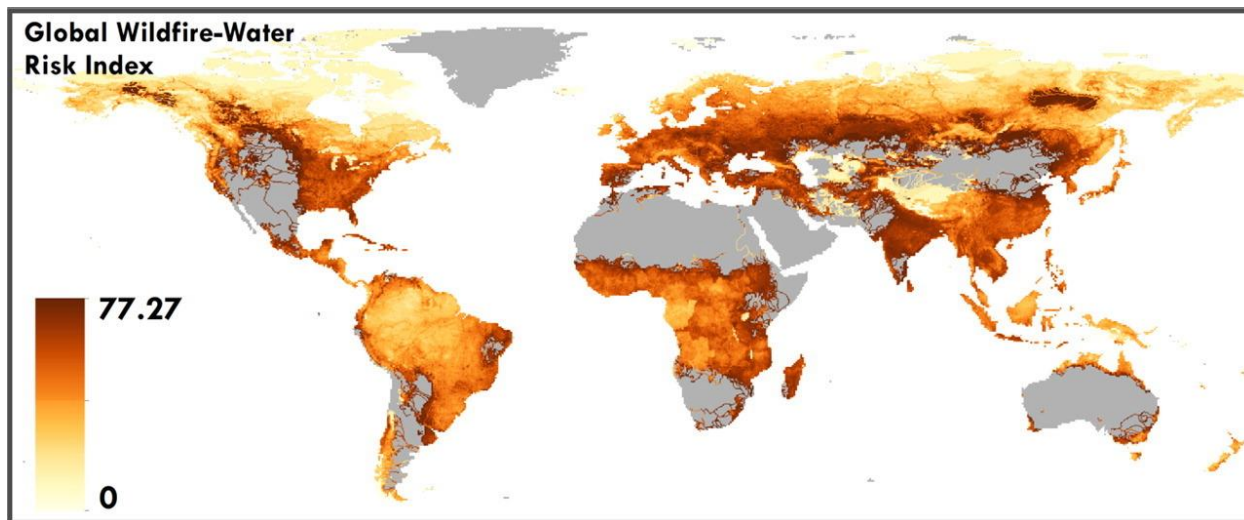


Climate Change

A Spatial Evaluation of Global Wildfire-Water Risks to Human and Natural Systems

François-Nicolas Robinne, Kevin D. Bladon, **Carol Miller**, Marc-André Parisien, Jérôme Mathieu, Mike D. Flannigan. *Science of the Total Environment* 610-611:1193-1206.

The large amount of media coverage of recent massive wildfires across the world has emphasized the vulnerability of freshwater resources. The extensive hydrogeomorphic effects from a wildfire can impair the ability of watersheds to provide safe drinking water to downstream communities and high-quality water to maintain riverine ecosystem health. Safeguarding water use for human activities and ecosystems is required for sustainable development; however, no global assessment of wildfire impacts on water supply is currently available. Here, we provide the first global evaluation of wildfire risks to water security, in the form of a spatially explicit index. We adapted the Driving forces-Pressure-State-Impact-Response risk analysis framework to select a comprehensive set of indicators of fire activity and water availability, which we then aggregated to a single index of wildfire-water risk using a simple additive weighted model. Our results show that water security in many regions of the world is potentially vulnerable, regardless of socio-economic status. However, in developing countries, a critical component of the risk is the lack of socio-economic capability to respond to disasters. Our work highlights the importance of addressing wildfire-induced risks in the development of water security policies; the geographic differences in the components of the overall risk could help adapting those policies to different regional contexts.



Publications	Year	Author(s)
A Global Index for Mapping the Exposure of Water Resources to Wildfire	2016	Robinne, F.-N.; Miller, C.; Parisien, M.-A.; Emelko, M.B.; Bladon, K.D.; Silins, U.; Flannigan, M
Opportunities to utilize traditional phenological knowledge to support adaptive management of social-ecological systems vulnerable to changes in climate and fire regimes	2016	Armatas, C. A., T. J. Venn, B. B. McBride, A. E. Watson, and S. J. Carver
Boundary Waters Canoe Area Wilderness – A Long History of Management Guided by Science	2016	Cole, D.
The US Wilderness Managers Survey: Charting a Path for the Future.	2016	Dawson, Chad, Cordell, Ken, Watson, Alan E., Ghimire, Ramesh, Green, Gary T
Science Informs Stewardship: Committing to a National Wilderness Science Agenda	2016	Fox, Hahn
A Synthesis of the Economic Values of Wilderness	2016	Holmes, T., Bowker, J.M., Englin, J., Hjerpe, E., Loomis, J., Phillips, S., Richardson, R.
Wilderness Stewardship in America Today and What We Can Do to Improve It	2016	Cordell, K., Barns, C., Brownlie, D., Carlson, T., Dawson, C., Koch, W., Oye, G., Ryan, C.
A Review and Synthesis of Recreation Ecology Research Supporting Carrying Capacity and Visitor Use Management Decisionmaking	2016	Marion, Jeffrey L.
Maintaining Relevancy: Implications of Changing Societal Connections to Wilderness for Stewardship Agencies	2016	McCool, S., Freimund, W.
Progress in Wilderness Fire Science: Embracing Complexity	2016	Miller, Carol, Aplet, Gregory H
Wilderness in the 21st Century: A Framework for Testing Assumptions about Ecological Intervention in Wilderness Using a Case Study of Fire Ecology in the Rocky Mountains	2016	Naficy, Cameron E., Keeling, Eric G., Landres, Peter, Hessburg, Paul F., Veblen, Thomas T., Sala, Anna.
Where the Wild Things Are: A Research Agenda for Studying the Wildlife-Wilderness Relationship	2016	Schwartz, Michael K., Hahn, Beth A., Hossack, Blake R.
The Evolution of Wilderness Social Science and Future Research to Protect Experiences, Resources, and Societal Benefits	2016	Watson, Alan E., Cordell, Ken, Manning, Robert, Martin, Steven
Technology Brings New Challenges to Wilderness Managers: An Example from the Bureau of Land Management- Managed Lost Coast of California	2016	Wick, R.
Understanding social–ecological vulnerability with Q-methodology: a case study of water-based ecosystem services in Wyoming, USA	2016	Armatas, Christopher, Venn, Tyron, Watson, Alan



Publications	Year	Author(s)
Participatory Geographic Information Systems as an Organizational Platform for the Integration of Traditional and Scientific Knowledge in Contemporary Fire and Fuels Management	2017	McBride, BB, Sanchez-Trigueros, F, Carver, S, Watson, A, Moon, L, Stumpff, Matt, R, Borrie, W
The US Wilderness Managers Survey: Charting a Path for the Future.	2016	Dawson, C., Cordell, K., Watson, A., Ghimire, R., Green, G
Potential Relocation of climatic environments suggests high rates of climate displacement within the North American protection network	2017	Batllori E, Parisien MA, Parks SA, Moritz MA, Miller C
Overlapping Land Claims Limit the Use of Satellites to Monitor No-Deforestation Commitments and No-Burning Compliance	2017	Gaveau DL, Pirard R, Salim MA, Tonoto P, Yaen H, Parks SA, Carmenta R
Beyond Fuel Treatment Effectiveness: Characterizing Interactions between Fire and Treatments in the US	2016	Barnett K, Parks SA, Miller C, Naughton HT
Influences of Prior Wildfires on Vegetation Response to Subsequent Fire in a Reburned Southwestern Landscape	2016	Coop JD, Parks SA, McClernan SR, Holsinger LM
A Mental Model of Science Informed by Public Lands Managers: Increasing the Chances for Management Based on Science	2017	Watson, A., Armatas, C.
A Review and Synthesis of Recreation Ecology Research Findings on Visitor Impacts to Wilderness and Protected Natural Areas	2016	Marion, J. L., Leung, Y. F., Eagleston, H., & Burroughs, K.
Evaluating effectiveness of IUCN protected area management Category 1b sites. Pages 136-140 in IUCN Wilderness Protected Areas: Management Guidelines for IUCN Category 1b Protected Areas	2016	Casson, Sarah A.; Martin, Vance G., Watson, Alan, Stringer, Angie, and Kormos, Cyril F.,
Using risk analysis to reveal opportunities for the management of unplanned ignitions in wilderness	2016	Barnett, K; Miller, C; Venn TJ.
Topographic and fire weather controls of contemporary fire refugia in forested ecosystems of northwestern North America	2016	Krawchuk, MA; Haire, S; Coop, J; Parisien, MA; Whitman, E; Chong, G; Miller, C.
Characterizing spatial neighborhoods of refugia following large fires in northern New Mexico, USA. Land 2017, 6, 19.	2017	Haire, SL; Coop, JD; Miller, C.
Wildland fire limits subsequent fire occurrence	2016	Parks SA, Miller C, Holsinger LM, Baggett LS, Bird BJ
How will climate change affect wildland fire severity in the western US?	2016	Parks SA, Miller C, Abatzoglou JT, Holsinger LM, Parisien M-A, Dobrowski SZ
Mapping wilderness character in Denali National Park and Preserve.	2016	Burrows, R., J. Tricker, D. Abbe, P. Landres, J. Paynter, D. Schirokauer, and P. Hooge.
"Weather, fuels, and topography impede wildland fire spread in western US landscapes	2016	Holsinger L, Parks SA, Miller C.



Publications	Year	Author(s)
Evaluating future success of whitebark pine ecosystem restoration under climate change using simulation modeling	2016	Keane RE, Holsinger LM, Mahalovich MF, Tomback, DF.
Effects of climate change on forest vegetation in the Northern Rockies. Chapter 5 in Climate Change and Rocky Mountain Ecosystems	2017	Keane RE, Mahalovich MF, Bolenbocher BL, Manning ME, Loehman RA, Jain TB, Holsinger LM, Larson AJ.
Analog-based fire regime and vegetation shifts in mountainous regions of the western US	2017	Loehman RA, Keane RE, Holsinger LM, Wu Zhiwei
Analog-based fire regime and vegetation shifts in mountainous regions of the western US	2017	Parks SA, Holsinger LM, Miller C, Parisien M.
A spatial evaluation of global wildfire-water risks to human and natural systems	2018	Robinne, FN; Bladon, KD; Miller, C; Parisien, MA; Mathieu, J; Flannigan, MD
Mapping wilderness character in the Boundary Waters Canoe Area Wilderness	2017	Tricker, J., A. Schwaller, T. Hanson, E. Mejicano, P. Landres
Climate change velocity underestimates climate change exposure in mountainous regions	2016	Dobrowski SZ, Parks SA
The spatially varying influence of humans on fire probability in North America	2016	Parisien MA, Miller C, Parks SA, DeLancey ER, Robinne FN, Flannigan MD
Wildland fire deficit and surplus in the western United States	2016	Parks SA, Miller C, Parisien, M-A, Holsinger LM, Dobrowski SZ, Abatzoglou JT
Mapping threats to wilderness in the Saguaro National Park Wilderness	2016	Tricker, J., B. MacEwen, R. O'Neil, and P. Landres
Wilderness in the 21st century: A framework for testing assumptions about ecological intervention in wilderness using a case study of fire ecology in the Rocky Mountains.	2016	Naficy, C., E. Keeling, P. Landres, P. Hessburg, T. Veblen, and A. Sala

