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A Perpetual Flow of Benefits: Wilderness Economic Values in an Evolving, Multicultural Society

Thomas P. Holmes, Editor

Abstract

Wilderness is a culturally constructed concept that evolves over time with changes in socioeconomic, technological, demographic, and political conditions. Societal transformations, including growth of minority and underserved populations along with greater calls for environmental justice, in combination with changes in climatic variables (e.g., temperature and precipitation) and natural disturbances (e.g., wildfires, droughts, and invasive species) are creating new challenges for wilderness management agencies. This report provides up-to-date knowledge on societal benefits and ecosystem service values provided by wilderness and associated wildlands while also suggesting research directions that can help policymakers better understand social values and tradeoffs inherent in the allocation of resources to support wilderness preservation and management.

Keywords: Anthropocene, benefit-cost analysis, cultural values, economic values, ecosystem services, public preferences, wildlands.

Cover Photographs: clockwise: Noatak Wilderness (5,814,000 total acres) in Alaska was designated in 1980 and is administered by the National Park Service. (Courtesy photo by Nyssa Landres); Cache Creek Wilderness (27,296 total acres) in California was designated in 2006 and is administered by the Bureau of Land Management. (Courtesy photo by Bob Wick); Lake Mead National Recreation Area in Nevada contains nine wilderness areas (242,391 total acres) that were designated in 2002 and are administered by the National Park Service. (Courtesy photo by Tim Devine); Joseph Battell Wilderness (12,336 total acres) in Vermont was designated in 2006 and is administered by the Forest Service. (Courtesy photo by wilderness.net/Ken Norden).

The Aldo Leopold Wilderness Research Institute operates under a Memorandum of Understanding among the Forest Service, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and U.S. Geological Survey.

A Perpetual Flow of Benefits: Wilderness Economic Values in an Evolving, Multicultural Society

by the Wilderness Economics Working Group of the Aldo Leopold Wilderness Research Institute
Rocky Mountain Research Station, U.S. Department of Agriculture, Forest Service

Thomas P. Holmes, Editor

Sangre de Cristo Wilderness (219,899 total acres) in Colorado was designated in 1993 and is administered by the Forest Service and the National Park Service. (Courtesy photo by wilderness.net)

Cadiz Dunes Wilderness (19,935 total acres) in California was designated in 1994 and is administered by the Bureau of Land Management. (Bureau of Land Management photo by Bob Wick)

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Acknowledgments

The Aldo Leopold Wilderness Research Institute would like to thank Dr. Tom Holmes, Emeritus Scientist with the U.S. Department of Agriculture, Forest Service, for leading this important work. The Wilderness Economics Working Group's contributions took considerable time and were completed with a modest budget over 5 years. The group's success is, in large part, due to Dr. Holmes' passion, dedication, and commitment. We would also like to thank the report's many authors and coauthors for their extensive contributions.

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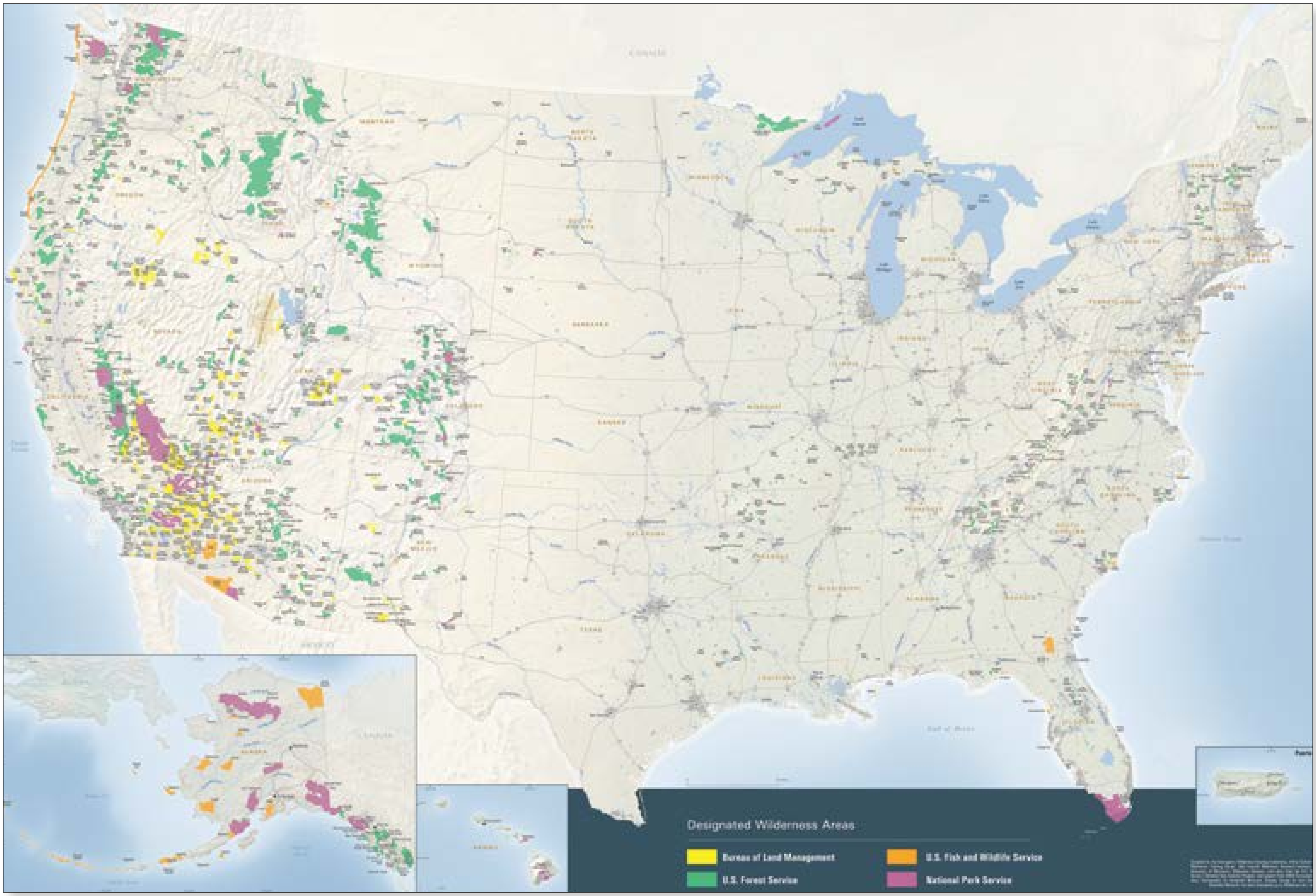
Preface

The Wilderness Act was signed into law in 1964. As presented in this report, "the socioeconomic character of American society has dramatically changed [in the decades since], necessitating a comprehensive assessment of the benefits provided by wilderness and how wilderness values are evolving." To meet this need, in 2014, when the Wilderness Act celebrated its 50th anniversary, the Aldo Leopold Wilderness Research Institute convened a working group of economists, social scientists, conservation biologists, wilderness managers, and others to undertake an assessment of wilderness benefits beginning with the question: What benefits do Americans derive from federally designated wilderness, those lands with highest level of protection of all federally managed lands in the United States?

The Wilderness Economics Working Group included scientists from the Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, and U.S. Geological Survey of the U.S. Department of the Interior; the Forest Service of the U.S. Department of Agriculture; several universities; and private industry. This report, an outcome of the working group, provides important progress in assessing the state and benefits of America's National Wilderness Preservation System and identifies priority needs and opportunities for additional investigation.

It is our hope that the work presented in this report, collectively, helps the American people better understand many of the benefits that federally designated wilderness lands provide, and also, that it serves as a resource for Federal managers, as well as Tribal, nongovernmental, and other managers and scientists, in their efforts to steward wilderness and wildlands protected areas in the United States and internationally.

— **Jason Taylor** and **Susan Fox** (retired),
Directors, Aldo Leopold Wilderness Research Institute



The National Wilderness Preservation System. (https://winapps.umt.edu/winapps/media2/wilderness/NWPS/documents/NationalWildernessPreservationMap_2019.pdf)

Executive Summary

"The Wilderness Bill preserves for our posterity, for all time to come, 9 million acres of this vast continent in their original and unchanging beauty and wonder."

— President Lyndon B. Johnson

President Lyndon B. Johnson signing the Wilderness Act into law on September 3, 1964. (National Park Service photo by Abbie Rowe)

Gates of the Arctic Wilderness (7,154,000 total acres) in Alaska was designated in 1980 and is administered by the National Park Service. (National Park Service photo by Nyssa Landres)

America looks much different now than it did in the years leading up to the signing of the Wilderness Act. Policymakers are facing new questions regarding the best, just and equitable uses of public lands, including Federal wilderness. New challenges for public land management are also being driven by climate change, which is altering ecosystem service provision, demand, and value within wilderness and comparable wildlands. Complex policy decisions benefit from unbiased information, and economic analysis can help policymakers better understand tradeoffs inherent in decisions regarding the valuation, allocation, and management of wilderness and wildland resources.

Non-Hispanic Whites made up more than 80 percent of the population upon signing of the Wilderness Act in 1964. However, Americans are now more ethnically and racially diverse. If recent trends continue, it is anticipated that within approximately two decades, no racial or ethnic group will constitute a majority of the U.S. population. The baby boomer generation (born roughly 1945–1965) was the largest generation in U.S. history but has been recently passed by millennials as the most populous generation. Leisure time trended upwards in the decades following signing of the Act, and per capita time spent in outdoor recreation doubled between 1965 and 2007, primarily driven by increases in participation rates. While participation in nature-based recreation (a subset of outdoor recreation) continued to increase during the first two decades of the 20th century, the amount of time participants spent pursuing nature-based recreation steadily decreased. Some have attributed this trend to the proliferation of electronic media and other leisure-oriented technologies that provide new alternatives for how leisure time is spent.

In 2014, when the Wilderness Act celebrated its 50th anniversary, the Aldo Leopold Wilderness Research Institute (ALWRI) convened the Wilderness Economics Working Group (WEWG), consisting of economists, social scientists, conservation biologists, wilderness managers, and wilderness advocates, who came together to investigate the evolving benefits of wilderness and related issues within an interdisciplinary framework. The work shared in this report was inspired by WEWG members and colleagues (see Acknowledgments) at workshops held in Shepherdstown, WV, and Fort Collins, CO.

Paria Canyon-Vermilion Cliffs Wilderness (110,816 total acres) in Arizona and Utah was designated in 1984 and is administered by the Bureau of Land Management. (Bureau of Land Management photo by Bob Wick)

Research results provided by members of WEWG, and detailed in chapters of this report, illustrate the coevolution of American society with an expanding constellation of social, economic, and cultural values provided by designated wilderness and comparable wildlands. Some of the highlights include:

- From 1980 to 2010, rates of population growth in rural western U.S. counties with wilderness were several times greater than rates observed in rural nonwilderness counties.
- Many wilderness areas are near large and expanding urban areas. For example, Charlotte, NC, has 21 wilderness areas within a 1-day drive (150 miles), and all but three large western cities (>500,000 people) have at least 20 wilderness areas accessible within 1 day (Las Vegas, NV, has >100).
- Recreational use of wilderness is growing rapidly. Although regional variations exist, recent data show that overall wilderness use increased at a rate exceeding general population growth by a factor of 3. Most of the increase in wilderness visits occurred in the western part of the country, especially the southwestern region. Wilderness visits in the eastern and southern regions have been declining.
- The proportion of wilderness visits by non-Hispanic Whites has dropped while large upward shifts in wilderness visits by non-Hispanic Asian/Pacific Islanders, Hispanics, and those identifying as "other" were observed.
- Hiking is the most popular primary activity in wilderness. Recent data show that day trips account for most wilderness visits, less than 20 percent of site visits exceed 12 hours, and backpacking accounts for about 6 percent of site visits.
- The economic value (consumer surplus) per wilderness trip, estimated using travel cost demand models and national forest data, exceeds the economic value of other types of recreational use.
- A disproportionately high percentage of the Nation's water supply of surface freshwater flows from wilderness versus other land uses. Watersheds with a higher percentage of

Middle Prong Wilderness (7,482 total acres) in North Carolina was designated in 1984 and is administered by the Forest Service. (Courtesy photo by wilderness.net/Jack Henderson)

water originating in wilderness tend to lie along major mountain ranges—the Rocky Mountains, the Sierra Nevadas, and the Cascades in the West; the Appalachian Mountains, which span much of the length of the east coast; and the Boston Mountains in Arkansas.

- Wilderness areas sequester carbon at a rate that is roughly equivalent to the rate of carbon sequestration on all other lands managed by Federal land management agencies. Using the best available estimates of the social value of carbon, the average annual economic value of carbon sequestered in the National Wilderness Preservation System in the conterminous United States is about $2.2 billion.
- A growing societal awareness of the need for environmental justice for Native Americans has led to new strategies in the use of wilderness designations and practices that support Tribal cultural values on Federal land. New wilderness models are being tested on Federal and Tribal lands that extend across cultures and spatially connected landscapes.

Each of these factors has implications for wilderness policy and are bringing novel challenges to wilderness management. Additional challenges are being driven by the unprecedented rate and scale of anthropogenic forces imposed upon climatic, physical, and biological systems that have pushed the Earth into a novel geological epoch referred to as the Anthropocene. Although the Wilderness Act accommodates many potential management actions that support climate change adaptation, the degree to which wilderness and other wildlands should be managed in response to anthropogenically induced stress is controversial and depends upon societal objectives and values. Proactive wilderness management strategies are being informed by scientific and traditional (including Indigenous) ecological knowledge. Economic analysis can help policymakers better understand societal values and tradeoffs inherent in the allocation of resources to support wilderness ecosystem services as well as strategies that promote wilderness adaptation to climate change.

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Accounting for Wilderness Economic Values in a Historical, Cultural, and Social Context

Thomas P. Holmes

King Range Wilderness (42,695 total acres) in California was designated in 2006 and is administered by the Bureau of Land Management. (Bureau of Land Management photo by Bob Wick)

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KEY MESSAGES

- Wilderness is a culturally constructed concept that evolves over time in response to socioeconomic, demographic, technological, and political changes. During the 18th century, a revolutionary intellectual doctrine emerged in Northern Europe that regarded wild landscapes as sublime. The doctrine of the sublime was cultivated in 19th century America by Romantic artists, writers, and philosophers and was infused with a frontier ethos of rugged individualism to create a uniquely American vision of wilderness. Rapid economic development during the 20th century, and the concomitant widespread destruction of wildlands, led to a growing public awareness of the scope of high-value natural assets at risk of being lost forever, ultimately resulting in the passage of the Wilderness Act. Although Euro-American conceptions of wilderness largely eclipsed values inherent in Indigenous cultural landscapes that were occupied and tended as homelands for countless generations, calls for environmental justice by Native Americans during the 21st century are influencing Federal wilderness policy, and the American wilderness vision is continuing to evolve.

- The Wilderness Act provided the American public with a natural endowment of extraordinary value and the legislative means to protect and grow the endowment in perpetuity. Methods used to estimate the economic value of natural environments were developed beginning shortly after the signing of the act and address the valuation, allocation, and management of amenity resources. Although methods initially focused on recreational values, economic models continue to be refined and applied to a wider range of ecosystem services.

- Economic values regarding the protection of natural environments are founded upon a mixture of core/cultural values and tradeoffs that one is willing to make given one's current socioeconomic situation. Resting on the same utility theoretic foundation as recreational (use) values, nonuse values (bequest, existence, and option values) reflect one's sense of public responsibility to respect and care for natural environments. This perspective is sometimes misunderstood in critiques of economic analysis.

KEY MESSAGES

- Institutions such as the Sierra Club and The Wilderness Society perpetuate core/cultural values regarding natural environments and help maintain societal wilderness values and preferences. Economic values for natural environments are further driven by economic circumstances, value creation/revision among generational cohorts, peer groups/social interactions, and technological changes.

- Although economic valuation methods are not strictly limited to monetization of tradeoffs, they require that tradeoffs only be applied to commensurate goods or services. Environmental management decisions that are primarily concerned with moral or ethical values should not rely upon economic analysis.

- The changing socio-economic-demographic composition of American society, a greater recognition of the need for environmental justice, and technological changes such as the profusion of electronic media are creating new demands on wilderness lands and other natural environments. Economic research can help identify how the demands being placed upon wilderness are evolving, how cultural values and economic behaviors are enhanced (or limited) by wilderness policies and practices, and how alternative models used to protect comparable wildlands (such as inventoried roadless areas or tribally designated wilderness) can complement the multiple benefits provided by federally designated wilderness and stimulate development of new approaches to wilderness and wildlands management.

The concepts of "wilderness" and "wilderness value" continue to evolve over time. These words are used throughout this report, and while their meaning can often be understood by the context in which they are found, some clarification of their use may assist the reader. Most chapters focus on federally designated wilderness areas, and in that context, "wilderness values" may refer to the values derived from those lands. However, there are other lands that may be managed with similar objectives, and other lands may have similar wilderness characteristics, qualities, and values. For example, the Blue Range Primitive Area in Arizona is the last designated "primitive area" and is managed the same as congressionally designated wilderness. The USDA Forest Service also manages Inventoried Roadless Areas, potential wilderness areas, and recommended wilderness areas in ways that can support future designation as wilderness. Moreover, Tribes and States have designated wilderness areas under their own sovereign authorities. Chapter 9 discusses examples of tribally designated wilderness areas as well as other formal designations to protect Tribal values. New models for protecting wilderness and comparable wildlands are continuing to be developed along with more nuanced understanding of wilderness values.

Introduction

As evidenced by the 2020 Census, the demographic makeup of American society continues to evolve. Looking back, the proportion of the U.S. population consisting of non-Hispanic Whites at the time that the Wilderness Act was signed in 1964 is diminishing, and this trend is expected to continue for the foreseeable future. Societal change ultimately raises questions regarding the ability of existing policies to maximize public welfare and the degree to which new policies might be needed. This is as true for wilderness policy and management strategies as for other issues of societal relevance. Economic analysis is one tool that can help policymakers evaluate tradeoffs regarding wilderness planning and resource allocation decisions (Irland 1976).

Policy issues regarding wilderness and other wildlands are typically concerned with adding protections to, or modifying uses of, natural environments that will ultimately benefit some groups of people while entailing costs (such as prohibited uses) for others. Unbiased evaluations of the true costs and benefits of policy proposals are needed to evaluate how tradeoffs will affect societal well-being (Krutilla and Fisher 1975). However, elements of policy decisions concerning ethical or moral issues are not generally amenable to economic analysis and must be addressed using other approaches.

Wilderness economics research grew rapidly in the decades following passage of the Wilderness Act (Public Law 88–577) as economists were motivated to develop new economic tools and data to understand and quantify the values inherent in proposals to add new units to the National Wilderness Preservation System (NWPS) (Bowker and others 2014, Cordell and others 2005). However, the past few decades have evidenced a dramatic drop in the number of new studies investigating wilderness economic issues, leaving decisionmakers to rely on old, outdated, and incomplete information regarding societal values and tradeoffs

(Holmes and others 2016). Further, new data and tools have become available in recent decades, such as geographic information systems, that now allow economic analysis to address wilderness policies in a spatially explicit manner. While enhancing the ability to better understand the societal benefits and tradeoffs inherent in recreational policies, recent innovations have widened the scope of wilderness economic analysis to include the valuation of ecosystem services such as wilderness water, carbon sequestration, biodiversity protection, and enhancement of the quality of life.

Management and policy initiatives regarding public lands do not arise in isolation but are driven by societal dynamics that coalesce into distinct perspectives and preferences regarding the use and value of nature. Within the context of wildland recreation, recent evidence suggests that the combined forces of immigration, the decline of the baby boom generation, and the emerging preeminence of the millennial generation are creating new orientations towards what is desired when taking wilderness trips (ch. 5). Further, contemporary technological advancements provide a constellation of new options for how people choose to use their leisure time that scarcely could have been imagined when the Wilderness Act was signed more than 50 years ago. It has been suggested that explosive growth in the amount of leisure time spent using electronic media has caused a "… pervasive and fundamental shift away from nature-based recreation…" (Pergams and Zaradic 2008: 2299). This issue is of great concern to institutions dedicated to the stewardship of natural resources (Kareiva 2008).

This chapter proceeds by, first, providing an overview of the way in which economists conceptualize the economic value of natural environments and a research framework is suggested that could be used to better understand and predict the evolution of wilderness values and benefits over time. Next, the emergence of the American Wilderness Model (AWM), combining European ideas regarding the sublime aspects of wild landscapes with American frontier (vigor, self-reliance) and transcendental (spiritual) values is summarized. This is followed by an overview of the American wilderness movement during the early 20th century. While most arguments for wilderness preservation during this period emphasized utilitarian values associated with recreation and scientific values, arguments were made within the Bureau of Indian Affairs to integrate wilderness preservation with protection of Native American cultural and religious values.

Next, the development of a new economics of preservation, providing a theory and methodology for bringing public preferences for wildlands under the lens of economic analysis, is described. This is followed by a brief discussion of current trends in the makeup of American society, the use of leisure time, and efforts that have been initiated to support Native American cultural heritage within wilderness. Finally, a brief summary of major ideas is presented along with conclusions.

Economic Approaches to Understanding the Evolution of Societal Values Regarding Wilderness Protection

Although the 1964 Wilderness Act made no direct mention of the economic value of wilderness, it stated that the NWPS is to be established and administered "for the protection of these areas, the preservation of their wilderness character, and for the gathering and dissemination of information regarding their use and enjoyment as wilderness" (Public Law 88–577, Sec. 1). At the time the Wilderness Act was passed, economic methods capable of measuring the values and benefits of natural environments derived from their use and enjoyment were yet to be developed. Today, however, the discipline of economics provides a rich array of tools capable of understanding and quantifying "the benefits of an enduring resource of wilderness" (Public Law 88–577, Sec. 1).

Economists now argue that amenity values of nature can be quantified by observing choices that people make over the set of opportunities that are available to them (Champ and others 2017). Choices involve tradeoffs, and environmental economists use data describing tradeoffs that people make between scarce resources, such as time or money, and environmental goods and services to infer underlying preferences and value (i.e., willingness to pay) for environmental quality. In a wilderness context, economic analyses help decisionmakers understand tradeoffs across a continuum of space-time scales. These considerations might include management issues such as changes in recreational access to a specific wilderness area so that Native American cultural values could be protected, or policy issues such as the total amount of land needed to be legislated as wilderness versus other land use designations to meet the needs of current and future generations.

Dramatic changes have occurred in the demographic and socioeconomic makeup of American society since the signing of the Wilderness Act. Within a diverse and multicultural society, it is not surprising to hear amplified calls being made for environmental justice that go beyond historical environmental justice concerns (Schlosberg 2013). Demands for environmental justice have a long history among Native Americans and encompass a broad conception of justice that addresses "the basic functioning of nature, culture, and community" (Schlosberg and Carruthers 2010: 12). Determining the path by which environmental justice may be realized for all current and future generations of Americans clearly presents a suite of challenges. A better understanding of how the demands being placed upon wilderness are changing, how cultural values and behaviors are enhanced (or limited) by wilderness policies and practices, and how ecocultural values interact among the matrix of wildlands (such as wilderness, inventoried roadless areas, and Tribal lands) could provide a first step in the realization of environmental justice for underserved populations.

Teasing out the influence of underlying core/cultural norms (such as the importance of respecting nature) from other factors (such as the growth in personal income or education) that influence tradeoffs that individuals and society are willing to make to protect nature over time is not easy. A research program designed to address these questions would, at the minimum, require temporally referenced data on demographic variables and market prices as well as changes in resource supply and the availability of substitutes (Boyd and Kousky 2016).

Recent economic thinking offers structural models of human preferences that can help to unravel the various influences driving tradeoffs that individuals and collectives are willing to make to protect nature. For example, Postlewaite (2011) argues that people have two types of preferences. Deep preferences are relatively stable over lifetimes and generations and reflect social/cultural norms that are taught by parents to their children at an early age. Founded upon deep preferences are what he calls reduced-form preferences (or, more generally, economic preferences) which are situational values that are sensitive to the context/social setting in which people make choices regarding specific goods or services. Reduced form preferences for nature, then, could be reflected in behavior such as donations made to environmental organizations. Taking this one step further into a wilderness context, the Postlewaite (2011) model suggests that economic values and willingness to pay for wilderness protection policies are motivated, to some degree, by deeper preferences based upon one's learned cultural norms as well as one's current situation (such as current income and expenses or the social group one identifies with).

The dual preference framework of Postlewaite (2011) is helpful for understanding two key issues that have recently arisen regarding economic valuation methods. First, this framework suggests there are limitations to the issues over which economic analysis can be meaningfully applied. Specifically, because cultural norms and values (deep preferences) provide meaning to one's life and help to guide moral and ethical decisions, as well as a foundation for situational economic decisions, economic analysis is limited in terms of the degree to which it can be applied to the evaluation and quantification of cultural values. This is because economic preferences are based upon tradeoffs, and economic analyses implicitly assume that substitutes are available that are commensurate with the item of trade. This assumption is often untenable in the case of cultural values. While it is recognized that the discipline of cultural economics has grown during the past decade, a debate continues over what cultural attributes might be reasonably subject to economic analysis, ranging from individual cultural artifacts to other cultural manifestations such as sacred sites and ways of life (Hirons and others 2016).

Although it is beyond the scope of this chapter to do more than raise awareness of this issue, it is noted that willingness-to-pay studies have been implemented that estimate economic values regarding aboriginal cultural artifacts and Tribal uses of natural resources (Boxall and others 2003, Duffield and others 2019). These studies, which are based upon limited (or marginal) representations of cultural expression, stand in contrast to a recent study estimating the economic value of the continued existence of an entire Native American culture (Carson and others 2020). It has been previously argued that this type of analysis is beyond the scope of meaningful economic analysis (Snyder and others 2003). Clarification is clearly needed regarding the degree to which economics can inform policies regarding cultural losses.

Second, the dual preference framework of Postlewaite (2011) suggests that long-term economic values for the protection of nature might be uncovered if underlying core/cultural values exert a substantive influence on environmental preferences over time. The temporal stability of economic preferences and willingness to pay for the services provided by nature is a topic receiving active interest among economists, and recent research has provided instances in which preferences demonstrate stability over years to decades for services such as clean/safe municipal water supplies (Price and others 2017) and whitewater boating in the Grand Canyon (Neher and others 2017). Within a wilderness context, recent research has revealed an increasing trend in the value of wilderness recreation over several decades[1] using data collected from wilderness permits.

Although it is unclear what specific factors are driving various trends that are currently being recognized in wilderness use and valuation, economic literature provides various explanations that might be usefully explored. First, it has been argued that wilderness values will increase over time along with increases in income, education, and resource scarcity (Krutilla and Fisher 1975). This argument is consistent with the proposal that technological advances and wealth enhance environmental values (Hays 1982, Inglehart and Baker 2000, Schwartz 2006). Second, economists have recognized that generational cohorts and peer groups/social interactions are drivers of value change (Hoff and Stiglitz 2016, Manski 2000, Ryder 1965, Venkatesen 1966, Zeng and Garritsen 2014). Thus, we might expect that millennials have a somewhat different set of values regarding wilderness use and values than, say, baby boomers (ch. 3). Third, economic research has demonstrated that cultural values influence the creation of institutions, and subsequently a feedback loop links institutions back to the maintenance of cultural beliefs (Alesina and Giuliano 2015, Bowles 1998). In a wilderness context, this perspective suggests that institutions such as The Wilderness Society or the Sierra Club were created based upon (Euro-American) cultural perspectives of wilderness and that, to the degree that such

[1] Englin, J.; Holmes, T.P. In review. The long-run evolution of wilderness values: a study of backcountry recreational demand.

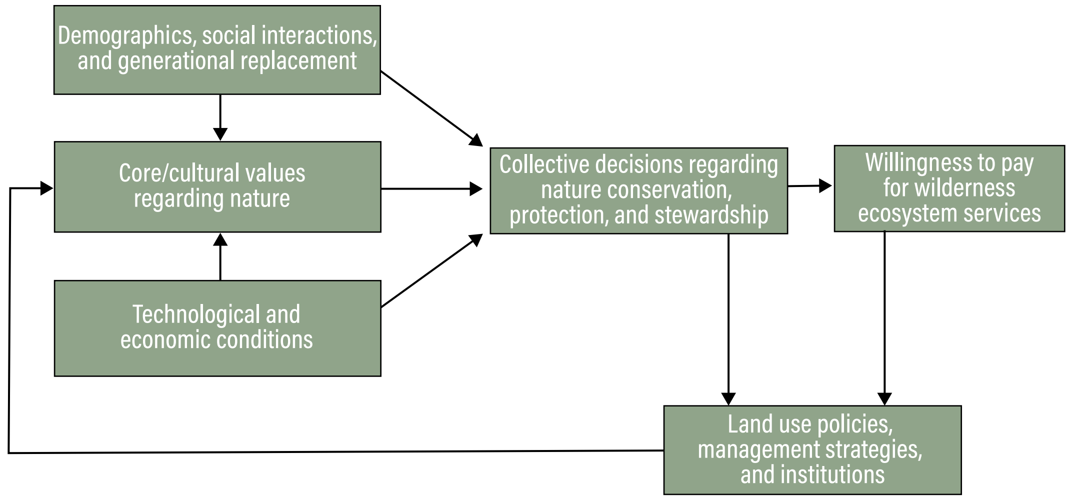

Figure 1.1—A dynamic socioeconomic framework for investigating collective and individual values for wilderness.

institutions continue to perpetuate (or not) a similar view of wilderness values, those values will continue to be perpetuated (or not). The mixture of long-run culturally derived wilderness values with evolving societal dynamics inherent in America makes the study and understanding of wilderness values especially relevant to the information needs of wilderness policymakers (fig. 1.1).

Cultural Values and the Perception of Wilderness

Cronon (1996) argues that wilderness is not an objective reality or place; rather, it is a cultural construct. Dimensions of the cultural construction of wilderness include a Romantic ideal in which people are separate from nature (nature/culture dualism) and visit wild places to restore their vigor and spirit (frontier and transcendental values) (Cronon 1996, Martinez 2003). In contrast,Indigenous cultural values are founded on kinship between people and nature (culture/nature overlap, kincentricity)—interconnected relationships necessitating active stewardship and care (Long 2020, Martinez 2003). The disparities between passive and active approaches to nature conservation are increasingly being recognized in international discourse and have initiated calls for a deeper appreciation of Indigenous knowledge in promoting conservation goals (Fletcher and others 2021). Within the United States, this conversation is typified in contrasting views of wilderness as expressed in Euro-American and Indigenous cultural values. Below, the apparent tension between these alternative, deeply held cultural systems of belief and action are reviewed with the goal of stimulating thinking about the ways in which the AWM might be extended along a continuum of possibilities for managing wilderness and other wildlands

The concept of wilderness is ancient, co-occurring with the emergence of agriculture in Northern Europe and providing a linguistic means of differentiating cultivated areas from "self-willed" landscapes outside of human control (Nash 1967). By the 18th century, European cultural perspectives of wilderness had evolved and highlight the sublime dimensions of nature as evidenced in a treatise on the subject by Edmund Burke.[2] According to Burke, the sublime experience of nature is congruent with the ability of landscapes to evoke intense feelings characterized by terror: "… whatever is in any sort terrible, or is conversant about terrible objects, or operates in a manner analogous to terror, is a source of the sublime; that is, it is productive of the strongest emotion

[2] "A Philosophical Enquiry into the Origin of Our Ideas of the Sublime and Beautiful" (1757).

which the mind is capable of feeling."[3] Burke lists properties of the sublime to include "objects of great dimension," "vastness," and "darkness," and emphasizes that terror "always produces delight when it does not press too close."[4]

The idea of the sublimity of nature had great influence upon American literature and art during the Romantic period, beginning in the early 19th century. American literature at the time was deeply influenced by Lake poets such as Samuel Coleridge and William Wordsworth (Huth 1957). Naturalistic themes found in European literature were developed by writers such as Ralph Waldo Emerson who, in 1835, published the volume "Nature" in which he states: "behind nature, through nature, spirit is present … spirit, that is the Supreme Being, does not build up nature around us but puts it forth through us." This spiritual/transcendental perspective of nature was further espoused by Henry David Thoreau and, later, by John Muir who arguably became the greatest spokesperson for the spiritual values of wilderness (Nash 1967). That Muir had read and embraced the philosophy of Emerson is clearly suggested:

> Wonderful how completely everything in wild nature fits into us, as if truly part and parent of us. The sun shines not on us, but in us. The rivers flow not past, but through us…. The trees wave and the flowers bloom in our bodies as well as our souls, and every bird song, wind song, and tremendous storm song of the rocks in the heart of the mountains is our song, our very own, and sings our love…. The song of God, sounding on forever (Muir 1872: 99).

The Romantic period further produced a new American approach to painting beginning with Thomas Cole, founder of the Hudson River School. In his "Essay on American Scenery," Cole expresses his sentiments towards wild nature as well as the forces threatening its status in America:

> … although an enlightened and increasing people have broken in upon the solitude, and with activity and power wrought changes that seem magical, yet the most distinctive, and perhaps the most impressive, characteristic of American scenery is its wildness… Yet I cannot but express my sorrow that the beauty of such landscapes are quickly passing away—the ravages of the axe are daily increasing—the most notable scenes are made desolate, and oftentimes with a wantonness and barbarism scarcely credible in a civilized nation (Cole 1836).

For Cole, and other artists and writers during this period, the religion of nature set America apart from Europe and contributed to a growing sense of national pride (Sanford 1957).

During westward expansion of the United States, a second theme developed that contributed to the transformation of wilderness into a peculiarly American cultural value (Cronon 1996). This is the idea that the trials faced by pioneers during settlement of the West created an ethos of rugged individualism as an essential quality of American character.[5] This theme was actively promoted during the early years of the 20th century by an avid hunter, lover of bird life, and 26th President of the United States—Theodore Roosevelt. Between 1901 and 1909, under the provisions of the Antiquities Act (16 USC 431-433), Roosevelt set

[3] As noted by the art historian Simon Schama: "Born from the oxymoron of agreeable horror, Romanticism was nursed on calamity. While the 18th century is conventionally thought of as the epoch of light … Edmund Burke set himself up as the priest of obscurity, of darkness. To be profound was to plumb the depths. So it would be in shadow and darkness and dread and trembling, in caves and chasms, at the edge of the precipice, in the shroud of the cloud, in the fissures of the earth, that, he insisted in his Inquiry, the sublime would be discovered" (Schama 1995: 450).

[4] Other philosophers of this era, including Immanuel Kant, expressed similar ideas regarding the possibility of sublime feelings experienced in nature: "consider bold, overhanging … threatening rocks, thunderclouds piling up in the sky and moving about accompanied by lightning and thunderclaps, … the boundless ocean heaved up, the high waterfall of a mighty river…the sight of them becomes all the more attractive the more fearful it is, provided we are in a safe place" (Ivanhoe 1997: 102). In the modern idiom, it seems appropriate to substitute the concept of "awe" for that of "terror."

[5] Frederick Jackson Turner is often credited with being the first to popularize this idea as reported in the essay "The Significance of the Frontier in American History" (1893).

aside for public benefit more than 230 million acres of wildland. Use of the Antiquities Act to establish these conservation lands was essential, he thought, for protecting wildlife habitat and providing opportunities for future generations to exercise frontier values such as vigor, independence, and creativity—characteristics that he felt were essential to the development of democratic ideals (Brinkley 2009).

What is quite obviously missing in the Romantic ideal portraying wildlands as sublime landscapes devoid of human inhabitants is the fact that 5 million or more Native Americans had been living in the continental United States for thousands of years prior to European colonization. These population numbers declined precipitously to roughly 240,000 by 1880–1900 due to the influence of pathogens, mass violence, and genocide (Madley 2015). Further trauma was inflicted upon Native Americans via the General Allotment Act of 1887 (the Dawes Act), which sought to assimilate Indians into American society by partitioning reservations into allotments that could be allocated to individual Tribal members. It was argued that by instilling the virtues of private land ownership, Indians would be prepared for U.S. citizenship. Not only did this policy break down Tribal identity and cultural values, but further insults were perpetrated by the Supreme Court ruling that "surplus" reservation land could be sold to non-Indians over a Tribe's objections (Catton 2016). The allotment process reached its apogee under the Roosevelt Administration when millions of acres of "surplus" reservation land that had been ceded to the U.S. Government after allotment were used, with the active support of Gifford Pinchot (the first chief of the USDA Forest Service), to support the creation of the National Forest System (Catton 2016). In the larger picture, while the Indian estate was being whittled down during the Roosevelt Administration, the National Forest System was expanding rapidly with the inclusion of public domain lands that had come under Federal jurisdiction during the Indian Wars (Catton 2016).

The stewardship practices of Native Americans prior to and during European colonization altered the environment in ways not understood by European settlers. For example, what John Muir saw as he traveled through the "pristine" wilderness of Yosemite Valley was, in fact, a gathering ground where Indigenous people had burned and tended the land for countless generations (Anderson 2005). Spatially extensive burning by Native Americans within forests of the Western and Eastern United States created open park-like stands (Anderson and Barbour 2003) as typified in paintings by Romantic artists such as Cole and Bierstadt. Thus, "high-value" landscapes typified as pristine and people-free erased the history and heritage of places frequented and stewarded by Indigenous people for millenia (Fletcher and others 2021).

Overall, the culture/nature dualism expressed in the Euro-American cultural perception that wilderness is separate from humans ("an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain") stands in stark contrast with the Native American view that people are an integral part of nature, stewarding plant and animal life using Indigenous knowledge, and that "culture overlaps with wild nature" (Martinez 2005: 248). The tension existing between Euro-American and Native American views of wilderness is summarized in the words of Luther Standing Bear, as recounted by Chief Oren Lyons (1989):

> We did not think of the great open plains, the beautiful rolling hills, and winding streams with tangled growth as "wild." Only to the White man was nature a "wilderness" and only to him was the land infested with "wild" animals and "savage" people. To us, it was tame. Earth was bountiful and we were surrounded by the blessings of the Great Mystery. Not until the hairy man from the east came and with brutal frenzy heaped injustices upon us and the families we loved was it "wild" for us.

> When the very animals of the forest began fleeing from his approach, then it was that for us the "Wild West" began.

In discussing the AWM, it is essential to recognize that alternative models of wilderness use have been implemented in the United States that permit traditional Indigenous cultural practices. The most prominent example is the Alaska National Interest Lands Conservation Act (ANILCA) that was passed by Congress in 1980 and mandated multiple National Park Service (NPS) units throughout Alaska to permit the continuation of traditional subsistence practices in designated wilderness. Although ANILCA created challenges for NPS management in terms of potential conflicts between the use of motorized equipment for subsistence harvesting practices and recreational use by visitors (Laven and others 2001), this wilderness model suggests that a continuum of land management strategies might be implemented to address alternative cultural values in wilderness and wildlands (see below for other examples).

The Modern American Wilderness Movement: Utilitarian Philosophy, Wildland Scarcity, and Tribal Roadless Areas

Utilitarian philosophy, originally articulated by Jeremy Bentham (1748–1832) and further developed by John Stuart Mill (1806–1873), played a prominent role in the development of Progressive Era governmental policies that sought to improve economic efficiency by introducing scientific principles to the management of natural resources.[6] A famous proponent of scientific management of natural resources at this time was Gifford Pinchot, who served as the first Chief of the U.S. Department of Agriculture, Forest Service from 1905 to 1910. Pinchot, adapting a phrase from Bentham, is perhaps most famous for his statement that "Where conflicting interests must be reconciled, the question shall always be answered from the standpoint of the greatest good of the greatest number in the long run." This perspective succinctly summarizes the philosophical orientation of the classical and neo-classical schools of economics—that governmental decision-making should be primarily concerned with the objective of maximizing the well-being of society.

During the early years of the 20th century, "automobiling" joined traditional outdoor sports such as hunting, fishing, and camping as means for enjoying wildlands in the American West. Sensing the need to address the growth of outdoor recreation on Federal lands, the USDA Forest Service commissioned Frank A. Waugh, a landscape architect, to conduct a comprehensive field study of existing conditions and write a report containing recommendations and policies regarding how the agency should address this emerging trend. The ensuing report developed Progressive Era scientific and economic arguments for managing outdoor recreation on par with other forest "utilities":

> The moment that recreation … is recognized as a legitimate Forest utility the way is opened for a more intelligent administration of the National Forests. Recreation then takes its proper place along with all other utilities. In each particular case these utilities are weighed against one another and a plan of administration devised to adjust and harmonize, to the utmost point practicable, the various forms of use so that the largest net total of public good may be secured. Where one must be subordinated to another, preference is given to that of highest value to the public (Waugh 1918: 5).

While Waugh argued that the "notable beauty" and "enticing wildness" of the national forests had "direct human value," awareness of the growing scarcity of wilderness as a land use

[6] The neoclassical theory of consumer demand is built upon the idea of utility, which is the ability of goods and services to satisfy human wants and needs. In 1844, Jules Dupuit argued that not only do commercial products provide utility to consumers of those products, publicly provided goods and services also help to satisfy human wants (Dupuit 1844). Dupuit made his arguments in reference to public projects, such as roads and canals, and his insights regarding the utility of public works were embraced by many Progressives.

led to a more explicit rationale for wilderness protection. Largely due to the efforts of Arthur Carhart, the first tract of national forest land to be protected for the preservation of wilderness was set aside in 1920 (Trappers Lake, CO) on the White River National Forest. At this time, a key proponent for wilderness preservation and employee of the Forest Service, Aldo Leopold, was encouraged in his thinking about the need for wilderness protection by his association with Carhart (Nash 1967). However, Leopold thought that "small patches of rough country which will remain practically in wilderness condition" due to their inaccessibility for more commercial purposes are "too small for a real wilderness trip." What Leopold had in mind was "a continuous stretch of country preserved in its natural state, open to lawful hunting and fishing, big enough to absorb a two weeks' pack trip, and kept devoid of roads, artificial trail, cottages, or other works of man" (Leopold 1921: 719). Arguing that demand for large areas of wilderness constituted their "highest use" and emphasizing frontier values, Leopold suggested that the headwaters of the Gila River, on the Gila National Forest (New Mexico), would be suitable for such a designation. In June of 1924, with the support of local sportsmen's associations and the Forest Supervisor, 574,000 acres were set aside for wilderness preservation (Nash 1967).

Leopold continued arguing for wilderness protection, emphasizing the importance of increasing scarcity in the face of economic development:

> Since the pilgrims landed, the supply of wilderness has always been unlimited. Now, of a sudden, the end is in sight. The really wild places within reach of the centers of population are going or gone. As a nation, however, we are so accustomed to a plentiful supply that we are unconscious of what the disappearance of wild places would mean, just as we are unconscious what the disappearance of winds or sunsets would mean (Leopold 1925: 602).

His final argument that wilderness should be preserved "for the edification of those who one day may wish to see, feel, or study the origins of their cultural inheritance" is contained in the chapter "Wilderness" in his philosophical treatise "The Upshot" (Leopold 1949). He concludes this essay arguing that:

> Wilderness was an adversary to the pioneer. But to the laborer in repose, able for the moment to cast a philosophical eye on his world, that same raw stuff is something to be loved and cherished, because it gives meaning and definition to his life.... Ability to see the cultural value of wilderness boils down, in the last analysis, to a question of intellectual humility.... (Leopold 1949: 200–201).

Equally important to his admonitions for preserving frontier values by setting aside large areas of wilderness, Leopold further argued that large tracts of undeveloped land were important for scientific reasons. His concern, later in life, with land health and the development of a land ethic is expressed in his argument that wilderness is needed as a land laboratory: "A science of land health needs, first of all, a base-datum of normality, a picture of how healthy land maintains itself as an organism" (Leopold 1941a). In the same year, Leopold integrates his thinking about the importance of wilderness recreation and scientific study, arguing that "there is no higher or exciting sport than that of ecological observation" (Leopold 1941b: 28).

Leopold's passionate calls for protecting large areas of wilderness influenced policy within the Forest Service. In 1929, the agency issued Forest Service Regulation L-20 with the objective of organizing and systematizing what were formerly piecemeal attempts at preservation of "primitive areas" (Nash 1967).[7] In some instances, management of these areas included construction of shelters, corrals, latrines, and trail signs. These conveniences upset the sensibility of some in the agency

[7] These areas were not referred to as wilderness by the agency as it was thought that such a term would convey a negative public connotation.

who felt that primitive areas should remain free of any trappings of civilization. One such agency advocate was Robert (Bob) Marshall (1901–1939), who dedicated his short life to wilderness preservation. A famous hiker, regularly covering 50 miles a day in remote areas such as the Brooks Range in Alaska, Marshall was forceful in promulgating the Forest Service U-Regulations in which 14 million acres of agency land were designated as wilderness. In the 2 years following establishment of the U-Regulations, 76 primitive areas were reclassified as wilderness areas (required to be >100,000 acres in size), 6 were reclassified as wild areas (between 5,000 and 100,00 acres in size), and 3 areas totaling about 1 million acres were consolidated into the Bob Marshall Wilderness area in Montana (ORRRC 1962).

A lesser known chapter in Bob Marshall's career depicts his efforts to protect wilderness while also protecting Native American cultural values. Prior to joining the USDA Forest Service, Marshall was head of the Indian Forest Service (1933–1937) within the Bureau of Indian Affairs, working under Indian Commissioner John Collier. Since the signing of the Dawes Act in 1887, Federal Indian policy had focused on assimilating Indians into American society by breaking down Tribal identity and disposing of Tribal lands. Although provisions of the Act gave Indians personal ownership of the Indian estate in parcels ranging from 80 to 640 acres and provided for sale of "surplus" Indian lands to homesteaders, the policy had disastrous cultural and economic consequences for Native Americans and reduced Indian lands from 138 million acres in 1887 to 48 million acres in 1933 (Collier and others 1933, Marshall 1937). Recognizing failures in Federal Indian policy, Collier instituted a series of efforts, collectively referred to as the "Indian New Deal," including the Indian Reorganization Act of 1934 that abolished the allotment system.

It was during this period of Indian policy reform that Marshall proposed assigning nearly 5 million acres of land on 16 Indian reservations as "roadless" and "wild" areas. Despite the appearance of an opportunistic appropriation of land for the wilderness system that Marshall desired (Catton 2016), the order included language describing the cultural benefits that would be provided to Indians: "If, on reservations where Indians desire privacy, sizeable areas are uninvaded by roads, then it will be possible for the Indians of these Tribes to maintain a retreat where they may escape from constant contact with White men" (Krahe, 2005: 280). Although the order was signed by Commissioner Collier (appearing in the Federal Register on October 25, 1937), the network of reservation roadless and wild areas was implemented without Tribal consultation or consent (Krahe 2005). This breach of trust, and blatant disregard of Tribal sovereignty, caused subsequent proposals to include reservation lands in a new, Federal wilderness system to be rejected. Consequently, Tribal lands were dropped from consideration in the Wilderness Act and all Tribal roadless areas were declassified (notably, except for the Shoshone and Arapaho who chose to retain the Wind River roadless area), with the last declassification occurring in 1965 (Catton 2016, Krahe 2005).

Opportunities to use designation of wilderness and other formal protections to safeguard Tribal interests were undermined by the way in which these proposals were advanced. However, the Wind River roadless area designation survived as the oldest example of such a formal protection. Furthermore, after the Wilderness Act was passed, several Tribes adopted various forms of wilderness protections on their lands, and Tribes have proposed new designations for public lands such as a Tribal cultural heritage designation for the Badger-Two Medicine Area (see below).

Emergence of the Economic Value of Wilderness

Prior to the 1960s, economic analysis of natural resource use was oriented towards efficient production of energy sources and material goods, while the amenity values of natural areas were considered as resources of intangible value that would need to be sacrificed in the name of economic progress. However, this perspective was fundamentally altered with the publication of "Conservation Reconsidered" in which John Krutilla presented a framework for treating natural amenity resources as economic resources that had values commensurate with material goods and services (Banzhaf 2016, Krutilla 1967). This new approach allowed economists to utilize benefit-cost analysis to inform management and policy decisions regarding natural amenity resources and emphasized that the benefits of natural area preservation pose opportunity costs for economic development (Porter 1982).

Development of a new economic paradigm for understanding the value of natural amenity resources did not arise in isolation but emerged during a period of rapid economic, social, and cultural change. In 1956, the United States became the first country to employ most of its labor force in the service sector, resulting in a cultural shift in postindustrial society with "increasing emphasis on quality-of-life, environmental protection, and self-expression" (Inglehart and Baker 2000: 21). This era also evidenced the emergence of the baby boom generation and the creation of the Interstate Highway System (authorized in 1956), greatly improving public access to the Nation's wildlands for a rapidly growing population.

In 1958, Congress enacted Public Law 85–470, authorizing creation of the Outdoor Recreation Resources Review Commission (ORRRC). The language of the act emphasized growing recognition of the contribution that outdoor recreation makes to "individual enjoyment … and the spiritual, cultural, and physical benefits that such outdoor recreation provides…."[8] Although the focus of the ORRRC efforts were not limited to wilderness issues, a special report on wilderness lands, promoted by the Sierra Club, was published by the Commission (ORRRC 1962). Concepts regarding the value of wilderness protection were neatly summarized in this report as pertaining to three categories: (1) recreational values, which arise from "deep personal revelations, experience of natural beauty"; (2) social values, including scientific study; and (3) knowledge that wilderness exists (ORRRC 1962: 7). The expansion of the set of perceived wilderness values to include values held by those members of society who do not participate in wilderness recreation ("nonusers") but who benefitted from wilderness preservation by simply knowing that wilderness exists was novel. This new perspective, consistent with new cultural orientations towards the environment, greatly increased the number of people who were now considered to have a stake in wilderness preservation.[9]

The wilderness values described by the ORRRC (1962) were formalized into concepts amenable to economic analysis by a team of economists at Resources for the Future, led by John Krutilla. Since the early 20th century, a tension had existed among conservationists who, like Gifford Pinchot, argued that natural resources should be scientifically managed for materialistic purposes (such as the sustainable provision of timber), while preservationists such as John Muir felt that nature should be left alone. Krutilla was remarkable in that he was able to bridge the gap between these two philosophies, arguing that human preferences for nature preservation were just as economic as were the values conferred by economic development (Banzhaf 2016). He accomplished this feat by arguing that amenity values of natural areas directly enter the utility function of people sympathetic to those landscapes, much as the goods and services produced from natural areas enter the utility function of people who consume those goods and services.

[8] The ORRRC was charged with three objectives: (1) to determine recreation wants and needs during the years 1976 and 2000, (2) to determine recreation resources anticipated to be available to meet those needs, and (3) to determine policies that would address meeting present and future outdoor recreation demand (Siehl 2008).

[9] The chapter of the report describing wilderness economic concepts and analyses was written by Irving Hoch, Wildland Research Center, University of California. The concept of existence value is also referred to in Clawson and Knetsch (1966: 181): "The justification of wilderness areas does not rest primarily on maximization of direct economic values to users, but on benefits to nonusers and preservation of a certain type of value or experience."

In doing so, Krutilla transformed cultural orientations, deriving from the spiritual, aesthetic, frontier, and scientific values of wilderness, into wilderness economic values. This set of values includes recreational (use) value as well as nonuse (existence, option, and bequest) values.

In addition to recreational use, which had long been considered a wilderness value, Krutilla (1967) embraced and popularized the concept of existence value. In his formulation, existence value is based upon "the mere existence of biological and/or geomorphological variety and its widespread distribution" (Krutilla 1967: 781).[10] This value can be understood as deriving from cultural orientations inherited from figures such as Emerson, Thoreau, Cole, and Muir and passed down through generations of Americans:

> When the existence of a grand scenic wonder or a unique and fragile ecosystem is involved, its preservation and continued availability are a significant part of the real income of many individuals … These would be the spiritual descendants of John Muir, the present members of the Sierra Club, the Wilderness Society, National Wildlife Federation, Audubon Society, and others to whom the loss of a species or the disfigurement of a scenic area would cause acute distress and a sense of genuine relative impoverishment (Krutilla 1967: 779).

In characterizing the value of knowing that other biological species and wildlands exist and contribute to the real income of many individuals, Krutilla further addressed concerns expressed by Aldo Leopold that many biological species are impaired or lost because they do not have explicit economic value (Banzhaf 2016).

A further source of fundamental benefits to society arising from the preservation of natural areas comes from the realization that a decision to preserve nature could always be reversed sometime in the future, while development of natural areas would be irreversible and unique characteristics of those landscapes would be lost to future generations. Arguing that, even if there were no immediate benefits to preservationists of protecting resources in a natural condition, the possibility that amenity benefits would flow from such resources in the future generates an "option value." Uncertainty about the future, combined with the irreversibility of development, generates an option demand for preserving unique natural areas in their undeveloped condition:

> This demand is characterized as a willingness to pay for retaining an option to use an area or facility that would be difficult or impossible to replace and for which no close substitute is available. Moreover, such a demand may exist even though there is no intention to use the area or facility in question and the option may never be exercised (Krutilla 1967: 780).

In addition to recreational use, existence, and option values of natural areas, Krutilla (1967) includes a final motivation for nature protection that he describes as bequest value. Although economic techniques used to estimate values for natural amenities are sometimes critiqued for their focus on individual utility and apparent disregard for the collective benefits (cultural identity or social responsibility) of nature protection (Chan and others 2016), Krutilla's (1967) taxonomy includes relational values in his conception that bequest values reflect a sense of public responsibility: "In this case also, my concern is with providing collective consumption goods for the present and future" (Krutilla 1967: p. 785, italics in original). Through the extension of conservation values to include other members of the present and future generations, the concept of bequest values broadens the scope of economic analysis to emphasize the importance of collectively held values as motivation for nature protection.

[10] It should be recognized that existence values are anthropocentric in the sense that they convey value to people. For characterization of intrinsic values of wilderness, not dependent upon rational human valuation, see Gudmundson and Loomis (2005).

By formalizing an economic rationale for preserving natural amenity resources, Krutilla greatly enhanced the ability of economists to contribute to policy and management decision making (Krutilla and Fisher 1975, Porter 1982). The economic concepts he promoted, combined with subsequent methodological developments that permitted economists to quantitatively measure nonmarket values (Champ 2017), have greatly enhanced society's understanding and growing appreciation of the suite of ecosystem service values provided by wilderness and other natural amenity resources.

Contemporary Trends Influencing Wilderness and Wildland Values

The demographic profile of American society has changed dramatically since the signing of the Wilderness Act in 1964, prompted to a large degree by the aging of the population and passage of the Immigration and Nationality Act of 1965 (Public Law 89–236). Since the 1920s, immigration policy had been based on a national-origins system that assigned quotas proportional to national representation in historical U.S. Census Bureau data—a system that heavily favored immigrants from Northern Europe. The new act replaced this approach with a quota system emphasizing family reunification and skilled labor. Consequently, the ethnic and racial diversity of the U.S. population was set upon a new trajectory, and the foreign-born share of the population increased rapidly. Nearly 59 million immigrants arrived in the United States between 1965 and 2015, and the foreign-born share of the population increased from about 5 percent to nearly 14 percent during this period (Lopez and others 2015).

Due to immigration and natural increase (the difference between births and deaths), Hispanic and Asian/Pacific Islander population shares of the U.S. population have grown rapidly, increasing from about 4 percent when the Wilderness Act was signed to about 24 percent in 2015. By 2030, international immigration is anticipated to exceed natural increase as the greatest driver of U.S. population growth (Vespa and others 2018). Long-run forecasts indicate that non-Hispanic Whites will make up less than half of the U.S. population by 2055 (Lopez and others 2015). The African-American share of the population is anticipated to remain relatively constant, increasing from about 13 percent in 2016 to about 15 percent in 2060 (Vespa and others 2018). The millennial generation, consisting of those Americans born between 1977 and 1994, is now the largest U.S. generation, and 57 percent of this generation is non-Hispanic White, the smallest share of any American generation to date (Cohn and Caumont 2016).

The implications of these trends for the evolution of wilderness values in America are important to consider, as the vast majority of people living in the United States when the Wilderness Act was signed were of European origin (Lopez and others 2015). Cultural orientations towards wild nature can vary widely across people with different ancestries, resulting in different degrees of interest in wilderness use and protection. A stark example is provided by the general ambivalence of African Americans towards wildlands, attributed to collective memories of places where forced labor and lynching were perpetrated (Johnson and Bowker 2004). Cultural orientations toward wild nature are reflected in patterns of recreational behavior and, in general, racial and ethnic minorities in the United States visit national forests and national parks at rates typically much less than their proportion in the population (Flores and others 2018, Scott and Lee 2018). However, as cultural orientations are gradually influenced through interactions with people holding other cultural values (Schwartz 2006), the proportion of total visits taken by Hispanics and Asian/Pacific Islanders to national forest wilderness areas have been steadily increasing (ch. 6).

These patterns of wilderness use are consistent with results of the 2000 National Survey of Recreation and the Environment (https://www.srs.fs.usda.gov/trends/nsre-directory/) that investigated the influence of immigration and ethnicity on wilderness values (Bowker and others 2006, Johnson and others 2004). These studies provide several conclusions:

- Compared to non-Hispanic Whites, other racial and ethnic groups were less likely to have visited wilderness in the past.
- The number of years an immigrant lived in the United States increased the likelihood that they had visited wilderness and that they plan to visit in the future.
- Hispanics and non-Hispanic Whites were equally likely to report anticipated future use.
- Asian/Pacific Islanders were the only ethnic minority to respond more positively than non-Hispanic Whites to the importance of protecting the existence (nonuse) values of wilderness.

Overall, these conclusions suggest that broad political support for wilderness may not diminish in the future as American society becomes more diverse. Further, programs helping to remove some of the obstacles faced by ethnic and racial minorities that limit their participation in wildland recreation—including socioeconomic constraints, concerns with personal safety, and lack of effective communication with communities of interest—may advance the likelihood that these groups will increasingly participate in nature-based recreation in the future (Johnson and others 2001, Scott and Lee 2018).

Everyone participating in outdoor recreation realizes that it requires a commitment of time, resulting in less time available for other leisure activities. Recognizing that time is an economic resource, to the degree that people attempt to maximize the utility of time spent in various activities subject to intertemporal time constraints (Becker 1965), economists have benefited from the availability of time-use data in understanding the tradeoffs that people make in allocating their time. Analyses of time-use data have shown that the amount of time Americans spent pursuing leisure activities increased between 1965–2003, with leisure time increasing by 6–9 hours per week for men and 4–8 hours per week for women (Aguiar and Hurst 2007). During the period from 1965 to 2007, the per capita amount of time spent in outdoor recreation and active sports more than doubled (Siikamäki 2009).[11] The vast majority of this increase, about 85 percent, was due to an increase in the proportion of Americans participating in outdoor recreation and active sports.

Time-use data provide a powerful tool for investigating questions related to the reported decline in nature-based recreation (Pergams and Zaradic 2008), including the suggested increase in "nature-deficit disorder" among adolescents (Louv 2005). It is possible to update, and refine, the findings reported in Siikamäki (2009) regarding the amount of time Americans spend pursuing nature-based recreation using more recent data presented in the American Time Use Survey (ATUS) (https://www.bls.gov/tus/).[12] Many analytical approaches using these data are possible, given the richness of demographic characteristics included in the dataset and the variety of econometric models that could be applied. However, even a simple analysis using reported data on respondent age can be implemented to examine general trends in time allocation based upon generational categories.[13]

Using ATUS data for the period 2003–2016, several important trends in the proportion of Americans participating in nature-based

[11] To consistently aggregate time-use data reported during this time period, it was necessary to combine the amount of time spent in outdoor recreation with time spent engaged in active sports.

[12] It is now possible to consistently disaggregate leisure activities into nature-based recreational activities which are defined here to include: hiking, biking, boating, climbing, horseback riding, fishing, hunting, running, skiing, and walking.

[13] For this analysis, generations were defined as in Williams and Page (2011): predepression generation if born before 1930, depression generation if born between 1930 and 1945, baby boom generation if born between 1946 and 1964, Generation X if born between 1965 and 1976, millennial generation if born between 1977 and 1994, and Generation Z if born after 1994. Note that the predepression generation and Generation Z were not included in the following analysis as survey responses from these generations contained too few observations to be considered reliable.

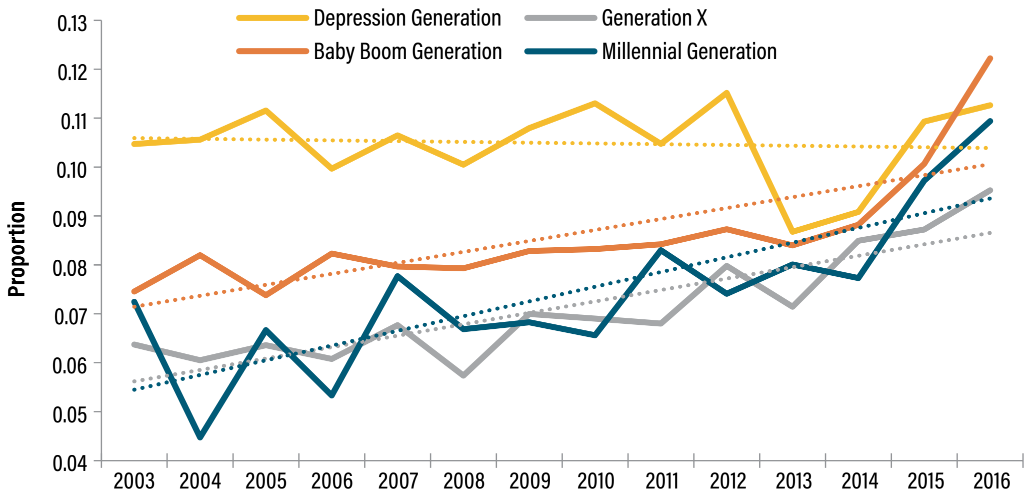

Figure 1.2—Participation in nature-based recreation by generation, 2003–2016. Data source: American Time Use Survey.

recreation can be identified (fig. 1.2).[1] First, the depression generation consistently evidenced the greatest proportion of its members participating in nature-based recreation throughout most of this period, only being surpassed by the baby boom generation in 2016. Members of the depression generation were between the ages of 19 and 34 when the Wilderness Act was signed, and it is remarkable that their rate of participation in nature-based recreation remained at high levels even as they aged (attaining ages ranging from 71 to 86 in 2016). Second, while participation rates by the depression generation were relatively constant, participation rates by other generations have been trending upward over time. The rate of participation in nature-based recreation by the baby boom generation exceeds participation rates by younger generations, which is consistent with the suggestion that younger generations are not as connected with nature as previous generations. However, using participation rates in 2003 as a baseline, overall changes in the rate of participation in nature-based recreation up to 2016 are impressive, increasing by 5 percentage points for baby boomers (participation rates growing from 7 to 12 percent), 4 percentage points for Generation X (participation rates growing from 6 to 10 percent), and 4 percentage points for the millennial generation (participation rates growing from 7 to 11 percent).

Although these results cannot be directly compared with earlier analyses using time allocation data (Siikamäki 2009), as our list of recreational activities is a subset of the previous study, we note a similar trend in participation rates. That is, both studies indicate that the proportion of the U.S. population participating in physically active recreation has been increasing over time. Further, these results are consistent with the increasing rate of visitation to wilderness since 2004 (ch. 5).

Contrary to trends in rates of participation, examination of the amount of time spent in nature-based recreation, for those who participate, indicates a decreasing trend across all generations (fig. 1.3). Despite the fact that the depression generation generally had the greatest participation rates, this generation consistently spent the least amount of time pursuing nature-based recreation activities. This is not surprising due to the age of this group. However, there seems to be little difference in the time allocated to nature-based recreation among participants from other generations. These results, while not being directly comparable, are consistent with recent

[1] Raw data, based upon stratified random samples, were adjusted to reflect characteristics of overall U.S. population using formulas described in the relevant ATUS User's Guides. Further, linear trends are included in figures 1.1 and 1.2 to smooth each series and indicate general patterns of change across time for the relevant generations.

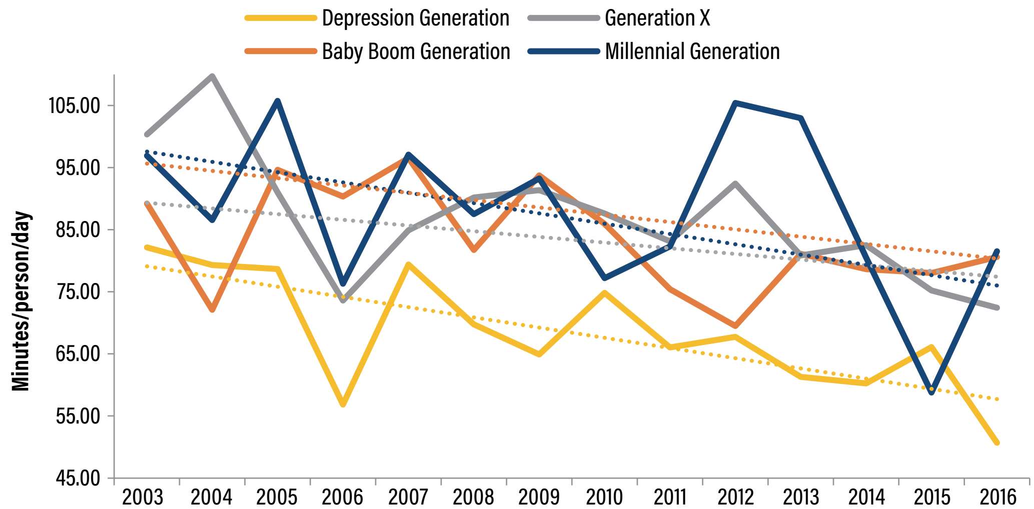

Figure 1.3—Time spent in nature-based recreation by participants, by generation, 2003–2016. Data source: American Time Use Survey.

findings that the amount of time that people spend recreating in wilderness has been decreasing since 2004 (ch. 5).

Finally, it is important to recognize emerging trends in the use of wilderness designations that are intended to support Tribal cultural values on Federal land as well as related efforts by Tribes. Awareness of strategies that are currently being tested can help to inform efforts to develop new wilderness models that offer alternatives to the traditional AWM along a continuum of possibilities for wilderness and comparable wildlands.

Various strategies have been developed that attempt to address concerns of Native Americans regarding the continuation of traditional practices on what is now designated wilderness. Comanagement/costewardship agreements between Tribes and various Federal agencies are used primarily for fish and wildlife management where off-reservation treaty rights exist. Protective land designations offer more permanent protection of cultural values and "Congress is increasingly recognizing Tribal values in passing wilderness legislation, and … some Tribal governments see Federal wilderness …as an effective way to protect cultural resources and sacred places" (Nie 2008: 624). Notably, these legislative actions are congruent with Bob Marshall's desire to jointly protect wilderness and Indigenous cultural values (see above).

As described by Nie (2008), explicit language supporting Indigenous cultural values appears in enabling legislation for the Cebolla Wilderness area and the T'uf Shur Bien Preservation Trust Area (located within the Sandia Mountain Wilderness in New Mexico). Further, provisions within omnibus wilderness legislation have been used to protect Indigenous cultural resources as described in the Steens Mountain Cooperative Management and Protection Act of 2000 (Oregon) and the California Coastal Wild Heritage Act of 2006. The Ojito Wilderness Act of 2005 (New Mexico) allowed the Pueblos of Zia to purchase Federal land containing significant cultural values and sacred sites, while allowing public access and creating a "virtual wilderness." Finally, as noted by Nie (2008), several proposed wilderness bills include provisions related to Tribal rights and sacred sites, including the Northern Rockies Ecosystem Protection Act (Idaho, Montana, Oregon, Washington, and Wyoming), the contemplated Blackfoot Cultural Heritage Area in the Badger-Two Medicine area (Montana), and the Seven Blackfoot Wilderness Study Area (Montana).

Beyond efforts at the Federal level that support Indigenous cultural values within designated wilderness, other efforts are being undertaken that provide alternative models to the traditional AWM. Specifically, Tribes have been providing wilderness experiences for non-Tribal visitors to Tribal lands (including the collection of fees for guiding services and recreational use). Innovative efforts implementing this approach include the Mission Mountains Wilderness (Salish and Kootenai Tribes, Montana), the Inter-Tribal Sinkyone Wilderness (ten Northern California Tribes), and the Mount Adams Recreation Area (Yakama Nation, Washington).

Summary and Conclusions

The seeds of American cultural orientations towards wildlands were planted during the late 18th and early 19th centuries, led by a cadre of American artists and writers who embraced the Northern European concept of sublime landscapes and Romantic ideals. This cultural paradigm was further infused with transcendental spiritual themes and American frontier values to create a peculiarly American wilderness model (AWM) as articulated in the Wilderness Act. The Act provided the American public with a natural endowment of extraordinary value and the legislative means to protect and grow the endowment in perpetuity.

Economic methods were developed in the years following signing of the Act that allowed natural amenity values to be measured in terms commensurate with material goods. Recreational use was emphasized in the Act and economic analyses initially focused on the recreational (use) value of wilderness. In subsequent years, economic analysis of wilderness and wildlands has expanded in scope to include a suite of nonuse (existence, option, and bequest) values as well as other ecosystem services including biodiversity, clean water, and carbon sequestration.

To the extent that the AWM validates a dualistic worldview in which humans remain outside of nature and visit wilderness and comparable wildlands to restore their vigor and spirit, alternative perspectives of human-nature interactions are disregarded and new models for wilderness and wildlands management may not be recognized. Looking back, the stewardship practices of Native Americans prior to and during European colonization altered the environment in ways not understood by European settlers, and landscapes typified as pristine and people-free erased the history and heritage of places frequented, valued, and used by Indigenous people for millennia. Historical facts help guide current and future decision-making and broaden societal awareness of the trauma suffered by Native Americans since the time of European colonization, the means by which the Federal government whittled down the Indian estate to expand the public domain, and continued calls for environmental justice by Native Americans are influencing Federal wilderness policy and management.

America looks much different now than it did in the years leading up to the signing of the Wilderness Act. The changing socio-economic-demographic composition of American society, a greater recognition of the need for environmental justice among underserved populations, and technological changes such as the profusion of electronic media are creating unprecedented demands on wilderness lands and other natural environments. Consequently, novel challenges need to be addressed regarding the best, just, and equitable uses of public lands including Federal wilderness and comparable wildlands. Economic analysis can help policymakers evaluate tradeoffs regarding wilderness planning and resource allocation decisions so that Americans may benefit across a broad array of cultures and socioeconomic conditions.

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2

Historic and Current Assessment of the National Wilderness Preservation System

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Flat Top Wilderness (230,830 total acres) in Colorado was designated in 1975 and is administered by the Forest Service. (Courtesy photo by Beth McCarley, www.beth.photo)

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KEY MESSAGES

- Wilderness areas have expanded greatly since the Wilderness Act was passed in 1964, and now the National Wilderness Preservation System (NWPS) encompasses over 109 million acres, which is about 16.3 percent of all federally managed lands.

- Despite this expansion and because wilderness areas are vital to biodiversity conservation, there is a lack of diversity and representation of ecological systems (i.e., habitat types) within the NWPS. However, land exists that is managed as wilderness that could be designated as wilderness.

- Strategic additions of designated wilderness could increase both the diversity and representation of ecological systems and preserve species biodiversity within the NWPS.

- The importance of further strategic expansion and connectivity of the NWPS becomes apparent when evaluating the number of wilderness areas within 150 miles of cities with populations greater than or equal to 500,000 and the rates of population and housing density change.

- The future integrity of the NWPS to conserve biodiversity and maintain wilderness character depends on understanding the current state of the NWPS and the factors, such as land use and climate change, that will shape it.

Introduction

The Wilderness Act (Public Law 88–577) of 1964 established a National Wilderness Preservation System (NWPS) "to secure for the American people of present and future generations the benefits of an enduring resource of wilderness." The NWPS is intended to preserve "natural conditions" and "ecological, geological, or other features of scientific, educational, scenic, or historical value" (Public Law 88–577). In 1964, at the time the Wilderness Act went into effect, 9.1 million acres of land in 54 wilderness areas managed by the U.S. Department of Agriculture (USDA), Forest Service were designated as part of the NWPS. To date, the NWPS is now composed of >109 million acres in 765 wilderness areas.[1] These wilderness areas span 44 States and are administered by 4 Federal agencies: the Forest Service (FS) and the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (FWS), and National Park Service (NPS) (table 2.1, fig. 2.1).

Our objectives are to trace the expansion of the NWPS over the last 50 years, evaluate the representation of ecological systems and biodiversity within wilderness areas, and assess how current federally managed lands could augment the NWPS. To meet these objectives, we provide an overview of the designation and assessment of wilderness areas in the NWPS since 1964, quantify representation of ecological systems and species richness within wilderness areas, describe research that evaluates the potential of designating new wilderness areas, and evaluate the proximity of wilderness areas to urban centers, which could influence the ecological, geological, or other features of value within wilderness areas.

[1] When reporting or discussing the number of wilderness areas in the Nation, it is important to distinguish the total number of wilderness areas in the NWPS from the total number of wilderness units. The total number of wilderness units administered by all 4 agencies is 801 rather than 765, because 36 wilderness areas are jointly administered by more than one agency. Each of these 36 wilderness areas is double counted when deriving the total number of wilderness units administered by the agencies, yielding the larger number.

Table 2.1—Total number of wilderness units, area of wilderness under Federal management, and percentage of wilderness area in the National Wilderness Preservation System (NWPS)[a] by managing agency

Agency	Number of wilderness units[b]	Area of wilderness under Federal management	Percentage of total NWPS area	Total area by agency	Percentage of wilderness by agency
		acres		*acres*	
BLM	224	8,760,478	8.03	248,345,551	3.53
FWS	71	19,862,488	18.20	89,092,711	22.29
FS	445	36,572,721	33.51	192,893,317	18.96
NPS	61	43,942,561	40.26	79,773,772	55.08
Total	**801**	**109,138,248**	**100.00**	**610,105,351**	**100.00**

BLM = Bureau of Land Management; FS = USDA Forest Service; FWS = U.S. Fish and Wildlife Service; NPS = National Park Service.

[a] These data include Alaska, Puerto Rico, and Hawaii.

[b] Note that when reporting or discussing the number of wilderness areas in the United States, it is important to distinguish the total number of wilderness areas in the NWPS from the total number of wilderness units. The total number of wilderness units administered by all 4 agencies is 801, but because 36 wilderness areas are jointly administered by more than one agency, the total number of unique wilderness units equals 765 (801 minus 36). Each of these 36 wilderness areas is double counted when deriving the total number of wilderness units administered by the agencies, yielding the larger number.

Source: NWPS unit and acreage data obtained from Wilderness Connect (2017).

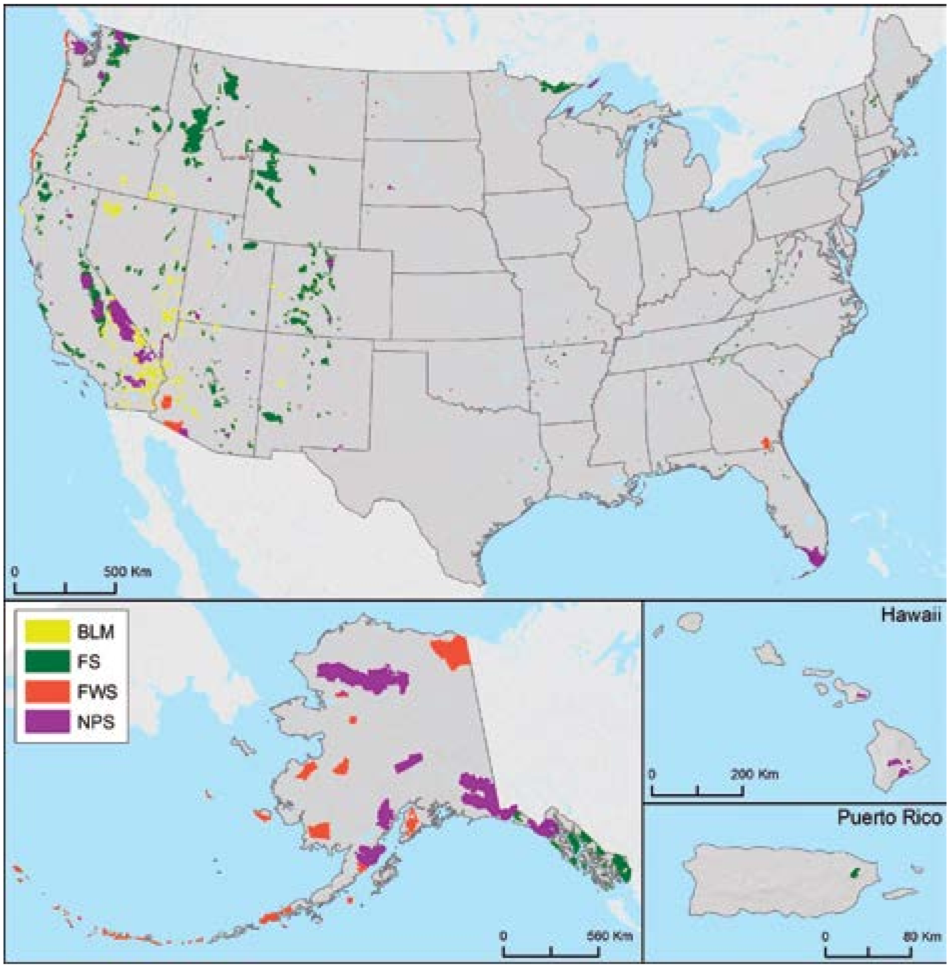

Figure 2.1—The spatial distribution of the current wilderness areas within the National Wilderness Preservation System (NWPS). BLM = Bureau of Land Management; FS = USDA Forest Service; FWS = U.S. Fish and Wildlife Service; NPS = National Park Service. NWPS boundaries obtained from Wilderness Connect (2017).

Designation and Assessment of Wilderness Areas Since 1964

There has been a steady increase in the number of wilderness areas and total area within the NWPS since 1964. However, there are annual variations in the designation of wilderness areas. To evaluate the trend and annual variations of wilderness area designations, we compiled data for the NWPS, including wilderness name, managing agency, State, and year of designation (Wilderness Connect 2017). Our intent was to update and expand on the key attributes and trends within the NWPS initially evaluated by Landres and Meyer (2000).

Wilderness Areas: Total Number and Area

The number of wilderness areas established and areas designated by each U.S. Congress show considerable yearly variation (fig. 2.2). There have been 18 individual years since the passage of the Wilderness Act when no acres of wilderness areas were added to the NWPS. More specifically, 1965 to 1967 was the only period of 3 consecutive years in which no wilderness area legislation was passed by the U.S. Congress.

In 1984, 189 wilderness areas were established, more than double any other year's addition (fig. 2.2). Despite the record number of new wilderness areas in 1984, the largest acreage of wilderness was designated in 1980 with the passage of the Alaska National Interest Lands Conservation Act (ANILCA) (Public Law

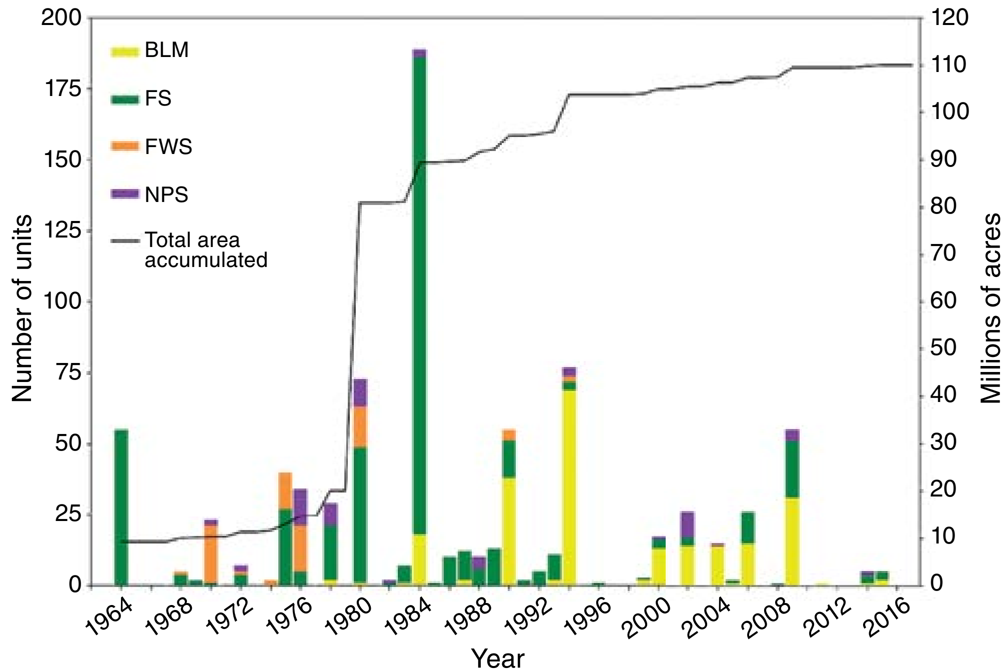

Figure 2.2—Accumulation of wilderness units and size of area (millions of acres) within the National Wilderness Preservation System (NWPS) since 1964. BLM = Bureau of Land Management; FS = USDA Forest Service; FWS = U.S. Fish and Wildlife Service; NPS = National Park Service. NWPS unit and acreage data obtained from Wilderness Connect (2017).

96–487), which added >56 million acres to the NWPS (Dawson and Hendee 2009, Scott 2001). Combined with other wilderness laws passed that year, nearly 61 million acres of wilderness were designated in 1980. This was an area six times greater than the area designated as wilderness in any single year (fig. 2.2).

As of 2018, there are 765 wilderness areas comprising 109,138,248 acres. This area of wilderness is 4.8 percent of the land area of the entire United States and about 16.3 percent of all Federal lands (table 2.2). However, in the contiguous United States (CONUS), area of wilderness occupies 2.8 percent of the land area, and 12.3 percent of all Federal lands.

Federal Management of Wilderness Areas

The Wilderness Act only designates federally managed land as wilderness areas for inclusion in the NWPS (Public Law 88–577). In 1964, the NWPS was established with the designation of 54 wilderness areas managed by the Forest Service (fig. 2.2) (Dawson and Hendee 2009, Scott 2001). In 1968, four Forest Service wilderness areas were added, along with the first FWS wilderness area. In 1969, two Forest Service wilderness areas were added. In 1970, the first 2 NPS wilderness areas were added, along with another 20 FWS wilderness areas and a single Forest Service wilderness area. This brought the total number of wilderness areas to 84. The first two BLM wilderness areas were added in 1978 (fig. 2.2). The 1970s decade saw steady additions to the NWPS across the Forest Service, FWS, NPS, and BLM.

In 1980, the 4 agencies designated a total of 72 new wilderness areas. In 1984, the number of Forest Service wilderness areas more than doubled from 165 to 340, and the number of BLM wilderness areas increased more than seven times from 3 to 22.

In 1990, BLM wilderness areas increased from 24 to 62. The California Desert Protection Act (Public Law 103–433), passed in 1994, more than doubled the number of BLM wilderness areas to 133. The last time a FWS wilderness area was added to the NWPS was in 1994. The next decade saw the addition of 88 BLM wilderness areas, 39 Forest Service wilderness areas, and 15 NPS wilderness areas. However, only 11 new wilderness areas have been added since 2010.

Table 2.2—Total area and percent area of wilderness in each State and in Federal land area by State within the National Wilderness Preservation System (NWPS)

State	Total area of wilderness	Total area of State	Total State area in wilderness	Total area of Federal land	Total Federal land area in wilderness
	-------------------- *acres*	--------------------	*percent*	*acres*	*percent*
Alabama	42,218	32,678,400	0.13	1,202,614	3.51
Alaska	56,572,549	365,481,600	15.48	243,847,037	23.20
Arizona	4,512,120	72,688,000	6.21	36,494,844	12.36
Arkansas	152,742	33,599,360	0.45	3,955,959	3.86
California	14,964,334	100,206,720	14.93	46,979,891	31.85
Colorado	3,735,074	66,485,760	5.62	23,174,340	16.12
Connecticut	—	3,135,360	0	15,212	0
Delaware	—	1,265,920	0	29,488	0
District of Columbia	—	39,040	0	10,284	0
Florida	1,421,587	34,721,280	4.09	4,605,762	30.87
Georgia	488,316	37,295,360	1.31	2,314,386	21.10
Hawaii	155,509	4,150,600	3.75	671,580	23.16
Idaho	4,795,782	52,933,120	9.06	35,135,709	13.65
Illinois	32,172	35,795,200	0.09	651,603	4.94
Indiana	12,472	23,158,400	0.05	534,126	2.34
Iowa	—	35,557,879	0	302,601	0
Kansas	—	51,869,158	0	641,562	0
Kentucky	17,187	25,512,320	0.07	1,706,562	1.01
Louisiana	17,047	28,867,840	0.06	1,501,735	1.14
Maine	18,628	19,847,680	0.09	164,003	11.36
Maryland	—	6,319,360	0	192,692	0
Massachusetts	3,244	5,034,880	0.06	105,973	3.06
Michigan	291,307	36,492,160	0.80	3,638,588	8.01
Minnesota	820,621	51,205,760	1.60	3,534,989	23.21
Mississippi	10,656	30,222,720	0.04	2,101,204	0.51
Missouri	71,914	44,248,320	0.16	2,237,951	3.21
Montana	3,502,496	93,271,040	3.76	29,239,058	11.98
Nebraska	12,437	49,031,680	0.03	1,458,802	0.85
Nevada	3,447,680	70,264,320	4.91	64,589,139	5.34
New Hampshire	138,407	5,768,960	2.40	830,232	16.67
New Jersey	10,341	4,813,440	0.21	180,189	5.74
New Mexico	1,695,010	77,766,400	2.18	26,518,360	6.39
New York	1,380	30,680,960	0	242,441	0.57
North Carolina	111,503	31,402,880	0.36	3,602,080	3.10
North Dakota	39,652	44,452,480	0.09	1,333,375	2.97
Ohio	77	26,222,080	0	457,697	0.02
Oklahoma	24,040	44,087,680	0.05	1,331,457	1.81
Oregon	2,475,735	61,598,720	4.02	30,638,949	8.08
Pennsylvania	9,005	28,804,480	0.03	724,925	1.24
Puerto Rico	10,154	2,192,960	0.46	71,571	14.19
Rhode Island	—	677,120	0	5,318	0
South Carolina	67,445	19,374,080	0.35	1,236,214	5.46
South Dakota	77,692	48,881,920	0.16	2,314,007	3.36
Tennessee	66,548	26,727,680	0.25	2,016,138	3.30
Texas	85,167	168,217,600	0.05	3,171,757	2.69
Utah	1,157,693	52,696,960	2.20	35,024,927	3.31
Vermont	100,874	5,936,640	1.70	450,017	22.42
Virginia	217,160	25,496,320	0.85	2,617,226	8.30
Washington	4,485,800	42,693,760	10.51	13,246,559	33.86
West Virginia	118,811	15,410,560	0.77	1,266,422	9.38
Wisconsin	79,967	35,011,200	0.23	1,981,781	4.04
Wyoming	3,067,696	62,343,040	4.92	31,531,537	9.73
Total	**109,138,248**	**2,272,637,157**	**4.80**	**671,830,869**	**16.25**

— = no data

Sources: NWPS unit and total area (acres) data obtained from Wilderness Connect (2017). Total area (acres) for total State land and Federal land obtained from U.S. GSA (2003). Total area for Puerto Rico obtained from U.S. Census Bureau (1994). Note the total area of Federal land includes lands managed by USDA Forest Service and DOI U.S. Fish and Wildlife Service, Bureau of Land Management, and National Park Service as well as U.S. Department of Defense and other Federal agencies.

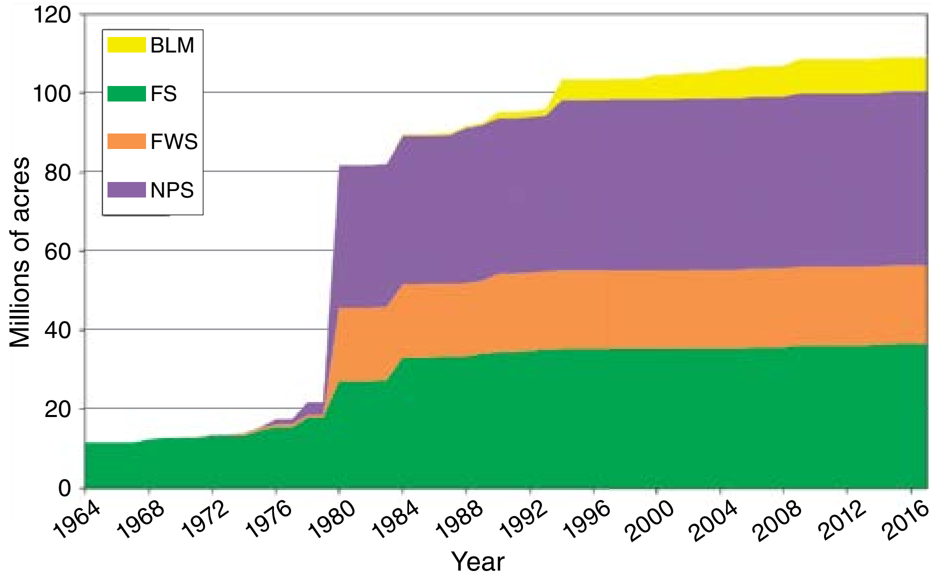

Figure 2.3—The cumulative area (millions of acres) of wilderness areas in the National Wilderness Preservation System (NWPS) by managing agency since 1964. BLM = Bureau of Land Management; FS = USDA Forest Service; FWS = U.S. Fish and Wildlife Service; NPS = National Park Service. NWPS unit and acreage data obtained from Wilderness Connect (2017).

The original 54 Forest Service wilderness areas created in 1964 comprised 9,139,721 acres (fig. 2.3). (Note: At the time of publication, the area for these 54 wilderness areas has increased to 11,554,343 acres because multiple legislated amendments have added acreage to these wilderness areas since their designation.) In 1970, >140,000 FWS acres and >93,000 NPS acres were added to the NWPS. In 1974, wilderness areas managed by FWS increased to 498,557 acres. Passage of ANILCA (Public Law 96–487) in 1980 increased wilderness areas managed by FWS more than 24 times to 18,510,014 acres and by NPS more than 11 times to 36,173,504 acres. Wilderness areas managed by BLM increased more than 22 times in 1984 and then again by more than three times in 1990 and 1994.

Among the 4 Federal agencies that manage wilderness areas, the NPS has the smallest number of wilderness areas at 61 but manages the largest acreage of wilderness with approximately 44 million acres, which represents 40 percent of the total area of the NWPS (table 2.1). The Forest Service manages the largest number of wilderness areas at 445. Forest Service wilderness areas cover >36.5 million acres, which represents 33.5 percent of the area of the NWPS. The FWS manages 71 wilderness areas with nearly 20 million acres, which represents 18 percent of the area of the NWPS, and the BLM manages 224 wilderness areas with nearly 9 million acres, which represents 8 percent of the area of the NWPS.

Among the four agencies that manage wilderness areas, the NPS manages the highest percentage (55 percent) of its total area as wilderness, while the BLM manages the smallest percentage (3.5 percent) (table 2.1). The Forest Service and FWS manage 19 percent and 22 percent of their total area, respectively, as wilderness.

Within the CONUS, the Forest Service manages the greatest amount of wilderness (31 million acres or 59 percent of the area of the NWPS within the CONUS), the NPS manages nearly 11 million acres (21 percent of the area of the NWPS within the CONUS), and the BLM manages 8.8 million acres (17 percent of the area of the NWPS within the CONUS). The FWS manages a little over 2 million acres (4 percent of the area of the NWPS within the CONUS), the smallest amount of wilderness in the lower 48 States.

Size of Individual Wildernesses

There are four wilderness areas in the NWPS with >5 million acres, all in Alaska. The largest wilderness area in the NWPS is the Wrangell-St. Elias Wilderness (NPS) with 9,078,065 acres, almost the same size as the entire NWPS in 1964, and 8.3 percent of the current NWPS area. The largest wilderness area outside of Alaska is the Death Valley Wilderness (NPS) in California and Nevada at 3,102,456 acres. The second largest wilderness area in the conterminous 48 States is the Frank Church-River of No Return Wilderness (Forest Service and BLM) in Idaho at 2,358,095 acres. Nineteen wilderness areas (2.5 percent of the NWPS) are >1 million acres, while 138 (18 percent) are >100,000 acres. The 10,000- to 50,000-acre size class has the greatest number with 336 wilderness areas, or 44 percent of the NWPS.

Although the Wilderness Act of 1964 defined wilderness, in part, as an area that is "at least 5,000 acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition" (Public Law 88–577), there are now 89 wilderness units <5,000 acres, of which 26 are <1,000 acres. The smallest wilderness unit is the 5.5-acre Pelican Island Wilderness (FWS) in Florida.

Distribution of Wilderness Areas Across States

Among the 50 States, Alaska has the greatest percentage of wilderness area (15.5 percent) (table 2.2). Furthermore, Alaska has 56,572,549 acres of wilderness, which represents 52 percent of the area of the NWPS. The State with the next greatest percentage of wilderness is California with 14.9 percent of the State designated as wilderness. In contrast, Connecticut, Delaware, Iowa, Kansas, Maryland, and Rhode Island lack designated wilderness areas. Florida has the most wilderness acreage of any Eastern U.S. State (1,421,587 acres). Area of wilderness in the 11 Western U.S. States (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) comprises slightly under 44 percent of the entire NWPS and nearly 91 percent of the NWPS in the CONUS. In the 37 Eastern U.S. States (i.e., all States east of Montana, Wyoming, Colorado, and New Mexico), the area of wilderness comprises slightly more than 4 percent of the entire area of NWPS and 8.7 percent of the NWPS in the CONUS.

Wilderness areas in the Eastern U.S. States are smaller, while the Western U.S. States have both a greater number of and larger wilderness areas (Landres and Meyer 2000). Western U.S. States have an average of 52 wilderness areas per State, compared to an average of 6 wilderness areas per State in the East. Western U.S. States have an average of 6.2 percent of their land area in wilderness, compared to Eastern U.S. States, which have an average of 0.5 percent land area in wilderness. The average size of a wilderness area in the Western U.S. States is 83,782 acres, compared to 22,918 acres in the Eastern U.S. States. These comparisons show that the 11 Western U.S. States have nearly 8.7 times the average number of wilderness areas per State and over 12 times the average proportion of their State land area in wilderness. Western wilderness areas are also over 3.5 times the average size of eastern wilderness areas.

Conserving Biodiversity in Wilderness Areas

The Wilderness Act of 1964 established the highest level of protection within the U.S. protected area network by designating wilderness areas; hence, the conservation of biodiversity in wilderness areas is vital (Aycrigg and others 2015, Dietz and others 2015). The representation of ecological systems (i.e., habitat types) within wilderness areas is a measure of biodiversity conservation because of the structure, function, and evolutionary potential of natural systems as well as the genetic, species, and community diversity within and supported by ecological systems (Dietz and others 2015). Protecting a representation of ecological systems helps protect the species that rely on them and their ecological processes (Bunce and others 2013, Rodrigues and others 2004). Furthermore, we can assess conservation of biodiversity within wilderness areas by assessing species richness within wilderness areas.

Wilderness areas are especially vital to biodiversity conservation because many anthropogenic stressors are restricted, including road building, logging, mining, energy development, agriculture, mechanical and motorized use, development of tourism facilities, and permanent structures (Public Law 88–577, Sec. 4c). The International Union for Conservation of Nature (IUCN) classifies wilderness as category 1b, which is the highest classification level of protection (IUCN and UNEP 2014). An assignment of category 1b (i.e., "wilderness areas") implies the objective is "to protect the long-term ecological integrity of natural areas that are undisturbed by significant human activity, free of modern infrastructure, and where natural forces and processes predominate, so that current and future generations have the opportunities to experience such areas" (Dietz and others 2015, Dudley 2008).

The concept of representation aims for a system of protected areas that encompasses the full variety of ecological systems across their geographical range to conserve genetic, species, and community diversity (Dietz and others 2015, Margules and Pressey 2000, Olsen and Dinerstein 1998). Dietz and others (2015) evaluated the accumulation of available ecological systems in wilderness areas for the CONUS during 1964–2014. They showed that the total area of the NWPS has risen steadily since 1964; however, the diversity of ecological systems accumulated in wilderness areas (436 ecological systems) reached an asymptote in 1984 (fig. 2.4). The total number of ecological systems found on Federal lands[2] is 553, which leaves 117 (21 percent) ecological systems unrepresented in wilderness areas (fig. 2.4) (Dietz and others 2015). Moreover, the number of ecological systems with >5

[2] There are 565 ecological systems within the lower 48 States, but only Federal lands (which contain 553 ecological systems) can be designated as wilderness.

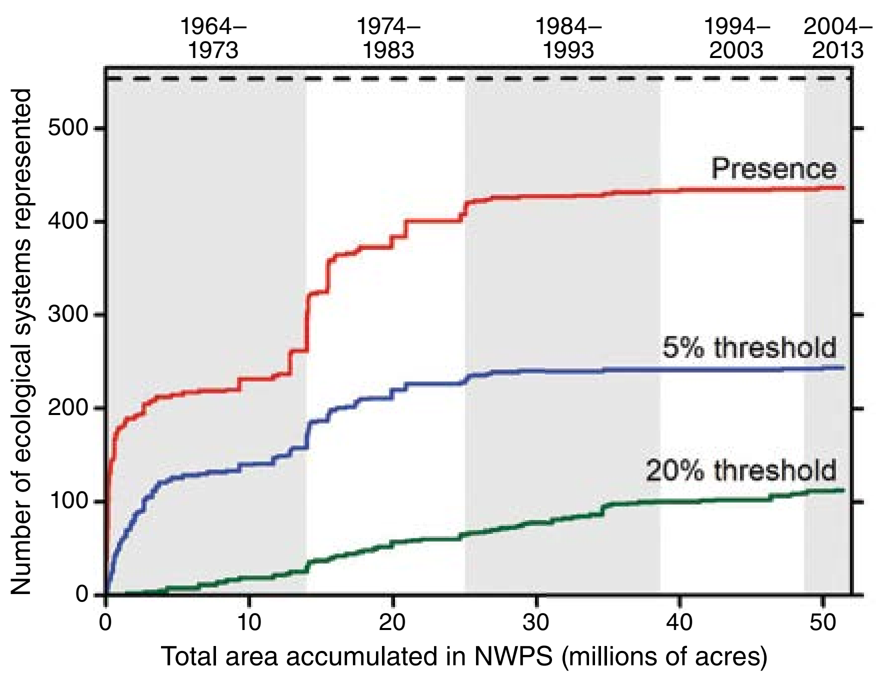

Figure 2.4—Number of unique ecological systems represented in the National Wilderness Preservation System (NWPS) as a function of total area accumulated. The red line indicates nominal presence of an ecological system in the NWPS. The blue and green lines represent ecological systems with >5 and >20 percent, respectively, of Federal land in wilderness. The maximum value along the y-axis represents the total number of ecological systems in the United States, while the dashed line represents the total number of ecological systems on Federal land. Decades starting with the 1964 passage of the Wilderness Act are shown as grey and white shading. Based on Dietz and others (2015).

percent of Federal land area in wilderness is 244; at the 20-percent threshold, this number drops to 113 ecological systems (fig. 2.4) (Dietz and others 2015).

One measure of biodiversity that we can assess within wilderness areas is species richness, which is the number of species occurring within a particular area (i.e., wilderness areas). We used data from Jenkins and others (2015) to assess species richness by taxa (i.e., amphibians, birds, mammals, and reptiles) for the CONUS and within wilderness areas. We assessed the spatial distribution of species richness for all U.S. species and endemic species (figs. 2.5–2.8) (McCarley and Aycrigg 2020). Endemics are those species for which their entire range is within the CONUS (see Jenkins and others 2015).

Most amphibian and reptile species occur in the Southeastern United States; hence, fewer amphibians and reptile species occur in wilderness areas because most wilderness areas occur in the Western United States (figs. 2.5 and 2.8) (McCarley and Aycrigg 2020). However, the difference in the mean number of amphibian and reptile species occurring within wilderness areas is minimally different from the CONUS. This is also the case for endemic amphibian and reptile species (figs. 2.5 and 2.8).

There are a small number of endemic birds within the United States because birds typically have large ranges (Jenkins and others 2015). Furthermore, Jenkins and others (2015) defined endemic bird species by combining both breeding and nonbreeding ranges, which further decreases the number of endemic birds occurring solely within the CONUS. Despite the small number of endemic birds identified by Jenkins and others (2015), the mean number of endemic birds occurring within wilderness areas is slightly more than the CONUS (fig. 2.6).

There were also more total bird species occurring within wilderness areas than the CONUS (fig. 2.6). This suggests that wilderness areas are important to conserving bird diversity, both total diversity and endemic diversity. However, there are high numbers of birds occurring in areas in which few wilderness areas occur (i.e., Midwestern United States) (fig. 2.6).

Wilderness areas are important for mammal diversity conservation because the mean species richness within wilderness areas is greater than for the CONUS (fig. 2.7). Numerous factors influence a species' range size, but large mammals (i.e., grizzly bears [*Ursus arctos*]), in particular, need large ranges in which to survive (Diniz-Filho and others 2005, Gaston 1996, Jenkins and others 2015). Some of the highest mammal-rich areas occur within wilderness areas because they occur in the Western United States, which has numerous wilderness areas (fig. 2.7) (McCarley and Aycrigg 2020). However, the highest numbers of endemic mammal species occur in the Southeastern United States, even though the mean number occurring on wilderness areas is almost equivalent to the mean number occurring within the CONUS (McCarley and Aycrigg 2020).

Overall, the diversity of amphibians, reptiles, birds, and mammals within wilderness areas is near that of the diversity within the CONUS (figs. 2.5–2.8). This could be attributed to the coarse resolution (i.e., 6.2 miles x 6.2 miles) of species range data used by Jenkins and others (2015), which may overestimate the number of species occurring in wilderness areas. Furthermore, the skewness towards one for the endemic species may minimize the actual difference in mean species richness (figs. 2.5–2.8). However, the general findings still indicate the importance of wilderness areas in conserving and providing habitat for numerous species.

Geographic Distribution of Wilderness Areas Within the NWPS

The distribution of wilderness areas within the NWPS as well as the representation of ecological systems and the distribution of biodiversity is a product of its legacy because the Wilderness Act states that the establishment and protection of wilderness areas is a policy of the U.S. Congress, which led to the designation process being influenced

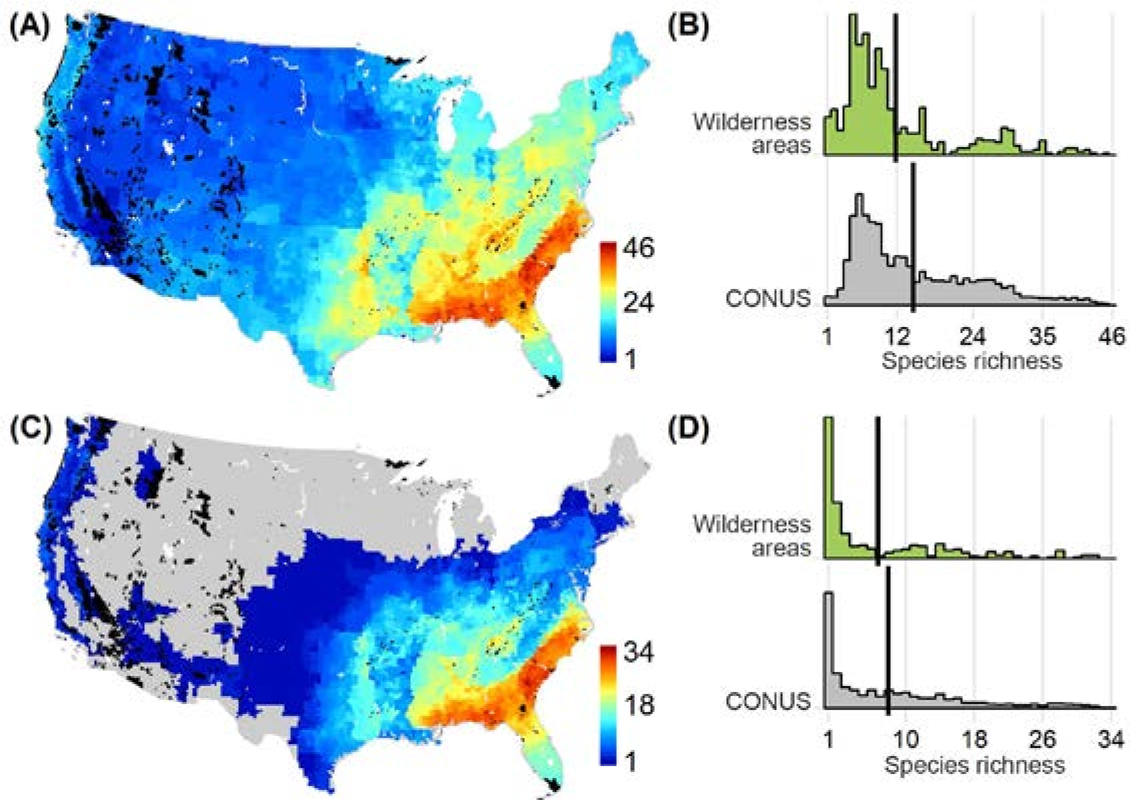

Figure 2.5—Geographic distribution and number of (A, B) amphibian species (n = 270) and (C, D) endemic amphibian species (n = 188) occurring within the CONUS and wilderness areas (shown in black). The vertical black line indicates the mean species richness value (B, D). Data from Jenkins and others (2015). See McCarley and Aycrigg (2020) and Jenkins and others (2015) for more details.

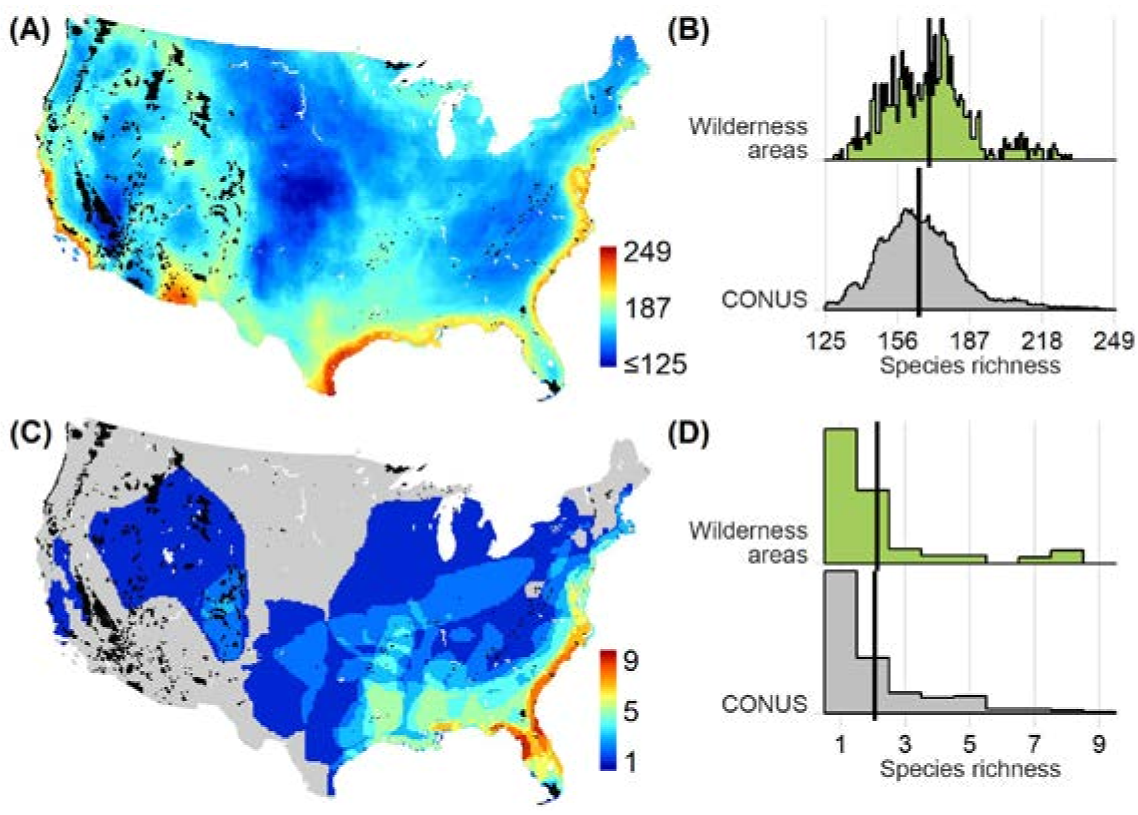

Figure 2.6—Geographic distribution and number of (A, B) bird species (n = 591) and (C, D) endemic bird species (n = 15) occurring within the CONUS and wilderness areas (shown in black). The vertical black line indicates the mean species richness value (B, D). Data from Jenkins and others (2015). See McCarley and Aycrigg (2020) and Jenkins and others (2015) for more details.

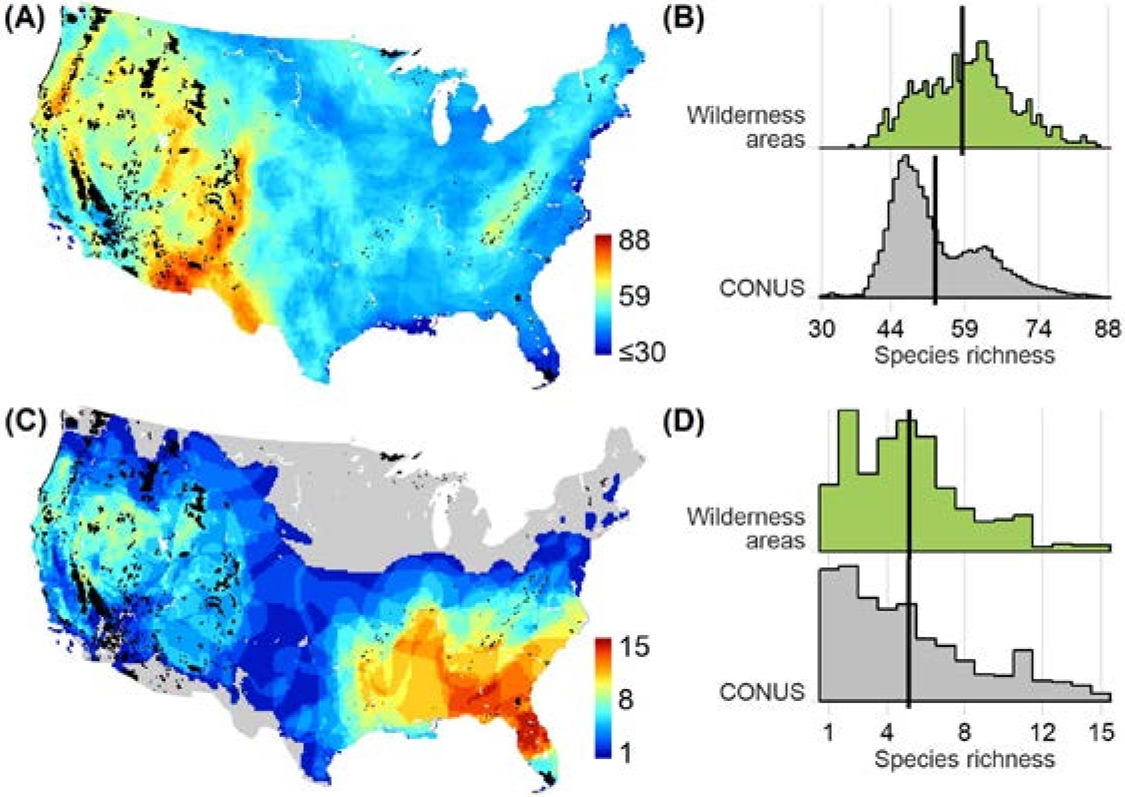

Figure 2.7—Geographic distribution and number of (A, B) mammal species (n = 359) and (C, D) endemic mammal species (n = 102) occurring within the CONUS and wilderness areas (shown in black). The vertical black line indicates the mean species richness value (B, D). Data from Jenkins and others (2015). See McCarley and Aycrigg (2020) and Jenkins and others (2015) for more details.

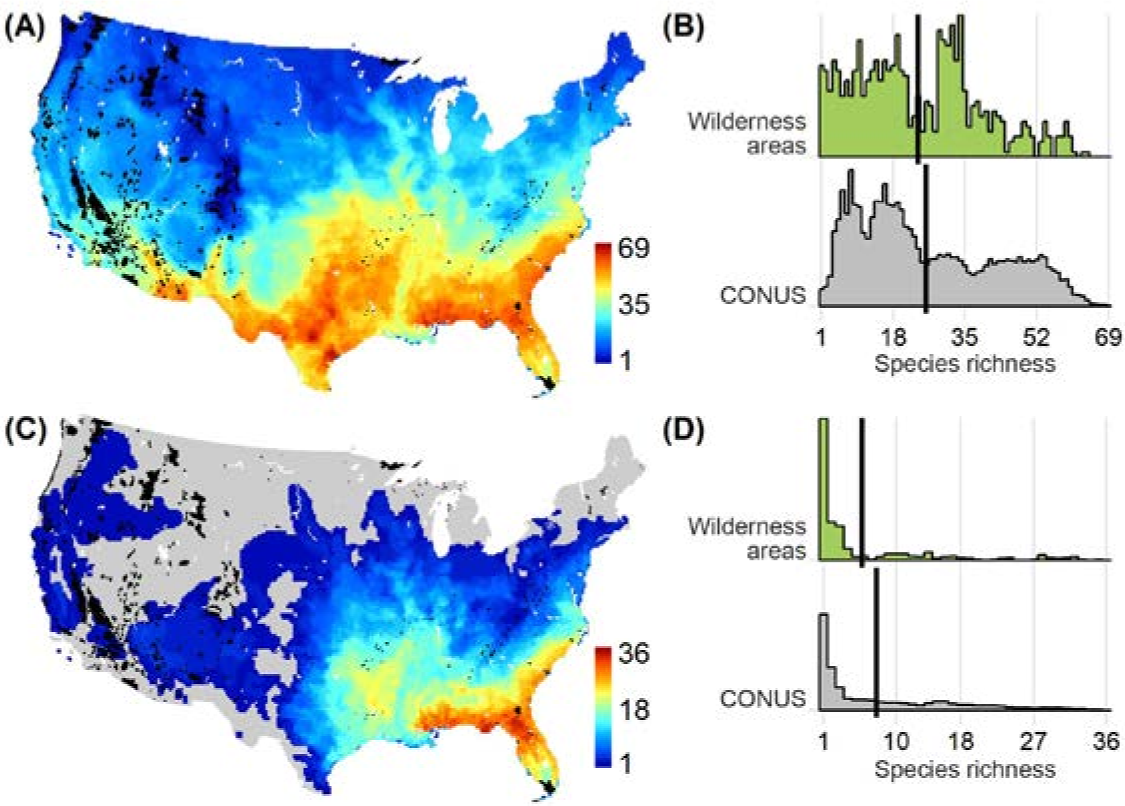

Figure 2.8—Geographic distribution and number of (A, B) reptile species (n = 295) and (C, D) endemic reptile species (n = 89) occurring within the CONUS and wilderness areas (shown in black). The vertical black line indicates the mean species richness value (B, D). Data from Jenkins and others (2015). See McCarley and Aycrigg (2020) and Jenkins and others (2015) for more details.

by additional laws and politics (Public Law 88–577). In 1964, when the Wilderness Act was signed, the Forest Service was the first and only agency to include wilderness areas in the NWPS because these areas were specifically designated (figs. 2.1–2.3) (Dawson and Hendee 2009). Furthermore, the Act directed the Secretaries of Agriculture and Interior to review, within 10 years, roadless lands within their jurisdiction for inclusion in the NWPS (Public Law 88–577). This review led to the development of criteria for wilderness area recommendation, such as distribution of potential wilderness areas across the United States, representation of as many ecosystems as possible, and balance of wilderness values with the opportunities lost to production of goods and services that benefit society (Dawson and Hendee 2009). During the 10-year review period after 1964, many wilderness areas managed by FWS and NPS met the criteria and were recommended for wilderness area designation, but only a few areas were designated by the U.S. Congress (figs. 2.2 and 2.3). Even though the recommended wilderness areas were distributed based on ecological and social criteria, the designated wilderness areas were distributed mostly based on political influence (Dawson and Hendee 2009).

In addition to the Wilderness Act, there were many more acts that influenced how and where designated wilderness areas were located. In 1975, the Eastern Wilderness Act (Public Law 93–622) was signed, which designated more wilderness areas managed by the Forest Service (fig. 2.2) (Scott 2004). Notably, it also included wilderness areas closer to urban areas and of smaller size than previous wilderness area designations (Dawson and Hendee 2009, Scott 2001).

The Federal Land Policy and Management Act (Public Law 94–579) of 1976 provided the BLM with the authority to evaluate and recommend wilderness areas. The BLM was given 15 years to inventory the lands they managed and recommend wilderness areas (Dawson and Hendee 2009). The increase in wilderness designations within BLM during the mid-1980s and early 1990s can be attributed to this act (figs. 2.2 and 2.3).

The Endangered American Wilderness Act (Public Law 95–237) created 1.3 million acres of wilderness in 17 new wilderness areas across the Western United States (i.e., Arizona, California, Colorado, Idaho, New Mexico, Oregon, Utah, Washington, and Wyoming) (Dawson and Hendee 2009, Scott 2004). This act was signed in 1978 and added the largest amount of area to the NWPS up to that time (fig. 2.2). Many of these wilderness areas were managed by the Forest Service because it recommended the wilderness areas to be included.

In 1980, ANILCA added >56 million acres to the NWPS (Public Law 96–487). Most of these wilderness areas were managed by NPS and FWS and, as the name of the act implies, all were located in Alaska (figs. 2.1 and 2.3, table 2.3) (Dawson and Hendee 2009; Scott 2001, 2004). With this act, NPS became the agency with the largest area of wilderness within the NWPS (table 2.3) (Scott 2004). Also, in the 1980s through the United States, there were 21 additional State-by-State national forest wilderness bills that designated about 8 million acres of Forest Service land as wilderness area in 1984 (fig. 2.2) (Scott 2001).

There were 69 new BLM wilderness areas designated in 1994 through the California Desert Protection Act of 1994 (Public Law 103–433) (figs. 2.1–2.3) (Dawson and Hendee 2009, Scott 2001). This act also transferred >3 million acres from BLM to NPS to expand Death Valley and Joshua Tree National Parks and to establish the Mojave National Preserve (Dawson and Hendee 2009, Scott 2001).

The pattern observed in the expansion and distribution of wilderness areas within the NWPS can be explained by these numerous acts authorized by the U.S. Congress. Environmental groups were influential in getting wilderness areas designated and working with the agencies to recommend wilderness areas. Many wilderness areas recommended for designation did not become part of the NWPS, but many could still potentially be designated as wilderness areas.

Table 2.3—Total area of wilderness by managing agency and by State within the National Wilderness Preservation System (NWPS)

State	Area of BLM land	Area of FWS land	Area of FS land	Area of NPS land	Total area of wilderness
	acres				
Alabama	—	—	42,218	—	42,218
Alaska	—	17,852,615	5,740,528	32,979,406	56,572,549
Arizona	1,396,966	1,343,444	1,327,655	444,055	4,512,120
Arkansas	—	2,144	115,665	34,933	152,742
California	3,845,316	9,172	5,098,963	6,010,883	14,964,334
Colorado	205,814	2,560	3,177,278	349,422	3,735,074
Connecticut	—	—	—	—	—
Delaware	—	—	—	—	—
District of Columbia	—	—	—	—	—
Florida	—	51,252	73,835	1,296,500	1,421,587
Georgia	—	362,107	116,303	9,906	488,316
Hawaii	—	—	—	155,509	155,509
Idaho	541,727	—	4,210,812	43,243	4,795,782
Illinois	—	4,050	28,122	—	32,172
Indiana	—	—	12,472	—	12,472
Iowa	—	—	—	—	—
Kansas	—	—	—	—	—
Kentucky	—	—	17,187	—	17,187
Louisiana	—	8,346	8,701	—	17,047
Maine	—	7,392	11,236	—	18,628
Maryland	—	—	—	—	—
Massachusetts	—	3,244	—	—	3,244
Michigan	—	25,309	89,684	176,314	291,307
Minnesota	—	6,180	814,441	—	820,621
Mississippi	—	—	6,026	4,630	10,656
Missouri	—	7,730	64,184	—	71,914
Montana	6,347	64,535	3,431,614	—	3,502,496
Nebraska	—	4,635	7,802	—	12,437
Nevada	2,079,696	—	1,131,195	236,789	3,447,680
New Hampshire	—	—	138,407	—	138,407
New Jersey	—	10,341	—	—	10,341
New Mexico	170,163	40,048	1,428,407	56,392	1,695,010
New York	—	—	—	1,380	1,380
North Carolina	—	8,785	102,718	—	111,503
North Dakota	—	9,732	—	29,920	39,652
Ohio	—	77	—	—	77
Oklahoma	—	8,570	15,470	—	24,040
Oregon	246,953	387	2,228,395	—	2,475,735
Pennsylvania	—	—	9,005	—	9,005
Puerto Rico	—	—	10,154	—	10,154
Rhode Island	—	—	—	—	—
South Carolina	—	29,000	16,745	21,700	67,445
South Dakota	—	—	13,548	64,144	77,692
Tennessee	—	—	66,548	—	66,548
Texas	—	—	38,317	46,850	85,167
Utah	260,356	—	772,931	124,406	1,157,693
Vermont	—	—	100,874	—	100,874
Virginia	—	—	137,581	79,579	217,160
Washington	7,140	805	2,734,755	1,743,100	4,485,800
West Virginia	—	—	118,811	—	118,811
Wisconsin	—	29	46,438	33,500	79,967
Wyoming	—	—	3,067,696	—	3,067,696
Total	**8,760,478**	**19,862,489**	**36,572,721**	**43,942,561**	**109,138,249**

— = no data

BLM = Bureau of Land Management; FS = USDA Forest Service; FWS = U.S. Fish and Wildlife Service; NPS = National Park Service.

Sources: NWPS unit and total area (acres) data obtained from Wilderness Connect (2017).

The Potential To Designate New Wilderness Areas

The Wilderness Act specifies that Congress can designate an area as wilderness and that only Federal lands are eligible for inclusion in the NWPS (Public Law 88–577, Sec. 2a). Initially, the Wilderness Act provided for establishing a wilderness system (Dawson and Hendee 2009) by proclaiming that all lands administered by the Forest Service as "wilderness," "wild," or "canoe" areas prior to 1964 would be designated wilderness areas. Furthermore, the Secretaries of Agriculture and Interior reviewed roadless areas within their respective jurisdictions and by 1974 recommended to the President the suitability of these areas for designation as wilderness. The Secretaries are to give public notice of proposed wilderness areas and hold public hearings to solicit views on the proposed areas from various stakeholders or interest groups, which must be included with any recommendations to the President and to the U.S. Congress (Public Law 88–577). Essentially, this is the process for designating new wilderness areas.

The Wilderness Act broadly defined wilderness, and input of citizens and congressional action have influenced the character of the NWPS (Worf 1980). Initially, areas that had significant human-caused impacts were not considered for wilderness designation (Dawson and Hendee 2009). However, in 1975, the Eastern Wilderness Act designated 15 new wilderness areas in the Eastern United States, including areas that were near urban areas, typically smaller in size, and showed more past evidence of human use than previously designated wilderness areas (Dawson and Hendee 2009). This change broadened the scope of which lands could be eligible for wilderness area designation; influenced the inventory, review, and recommendation process for all the wilderness managing agencies; and allowed stakeholder groups a greater role in the wilderness area designation process (Dawson and Hendee 2009).

To date, all four wilderness managing agencies (BLM, FS, FWS, and NPS) manage areas recommended as wilderness. Using the areas recommended as wilderness, Aycrigg and others (2015) expanded upon the analysis completed by Dietz and others (2015) to explore the potential for increasing the diversity and representation of ecological systems within the NWPS. More specifically, the objectives were to determine the change in how many ecological systems (i.e., diversity) and what proportion of an ecological system (i.e., representation) were included when areas recommended as wilderness were added to the NWPS (Aycrigg and others 2015).

Aycrigg and others (2015) identified four land designation categories in the following sequence for potential addition to the NWPS (see Aycrigg and others [2015] for more information on each of the designation categories):

1. **NPS lands that are not designated as wilderness but are eligible for wilderness area designation** (excluding national parks established for cultural resources, as scenic roadways, or <5,000 acres [i.e., the minimum size for wilderness areas] [Public Law 88–577, Sec. 2c]).
2. **Lands currently managed so as not to degrade their wilderness character**—This includes congressionally or administratively recommended wilderness, such as Forest Service and BLM Wilderness Study Areas, and wilderness areas recommended by Forest Service, BLM, and FWS.
3. **Forest Service Inventoried Roadless Areas (IRAs) not included in the second category above.**
4. **BLM roadless areas not included in the second category above.**

These categories were chosen because they represent the current level of protection for these lands and the likelihood of gaining public support for their addition to the NWPS.

The spatial data included the boundaries of wilderness areas in the NWPS (Wilderness Connect 2017), national park boundaries from the Protected Areas Database of the United States (PAD-US version 1.3) (USGS GAP 2012), boundaries of lands managed so as not to degrade their wilderness character and Forest Service IRAs (aggregated data from the four agencies), and BLM roadless area boundaries (Zachmann and others 2014). The National GAP Land Cover dataset of ecological systems was used to quantify the diversity and representation of ecological systems in the four designation categories (USGS GAP 2011; see also Aycrigg and others 2013, Dietz and others 2015). Only ecological systems that represent natural and seminatural vegetation were included, while highly human-modified areas (e.g., high-intensity development, cultivated cropland) and open water, such as fresh, brackish/salt, and aquaculture, were excluded (Aycrigg and others 2015).

The results of Aycrigg and others (2015) show that within the CONUS, the NWPS encompasses 51.6 million acres (12.8 percent of Federal lands). The NPS lands that are not designated as wilderness include 14.5 million acres (3.6 percent of Federal lands), while lands managed so as not to degrade their wilderness character consist of 16.6 million acres (4.1 percent), Forest Service IRAs are 39.2 million acres (9.8 percent), and BLM roadless areas are 72.3 million acres (18 percent) (Aycrigg and others 2015). Including all four land designation categories would increase the area of the NWPS by 142.7 million acres and comprise 48.3 percent of all Federal land within the CONUS.

An additional 46 ecological systems would be represented in the NWPS if all 4 land designation categories were added (fig. 2.9) (Aycrigg and others 2015). This is a 9-percent increase in total diversity of ecological systems within the NWPS. Even though this is a small

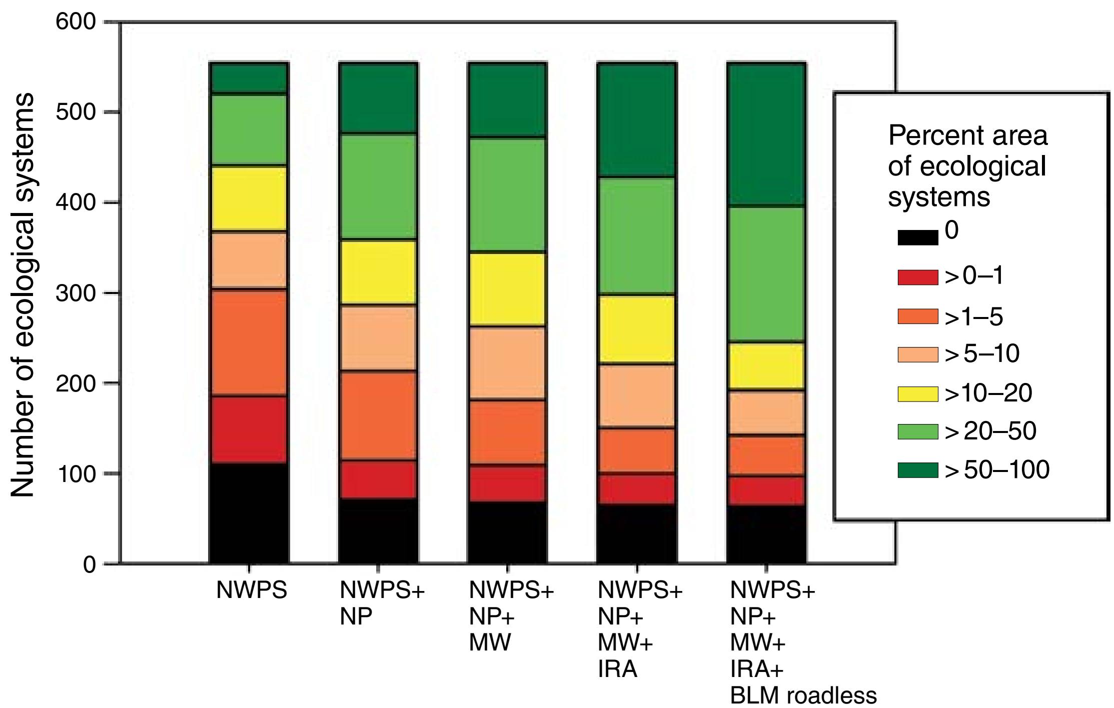

Figure 2.9—Number of ecological systems in the National Wilderness Preservation System (NWPS) plus each cumulative land designation category shown by percent area of those ecological systems. The four land designation categories are: all NPS lands (NP) that have yet to be designated wilderness within the NPS lands; lands managed so as not to degrade their wilderness character (MW) and that have been studied by Congress or recommended by Federal land management agencies, including FS, BLM, and FWS, for wilderness designation; the remaining FS Inventoried Roadless Areas (IRA); and the remaining BLM roadless lands (BLM roadless). Each category is spatially separated from the others. BLM = Bureau of Land Management; FS = USDA Forest Service; FWS = U.S. Fish and Wildlife Service; NPS = National Park Service. See Aycrigg and others (2015) for more details.

Table 2.4—Accumulated area, total diversity, and representation of ecological systems in the National Wilderness Preservation System (NWPS) plus each of four land designation categories that could be added to the NWPS

Land designation category[a]	Accumulated area	Total diversity	Representation						
	millions of acres	*number*	*number by percent area*						
			0	>0–1	>1–5	>5–10	>10–20	>20–50	>50–100
NWPS	51.6	444	110	76	118	64	73	79	34
NWPS + NPS	66.2	483	71	43	99	73	73	117	78
NWPS + MW	68.2	449	105	65	96	76	85	91	36
NWPS + IRA	90.9	453	101	62	87	64	60	110	70
NWPS + BLM roadless	124.0	449	105	59	76	57	77	135	45
NWPS + NPS + MW + IRA + BLM roadless	194.4	490	64	33	45	50	53	151	158

NPS = All national park lands that have yet to be designated wilderness within the National Park Service; MW = Lands managed so as not to degrade their wilderness character and that have been studied by Congress or recommended by Federal land management agencies, including Forest Service, Bureau of Land Management, and U.S. Fish and Wildlife Service for wilderness designation; IRA = Remaining Forest Service Inventoried Roadless Areas; BLM roadless = Remaining Bureau of Land Management roadless lands.

[a] Each category is spatially separate from the others. See Aycrigg and others (2015) for more details.

percentage increase in ecological systems overall, the ecological systems with >20-percent representation increased from 20 percent to 56 percent (or 113 to 309 ecological systems) (fig. 2.9). This increase in representation comes from including more area within the NWPS of 196 ecological systems (note the increase of green in the bars in fig. 2.9; table 2.4).

The increase in representation of ecological systems at the >20-percent level occurs mostly in the West, but also in the Appalachian Mountains, Florida peninsula, Texas, and Northeastern United States (fig. 2.10) (Aycrigg and others 2015). The large increase in representation of ecological systems in the West can be attributed to where most Federal land occurs.

Even though the result of adding all four land designation categories to the NWPS is the same no matter what sequence of land designation categories is used, adding the land designation categories individually instead of sequentially to the NWPS differs (Aycrigg and others 2015). The greatest diversity of ecological systems is obtained by adding the NPS lands (table 2.4). However, the greatest representation of ecological systems in the >20-percent group and the largest total area would be obtained by adding the BLM roadless areas (table 2.4).

Aycrigg and others (2015) showed there are opportunities for increasing the ecological systems diversity and representation within the NWPS. Adding all four land designation categories eligible for wilderness area designation would increase the >20-percent representation of ecological systems in wilderness areas by 56 percent.

Beyond increasing diversity and representation of ecological systems, expanding the NWPS has other benefits. The size of individual wilderness areas could be increased, which would reduce habitat fragmentation and conserve current ecological processes (i.e., plant and animal dispersal) (Aycrigg and others 2015, Groves 2003). Even though biodiversity within wilderness areas may be similar to that of the CONUS, expansion of the NWPS could increase protection of threatened and endangered species by reducing habitat fragmentation and thereby preserving biodiversity. Current research is building on our species richness analysis but using higher resolution data for species ranges, which will improve the representation of species occurring within wilderness areas.

Increasing the area of the NWPS could also minimize the influence of direct and indirect threats (i.e., land use and climate change) occurring outside the boundaries of protected Federal lands (e.g., NPS and Forest Service lands) (Geldmann and others

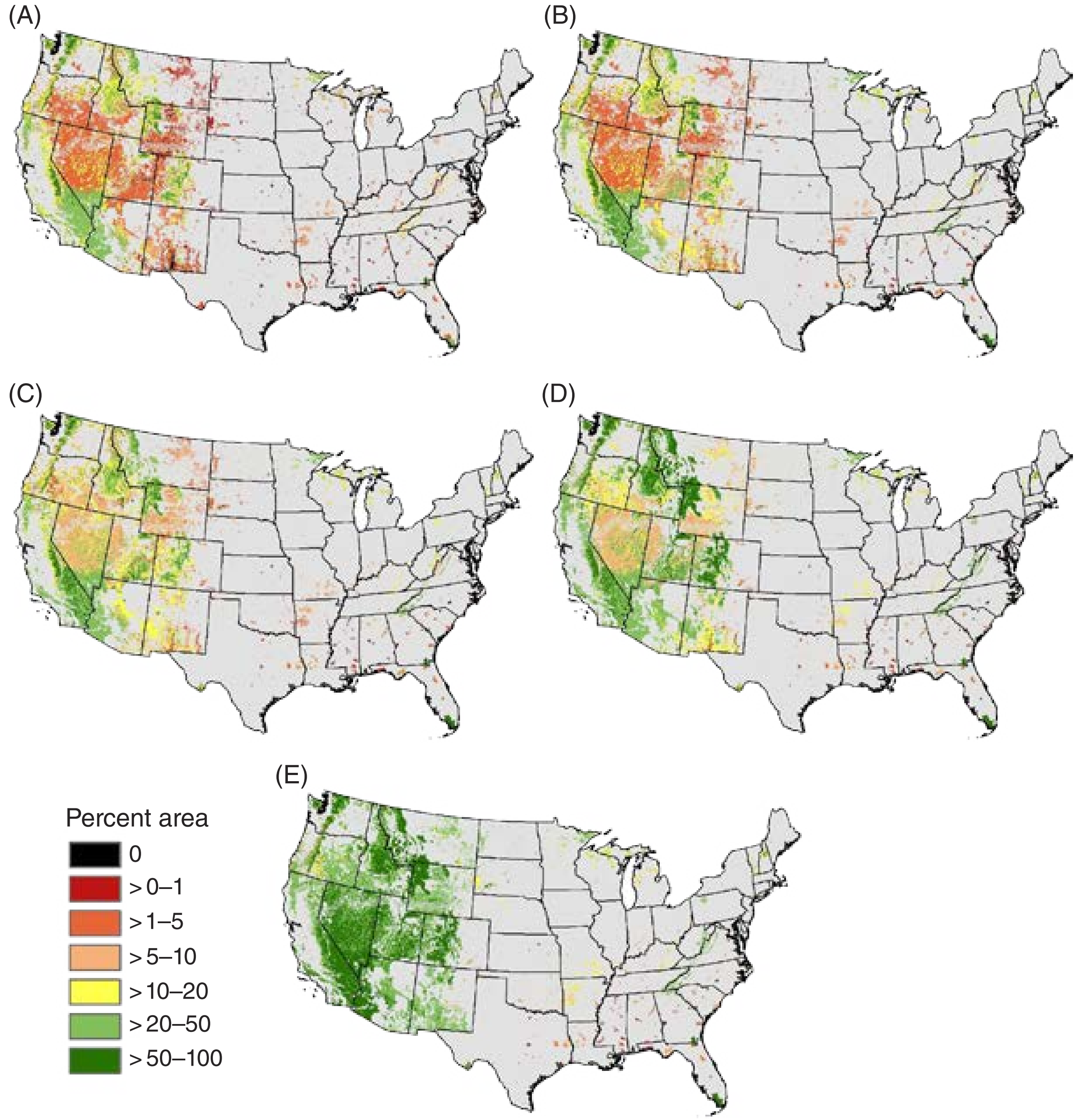

Figure 2.10—Percent area of ecological systems in the National Wilderness Preservation System (NWPS) within the CONUS plus each of four land designation categories by percentage group. (A) NWPS; (B) all NPS lands that have yet to be designated wilderness within the NPS; (C) lands managed so as not to degrade their wilderness character and that have been studied by Congress or recommended by Federal land management agencies, including FS, BLM, and FWS, for wilderness designation; (D) the remaining FS Inventoried Roadless Areas (IRA); (E) the remaining BLM roadless lands. The percent area is based on the total area of each ecological system within the total area of Federal lands, which includes the area in all the above categories plus the Federal land area excluded from the above categories. Each category is spatially separated from the others. BLM = Bureau of Land Management; FS = USDA Forest Service; FWS = U.S. Fish and Wildlife Service; NPS = National Park Service. See Aycrigg and others (2015) for more details.

2013, Martinuzzi and others 2015). Urban expansion around wilderness areas is and will continue to be a major threat to the integrity of wilderness areas and their surrounding natural vegetation (Martinuzzi and others 2015). The Eastern United States and west coast are projected to experience the greatest changes in the surrounding land use according to future scenarios modeled by Martinuzzi and others (2015). The opportunity to expand the NWPS could be critical for minimizing the direct and indirect influences of land use change (Aycrigg and others 2015). The increasing rate of land use and climate change increases the importance of using wilderness areas as a baseline for evaluating these changes (Belote and others 2016). Furthermore, evaluating the connectivity or degree of isolation of wilderness areas as well as the threats to connectivity will be important for maintaining the integrity of wilderness areas. Current research is delving into the impacts of land-use change surrounding wilderness areas and climate change in and around wilderness areas. The wilderness areas most vulnerable to these changes will be assessed. Future research could determine the barriers that prevent or minimize connectivity between wilderness areas (see Belote and others 2016).

Proximity of Wilderness Areas to Large Cities

Even if the diversity and representation of ecological systems were increased through adding wilderness areas to the NWPS, there would still be the concern of urban development occurring around protected areas and more specifically around wilderness areas (fig. 2.11). One of the criteria used by the Forest Service for recommending wilderness areas for inclusion in the NWPS was to identify some near urban areas (Dawson and Hendee 2009). Furthermore, the Eastern Wilderness Act of 1975 designated wilderness areas near urban areas. However, the proximity of urban areas to wilderness areas has benefits and drawbacks. Benefits include accessibility of wilderness areas to an urban population, which could increase the value and interest in existing wilderness areas as well as the natural processes provided by wilderness areas, such as clean water (Watson and others 2015). Drawbacks include the risk of recreational overuse, introduction of invasive species, habitat

Figure 2.11—U.S. cities with a population ≥500,000 surrounded by a 150-mile buffer. Wilderness areas within the National Wilderness Preservation System (NWPS) are shown. NWPS boundaries obtained from Wilderness Connect (2017) and U.S. major cities data as of 2010 obtained from ESRI (2017).

fragmentation, and isolation of individual wilderness areas (Foley and others 2005).

Thirty-three U.S. cities with populations ≥500,000 as of 2010 were obtained from ESRI (2017). A 150-mile buffer was placed around each city (fig. 2.11). This represents the distance a visitor to a wilderness area could drive within 1 day. It indicates what wilderness areas are within a 1-day drive of a major U.S. city. The boundaries of the NWPS were obtained from Wilderness Connect (Wilderness Connect 2017) and overlaid onto the U.S. cities with the 150-mile buffer.

Data from the U.S. Department of Commerce, Census Bureau on total population and housing density in 1990, 2000, and 2010 were used to determine percentage of change in population and housing density (number of housing units per 150-mile buffer area) between 1990–2000 and between 1990–2010 for the 33 cities with populations ≥500,000. The U.S. Census Bureau data were modified to standardize the census block data between decades (University of Wisconsin 2017).

Because wilderness areas occur predominantly in the Western United States, Western U.S. cities have the highest number of wilderness areas (i.e., Las Vegas, NV, and Phoenix, AZ) and have the largest area of wilderness (Las Vegas, NV, and Seattle, WA) within a 150-mile buffer (fig. 2.12). Charlotte, NC, has 21 wilderness areas within a 150-mile buffer, making it the Eastern U.S. city with the highest number of wilderness areas surrounding it (figs. 2.11 and 2.12). The Eastern U.S. city with the most area of wilderness surrounding it is Jacksonville, FL (fig 2.12). Furthermore, all cities with less area of wilderness area than Jacksonville, FL, occur in the East, while all cities with more area of wilderness occur in the West. This is another indication that there is a western bias in where wilderness areas are located. This pattern is not as apparent in the number of wilderness areas, but the only cities in the Western United States with fewer wilderness areas within a 150-mile buffer than Charlotte, NC, are San Francisco and San Jose, CA, and El Paso, TX (figs. 2.11 and 2.12).

All cities with populations ≥500,000 had a positive change in population between 1990 and 2010 except Detroit (fig. 2.13). The largest percentages of change occurred in mostly Western U.S. cities (i.e., Las Vegas, NV; Phoenix and Tucson, AZ), but Austin and San Antonio, TX, as well as Jacksonville, FL—all Eastern U.S. cities—also had large percentages of change in population between 1990 and 2010. Most Eastern U.S. cities had the smallest percentages of change in population between 1990 and 2010.

Change in housing density is not only an index to accessibility of wilderness areas, but also of land use change and potentially habitat fragmentation. As more area is developed for housing, less area is available for connecting wilderness areas or protected areas, in general (Belote and others 2016). Regarding housing density changes, Las Vegas, NV, not only had the largest percentage of change in population between 1990 and 2010, but also had the largest percentage of change in housing density between 1990 and 2000 and between 1990 and 2010 (fig. 2.14). Among cities in the Eastern United States, Jacksonville, FL, had the largest percentage of change in housing density between 1990 and 2010. Geographic patterns in housing density changes between 1990 and 2010 are not apparent, but all cities had an increase in housing density during this time.

These changes in population and housing densities in cities within a 150-mile buffer of wilderness areas could indicate greater accessibility to these wilderness areas. This could lead to a greater number of visitors and more frequent visits to wilderness areas (Holmes and others, this volume, ch. 6). More visitors to wilderness areas could increase wilderness appreciation, including appreciation for the ecosystem services provided by wilderness and the plants and wildlife that exist within wilderness areas (Rasch 2018). Clean water is an ecosystem service provided by wilderness areas that is vital to visitors of wilderness areas and residents of cities (Meldrum and Huber, this volume, ch. 8; Rasch 2018; Watson and others 2015).

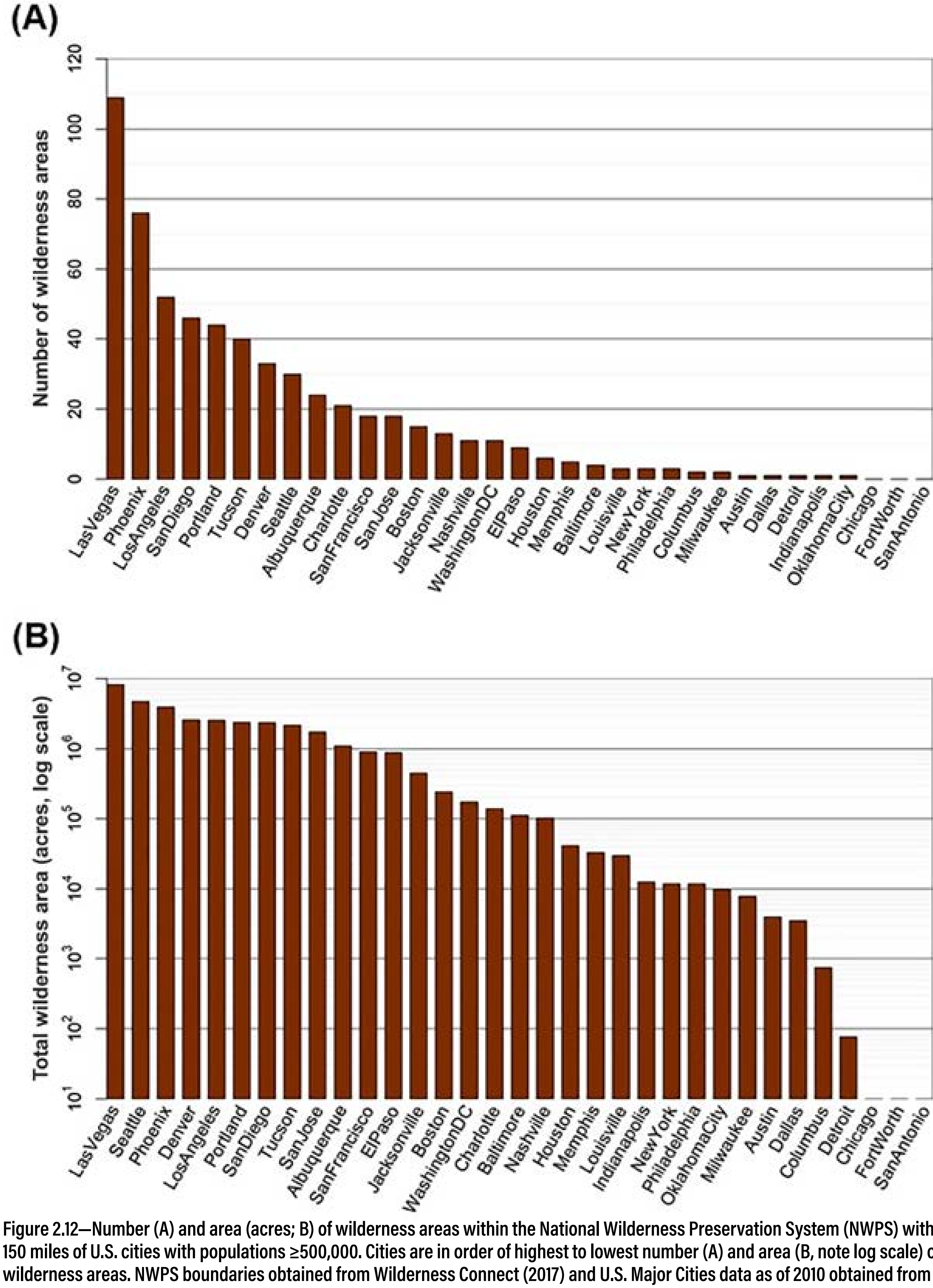

Figure 2.12—Number (A) and area (acres; B) of wilderness areas within the National Wilderness Preservation System (NWPS) within 150 miles of U.S. cities with populations ≥500,000. Cities are in order of highest to lowest number (A) and area (B, note log scale) of wilderness areas. NWPS boundaries obtained from Wilderness Connect (2017) and U.S. Major Cities data as of 2010 obtained from ESRI (2017).

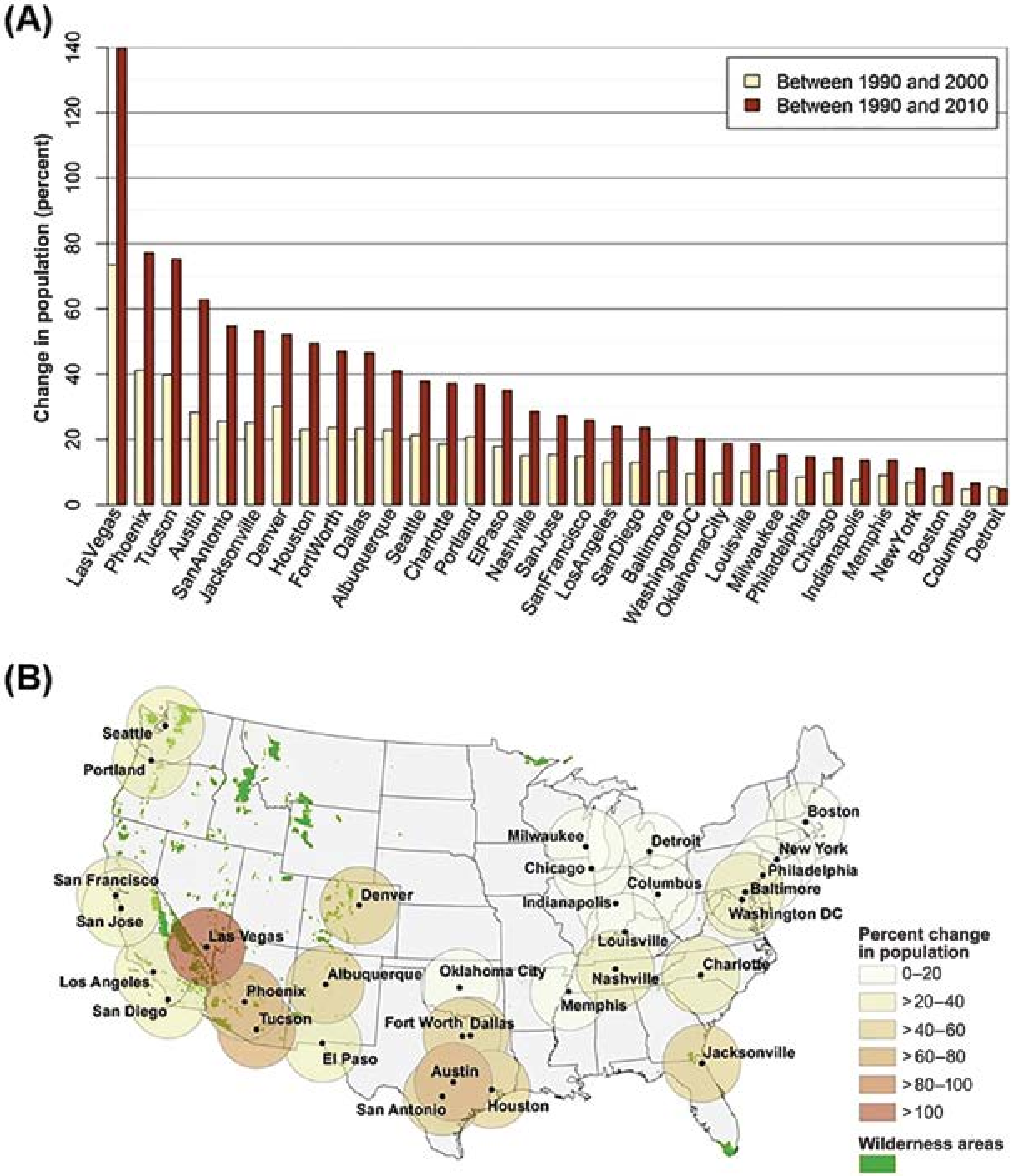

Figure 2.13—Percentage of change in population during 1990–2000 and 1990–2010 (cumulative; A) and the spatial representation of percentage of change in population during 1990–2010 (cumulative; B) for U.S. cities with populations ≥500,000. Cities are in order of highest to lowest percentage of change in population during 1990–2010. Percentage of change in population based on total population data from the University of Wisconsin (2017). NWPS boundaries obtained from Wilderness Connect (2017) and U.S. major cities data as of 2010 obtained from ESRI (2017).

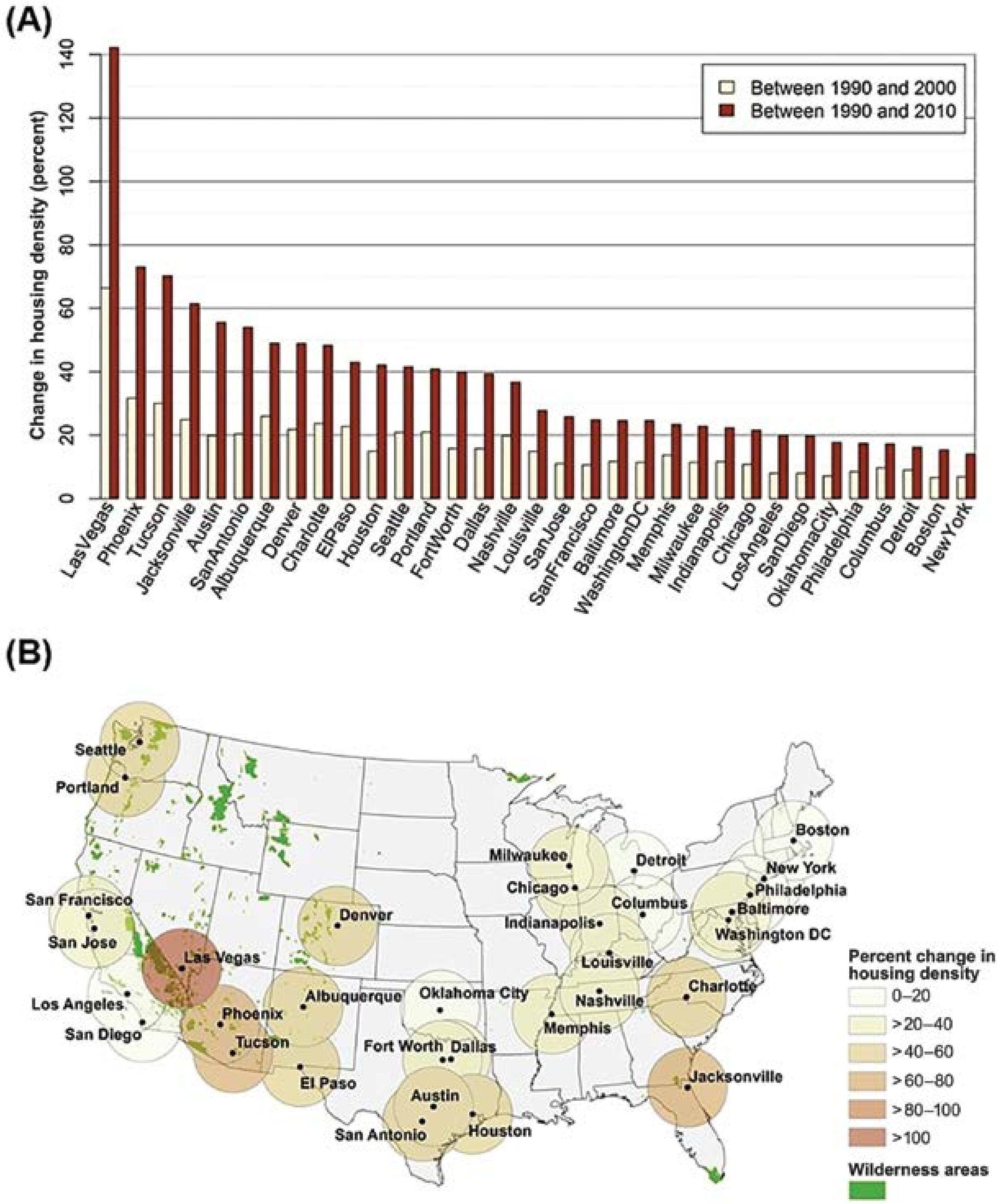

Figure 2.14—Percentage of change in housing density (number of houses per 150-mile buffer area) between 1990–2000 and between 1990–2010 (cumulative; A) and the spatial representation of percentage of change in housing density during 1990–2010 (B) for U.S. cities with populations ≥500,000. Cities are in order of highest to lowest percentage of change in housing density during 1990–2010. Percentage of change in housing density based on total number of housing units from the University of Wisconsin (2017). NWPS boundaries obtained from Wilderness Connect (2017) and U.S. major cities data as of 2010 obtained from ESRI (2017).

Greater accessibility to wilderness areas also has drawbacks, such as potential introduction of invasive species, illegal harvest of native species, increased habitat fragmentation, and isolation of wilderness areas (Radeloff and others 2005, 2010). Increasing housing density over time limits the potential to reduce habitat fragmentation by connecting isolated wilderness areas. Radeloff and others (2010) found that the housing growth by decade within 50 km of wilderness areas during 1940–1990 exceeded the U.S. average.

Given the benefits and drawbacks of population and housing density changes within cities having populations ≥500,000 within 150 miles of wilderness areas, a new project is underway to evaluate the land use impacts occurring around all wilderness areas within the NWPS. This project will identify the wilderness areas most at risk to the impacts of land use change as well as assess how other federally managed lands could reduce the risk of land use impacts to wilderness areas.

Summary

Wilderness areas have expanded greatly since the Wilderness Act was passed in 1964, and now the NWPS encompasses >109 million acres, which is about 16.3 percent of all federally managed lands. Despite this expansion and because wilderness areas are vital to biodiversity conservation, there is a lack of diversity and representation of ecological systems (i.e., habitat types) within the NWPS. However, land exists that is managed as wilderness that could be designated as wilderness. Strategic additions of designated wilderness could increase both the diversity and representation of ecological systems and preserve species biodiversity within the NWPS. The importance of further strategic expansion and connectivity of the NWPS becomes apparent when evaluating the number of wilderness areas within 150 miles of cities with populations ≥500,000 and the rates of population and housing density change. The future integrity of the NWPS to conserve biodiversity and maintain wilderness character depends on understanding the current state of the NWPS and the factors, such as land use and climate change, that will shape it.

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3

Societal Relevance of Wilderness Lands

Rebecca Rasch

Cohutta Wilderness (37,033 total acres) in Georgia and Tennessee was designated in 1975 and is administered by the USDA Forest Service. (Courtesy photo by wilderness.net/Steve Boutcher)

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KEY MESSAGES

- Some wilderness values may be shifting in younger generations though ecosystem protection values are seemingly universal across generations.
- Nonuse values may be losing their appeal for younger cohorts who are less likely to have had firsthand experiences connecting with and/or being inspired by natural settings.
- Younger generations may be more in favor of active wilderness management, including restoration and intervention projects.
- There is a clear need to collect more recent data on wilderness values to ensure that wilderness managers are keeping in step with newly emerging public values and attitudes toward wilderness preservation and management.

Introduction

Since 1964, the year the Wilderness Act (Public Law 88–577) was passed, American society has become more urban, more educated, more culturally diverse, and more attached to new media technologies. In 1964, only 11.7 percent of males and 6.8 percent of females had completed at least 4 years of college. By 2015, those numbers had increased dramatically, to 32.3 percent and 32.7 percent, respectively (U.S. Census Bureau 2016a). New media technologies, such as social networking, online gaming, and instant messaging, have also become increasingly more intertwined with everyday activities. In 1964, mobile computing was still science fiction. Today, smart phones are ubiquitous. This phenomenon of increasing embeddedness of new media technology in everyday life has grown exponentially, particularly in younger generations. A Pew Research Center survey found that 24 percent of teenage respondents were online "almost constantly" (Lenhart and others 2015). Given these changing demographics and technological trends, it is reasonable to question whether environmental values in general, and wilderness values in particular, are changing as well. Environmental values, for the purposes of this discussion, refer to people's concern for environmental issues and levels of nature-relatedness, i.e., one's subjective connection to nature. While other chapters in this report discuss values in monetary terms, this chapter focuses on values from a nonmonetary perspective. It provides insight into trends related to societal concern for environmental issues and/or connections to nature, which can be considered indicators of the relevance of the social construct of wilderness in today's society.

Environmental Values and Connections to Nature

Data relating to environmental concern in the General Social Survey (GSS) provide insight into the state of environmental values in American society and how those might be shifting in younger generations. The GSS is a project of NORC at the University of Chicago, an independent research organization, with principal funding from the National Science Foundation. The survey provides nationally representative survey data designed to chart changes in social characteristics and attitudes in American society (Smith and others 2015). In 2010, the vast majority of Americans surveyed did not consider the environment a top concern. Top concerns were healthcare, education, and the economy. However, over half of Americans were concerned, and a third were very concerned, about environmental issues. The most important environmental problem identified in the GSS was "using up our natural resources." Analysis of the 2010 data suggests that younger generations have different environmental values compared to those born in the baby boom generation (those born between 1946 and 1964). Younger birth cohorts, those born post-1970, are more likely than those born pre-1970 to agree with the following statement: "Modern science will solve our environmental problems with little change to our way of life" (Smith and others 2015).

It is possible to glean additional understanding of how traditional environmental values may be shifting by looking at trends in fishing, hunting, and wildlife-associated recreation over the past 30 years. While participation in outdoor recreation is not a prerequisite for developing a connection to nature, those who do participate in nature-related activities tend to have strong connections to nature and are concerned about environmental issues. The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, a project of the U.S. Fish and Wildlife Service of the U.S. Department of the Interior, collects data on national recreation trends (USFWS and U.S. Census Bureau 2014). Comparable data are available for some questions as far back as 1980 and as recently as 2011.[1] Between 1991 and 2011, participation rates in fishing, hunting, and wildlife viewing declined on a per capita basis. However, spending related to these activities increased overall. The sharpest declines in participation were for children aged 6 to 15. For example, in 1985, 51 percent of children engaged in wildlife watching. By 2011, that number dropped down to 31 percent. In 2011, only 29 percent of children self-identified as sportspersons (those who engaged in hunting, fishing, or both), compared with 34 percent in 1980. There are also significant variations in child wildlife-related recreation participation across States. In 2011, States with the highest rates of children engaged in wildlife viewing away from their homes included Idaho (44 percent), Wyoming (42 percent), South Dakota (37 percent), Montana (36 percent), and Vermont (30 percent). States with the lowest rates were Oklahoma (9 percent), Texas (8 percent), Alabama (7 percent), Pennsylvania (6 percent), and South Carolina (5 percent) (fig. 3.1). While close proximity and easy access to nature likely contribute to these disparities, there are also cultural issues at play. Rasch and Hahn (2018), in their work examining metropolitan populations with the highest rates of visitation to wilderness areas on Forest Service lands, find that even when some populations are located within close proximity to wilderness areas, they may not have high rates of visitation. This phenomenon is possibly due to the availability of a plethora of leisure activities which urban populations find more appealing.

There are also connections between socioeconomic status, ethnicity, and wildlife-associated recreation participation among children (USFWS and U.S. Census Bureau 2014). Children from low-income families and Hispanic children have the lowest levels of participation in wildlife-associated recreation. Non-Hispanic children were nearly twice as likely to participate in wildlife watching, compared to Hispanic children, in 2011 (34 percent of non-Hispanic children compared to 18 percent of Hispanic children).

Cultural differences in wildlife value orientations (WVO) may partially explain the observed disparities in rates of participation in wildlife-related recreation across ethnic groups. The WVO framework identifies a continuum of wildlife values, where a "domination of wildlife" view occupies one end of the value orientation spectrum and "mutualism," a

[1] At the time of writing, the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation provided the most recent data. More recent data have since been published in the 2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (https://www.census.gov/library/publications/2018/demo/fhw-16-nat.html).

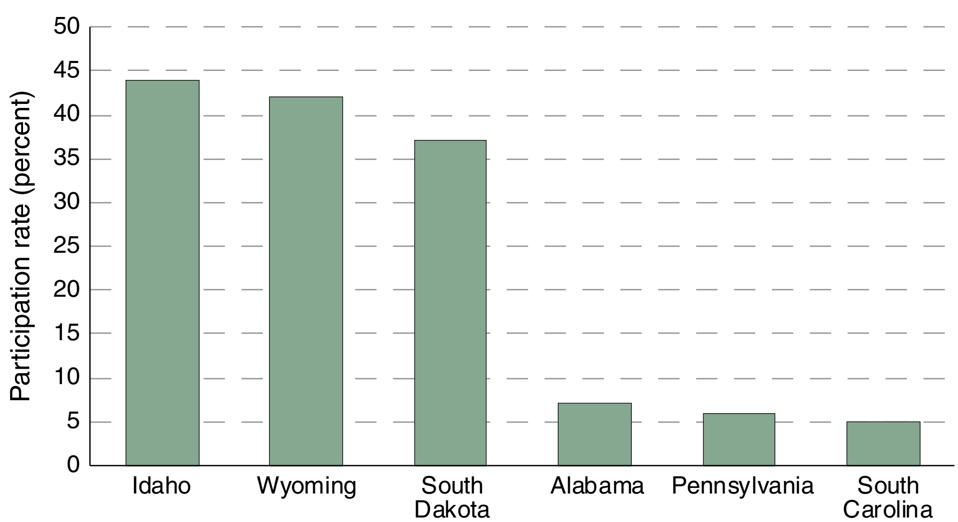

Figure 3.1—States with the highest and lowest percentage of children participating in wildlife viewing away from their homes. Data source: National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (2014).

value of living harmoniously with wildlife, is on the opposite end. Chase and others (2016) find that Latino groups tend to fall closer to the mutualism end of the WVO spectrum. Cultural groups holding differing WVO may also differ in their level of connection to nature. Kerr and others (2016) also identify differences in environmental values across immigrant and ethnic groups, and Scholte and others (2015) highlight the importance of acknowledging the roles of social context and culture in environmental value creation.

Wilderness Values

Wilderness values are complex and not easily encapsulated into a single framework. Instead, wilderness values are often described as including a broader range of benefits to people, including both use values (e.g., recreation) and nonuse values (e.g., just knowing that wilderness lands exist). Wilderness values can also be defined in relation to the services wilderness provides to people and other living things (Cordell and others 2005). Cordell and others (2005) provide a comprehensive summary of the many wilderness value frameworks used by scholars across disciplines. Bergstrom and others (2005) suggest that wilderness values are a function of wilderness attributes, functions, and services. In their framework, wilderness is a natural capital asset with four distinct categories: social, economic, ecological, and ethical (Morton 1999). Williams and Watson (2007) posit that wilderness values are fluid. Instead of solely being functions of attributes and services of wilderness, their view suggests that wilderness values are products of larger societal trends and can therefore be heavily influenced by changes in societal values over time (Williams and Watson 2007).

Cordell and others' (2005) wilderness values typology focuses on measuring the importance people place on a suite of benefits wilderness areas provide. While these benefits may apply to nature, in general, they are commonly used to describe the benefits specific to wilderness areas. These benefits are:

- Protecting water quality
- Knowing that future generations will have wilderness areas
- Providing recreation opportunities
- Protecting wildlife habitat
- Providing spiritual inspiration
- Preserving natural areas for scientific study
- Preserving unique plant and animal ecosystems and genetic strains
- Knowing that in the future there will be the option to visit a wilderness or primitive area of one's choosing
- Protecting air quality
- Providing income for the tourist industry
- Protecting rare and endangered species
- Providing scenic beauty
- Just knowing that wilderness and primitive areas exist

These benefits of wilderness were derived by itemizing a suite of values (direct and indirect) (Cordell and others 2003, Mountford and Kepler 1999). Cordell and others (2005) further aggregated wilderness values into a three-pronged typology:

- *Ecological services* values are those benefits such as protecting clear air and clean water, which indirectly contribute to human health and well-being (Schuster and others 2005).
- *Ecosystem protection* values include protecting wildlife habitat, preserving unique plant and animal ecosystems and genetic strains, and protecting rare and endangered species.
- *Amenities for humans* include both use and nonuse values that contribute to social or economic well-being. These include providing recreation opportunities, providing income for the tourist industry, providing scenic beauty, just knowing that wilderness and primitive areas exist, knowing that in the future there will be the option to visit a wilderness area or primitive area of one's choice, knowing that future generations will have wilderness areas, providing spiritual

inspiration, and preserving natural areas for scientific study.

While these wilderness values are undoubtedly interdependent, the key benefits within each value grouping are distinct. Ecological services are those benefits that are essential for human existence. For instance, without clear air and water, humans and most other life forms could not survive. Ecosystem protection benefits focus on the overall values of the ecosystem for wildlife and biodiversity. Amenities for humans are benefits that improve our quality of life. Though these amenities are not essential for our existence, they contribute to happiness and general well-being. The remainder of this chapter will focus on these three key wilderness value themes identified in Cordell and others' (2005) typology.

Societal Trends Influencing Wilderness Values

Societal trends related to urbanization, educational attainment, technological embeddedness (the extent to which people are engaged with technology), and increasing cultural diversity are often cited in the wilderness literature as influencing the relevance of wilderness to society. Williams and Watson (2007) suggest that emerging adults, coming of age in a more urban, educated, and technologically dependent society, will develop an increased appreciation of wilderness—an otherworldly place, so remote and different from their daily lives. Others warn that cohorts growing up surrounded by screens, rather than climbing trees, are not learning to appreciate nature (Dickinson 2013, Louv 2005). Many Americans are not even aware of wilderness areas (Cordell and others 2003) and consequently fail to appreciate the full suite of benefits that wilderness areas provide. With the increases in television content, video games, internet sites, and social media platforms, the "great outdoors" has a lot more competition for young people's attention than it once did.

Urbanization

In 1960, around one in three Americans lived in a rural area[2] (U.S. Census Bureau 2016b), and the vast majority of Americans completed their formal education with a high school diploma. By 2010, just 19 percent of Americans were living in rural areas (U.S. Census Bureau 2016c) and around 30 percent had earned at least a college degree (U.S. Census Bureau 2016a). There is a vast literature on how urban migration impacts societal values (Knox and Pinch 2014). Urban dwellers (those living in populated areas of at least 2,500 people) tend to be more highly educated and have more access to new ideas, technological innovations, and interactions with those outside their direct networks (Ratcliffe 2016). Urbanites are more relationally embedded, i.e., have more social ties (Granovetter 1985), providing them with larger social networks and opportunities for transfer of new ideas and information. With the introduction of the internet to more rural areas, this imbalance between urban and rural information networks is likely leveling, but there is still an "urban" advantage, both with access to high-speed internet and exposure to people with differing ideas and backgrounds. As such, it is likely that urbanization may be shifting wilderness values.

Watson and Williams (2007) address how urbanization trends may be influencing wilderness values, positing that as populations continue to urbanize, the value of wilderness will increase. This rise in value is linked to the economic concept of scarcity. As more open lands are transformed into suburban centers, protected lands and particularly wilderness should increase in value. Additionally, wilderness, as both a symbol and an experience, becomes increasingly unique. As a natural, untrammeled place, wilderness provides a stark contrast to the daily, human-centric existence of urban dwellers. The more robust information networks in urban environments also allow for more rapid flows of information. Stories and evidence of environmental degradation are more readily part of the urban nomenclature,

[2] A rural area is defined by the U.S. Census Bureau as a place with <2,500 residents.

thus furthering the perception of scarcity of wilderness lands, which, in turn, should lead to an increasing valuation of wilderness lands. Louv's (2005) argument, that fewer children are exposed to nature, provides a counterpoint to Watson and William's perspective. It is equally plausible that urbanization could cause declines in wilderness values as fewer children have firsthand experience with nature and exposure to the benefits that visiting wild areas can provide.

Educational Attainment

Educational attainment can lead to changes in wilderness values. A more educated public has a firmer grasp on environmental systems and human-environment interactions (Cortese 2003). Some college degree programs require coursework in the natural sciences, where students learn the basic ecological processes and the link between protected land and ecological services such as protecting clean air and clean water. As more of the public enters the higher education system, more have the opportunity to become fluent in fundamental ecological processes (e.g., how ecosystems purify the air and/or provide habitat for rare and endangered species) and understand the value to society of ecosystem protection (Yung and others 1998). While higher education provides students with greater opportunities to learn about natural systems, those who do not continue past high school may not have access to environmental education and thus the opportunity to learn about the benefits of wilderness. With the increasing emphasis on teaching a core curriculum and standardized testing in K–12 education, environmental education may be viewed as a secondary priority, compared to more mainstream subjects such as math and history. When budgets are tight, it is likely that environmental education programs at the primary and secondary level, much like art and music programs, suffer. This could create a schism, where those with a college degree have different wilderness values than those without a degree.

Technological Embeddedness

Technological embeddedness (Peng and others 2009, Sassen 2002, Volkoff and others 2007) describes the condition where daily routines have become embedded in technology. For example, an emoji text message may take the place of a face-to-face greeting. The greeting becomes embedded within technology, and the act becomes more "material" or tangible. Theorists suggest this technological embeddedness can lead to social change (Volkoff and others 2007) as once an act shifts from intangible to tangible, it is approached and processed differently by the actors. Technological embeddedness thus fuels the tacit hierarchy of the tangible over the intangible.

Trends in technological embeddedness may explain shifts in wilderness values in younger cohorts, i.e., those born after the baby boom generation. Younger generations, who came of age in a society where daily routines were embedded in technology, are undoubtedly different from their predecessors (Ryder 1965). Social psychologists have studied generational differences in values and attitudes and found significant evidence of a decline in nature relatedness, one's subjective connection to nature (Metz 2014, Twenge and others 2012, Zelenski and Nisbet 2014), in younger cohorts. Nature relatedness is highly correlated with environmental values (Zelenski and Nisbet 2014). Thus, waning nature relatedness, posited as an artifact of higher technological embeddedness, may result in shifts in wilderness values.

In 2008, Americans spent around 3 hours per day watching television or using their computers (U.S. Bureau of Labor Statistics 2008) and around 16 minutes per day participating in sports, exercise, and/or recreation. The ratio of technologically embedded activities (i.e., watching television or using their computer) to nature-related leisure time for Americans age 16 and older was 11:1.[3] The more time younger cohorts spend in

[3] This is a conservative estimate as some exercise, sports, and recreation are performed indoors.

technologically embedded settings (e.g., using their smartphones), the less time they spend appreciating natural settings (DiMaggio and others 2001, Louv 2005).

Emerging adulthood, the period between 18 and 25, is thought to be the time when young adults form environmental values and leisure social identities that will stick with them throughout their lifetime (Brooks and Williams 2012, Watson 2013). Those adults who emerged in a time of higher technological embeddedness may have a significantly different connection to nature, though not necessarily weaker, compared to those who came of age in a time when enjoying the great outdoors was a more common leisure activity. Additionally, the implicit prioritization of the tangible over the intangible, which technological embeddedness tends to advance, may be impacting how younger cohorts value the more emotional benefits of wilderness, such as its value as a symbol of human humility.

Cultural Diversity

Concern for and appreciation of wilderness lands have been critiqued as values belonging to a particular class and status group, specifically White, affluent, urban men (Cronon 1996, Dickinson 2013). However, more recent studies have shown that the value of wilderness, as an ecological concept and/or social construct, tends to cross racial and ethnic divides (Johnson and others 2004), even though there are differences in visitation rates to wilderness areas by race and ethnicity (Bowker and others 2006). Wilderness values are sociocultural productions. The extent to which different racial and ethnic groups have historically experienced wildlands, and the extent to which new immigrants assimilate into the dominant culture, will play significant roles in how values are shaped in younger generations (Johnson and Bowker 2004). As American society continues to become more racially and ethnically diverse, through both natural increase and immigration, shifts in wilderness values are likely.

Recent Findings

Rasch's analysis (2018), drawing on data from the National Survey on Recreation and Environment (NSRE 2000–2008) dataset, employs factor analysis and multi-level, mixed effects cohort models to parse out whether wilderness values are shifting in younger cohorts. A factor analysis of the suite of benefits wilderness provides identified four core wilderness value themes: ecological services, ecosystem protection, use amenity values, and nonuse amenity values. Table 3.1 shows the overarching wilderness value analyzed and the specific wilderness benefit that represents how that value is represented in the analysis.

The four wilderness values generated in the factor analysis were then entered as dependent variables in multi-level cohort models, controlling for gender, exposure to wilderness (i.e., whether one lives in close proximity to a wilderness area), years of education, urban status (i.e., whether one lives in an urban area), and K–12 spending by State. Figure 3.2 shows the four predicted wilderness values by birth year. Predicted values are parsed out between college-educated and non-college-educated respondents to highlight the significant relationships between educational attainment and wilderness values. Interestingly, while higher educational attainment is associated with higher ecological services and ecosystem protection values, the reverse is true for both

Table 3.1—Overarching wilderness value and related specific benefit

Overarching wilderness value	Specific benefit
Ecological services	Protecting water quality
Ecosystem protection	Preserving unique plant and animal ecosystems
Amenities for humans (use)	Providing spiritual inspiration and recreation opportunities
Amenities for humans (nonuse)	Just knowing that wilderness and primitive areas exist

use and nonuse amenity values. The relationships between wilderness values and independent variables in the models are summarized in table 3.2.

Ecological Services: Younger cohorts hold weaker ecological services values, compared to their baby boomer predecessors. This is evidenced in figure 3.2A, where predicted values for ecological services begin to decline for those born in the late 1960s and early 1970s.

Ecosystem Protection: While younger cohorts hold slightly weaker values than the baby boom generation, the effect is much smaller than that for ecological services. Figure 3.2B shows only moderately significant differences in ecosystem protection values between those born in the 1950s and 1960s and those in later years.

Use Amenities: Unique among the four values, only the use amenity value is declining linearly across cohorts (fig. 3.2C). Educational attainment, and particularly a college degree, is related to lower use amenity values.

Nonuse Amenities: Similar to ecological values, nonuse amenities values, such as the value of knowing wilderness exists, appear to be on the decline in younger birth cohorts, compared to the levels observed in the baby boom generation. The relationship is clearly visible in figure 3.2D, where the decline in predicted nonuse values starts with those born in the late 1960s.

For the four wilderness values in Rasch's analysis, including use amenity values, females expressed significantly stronger support for the given wilderness value. This is not surprising considering the extensive literature on gender and environmental values, which notes that women often hold stronger environmental values, compared to men (McCright and Xiao 2014, Strapko and others 2016). This finding also highlights the importance of decoupling predictors of wilderness values from wilderness visitation. Women visit wilderness less frequently than men (Green 2006, Johnson and others 2004, USDA Forest Service NVUM 2016), yet hold stronger wilderness values. As many wilderness scholars (Cole 2005, Johnson and others 2004, Schroeder 2007) have posited, one does not need to visit a wilderness area to appreciate its value.

Societal trends appear to be stabilizing ecosystem protection and ecological services values while weakening use and nonuse amenity values. While it was beyond the scope of Rasch's analysis to unequivocally identify the mechanisms of change, the data do support the notion that technological embeddedness may be playing a significant role in the observed shifts in wilderness values in younger cohorts. In the case of ecological services values, Rasch found that educational attainment appears to play a larger role than urbanization. A possible explanation is that knowledge of ecological services is acquired through more formal education channels, rather than passed along through urban

Table 3.2—Summary of mixed effects, random intercepts regression models showing relationships between wilderness values and independent variables

Variables	Differences in wilderness values			
	Ecological services	Ecosystem protection	Use amenities	Nonuse amenities
Younger generations	Lower	Slightly lower	Lower	Lower
Women	Higher	Higher	Higher	Higher
More years of education	Higher	Higher	Lower	Lower
Exposure to wilderness	—	Lower	—	Higher
Urban	—	Higher	—	—
Higher per pupil K–12 spending	Higher	Higher	—	—
States	—	—	Varies	—

Number of observations = 4,734
— = a lack of statistical significance (i.e., a *p*-value >0.05)

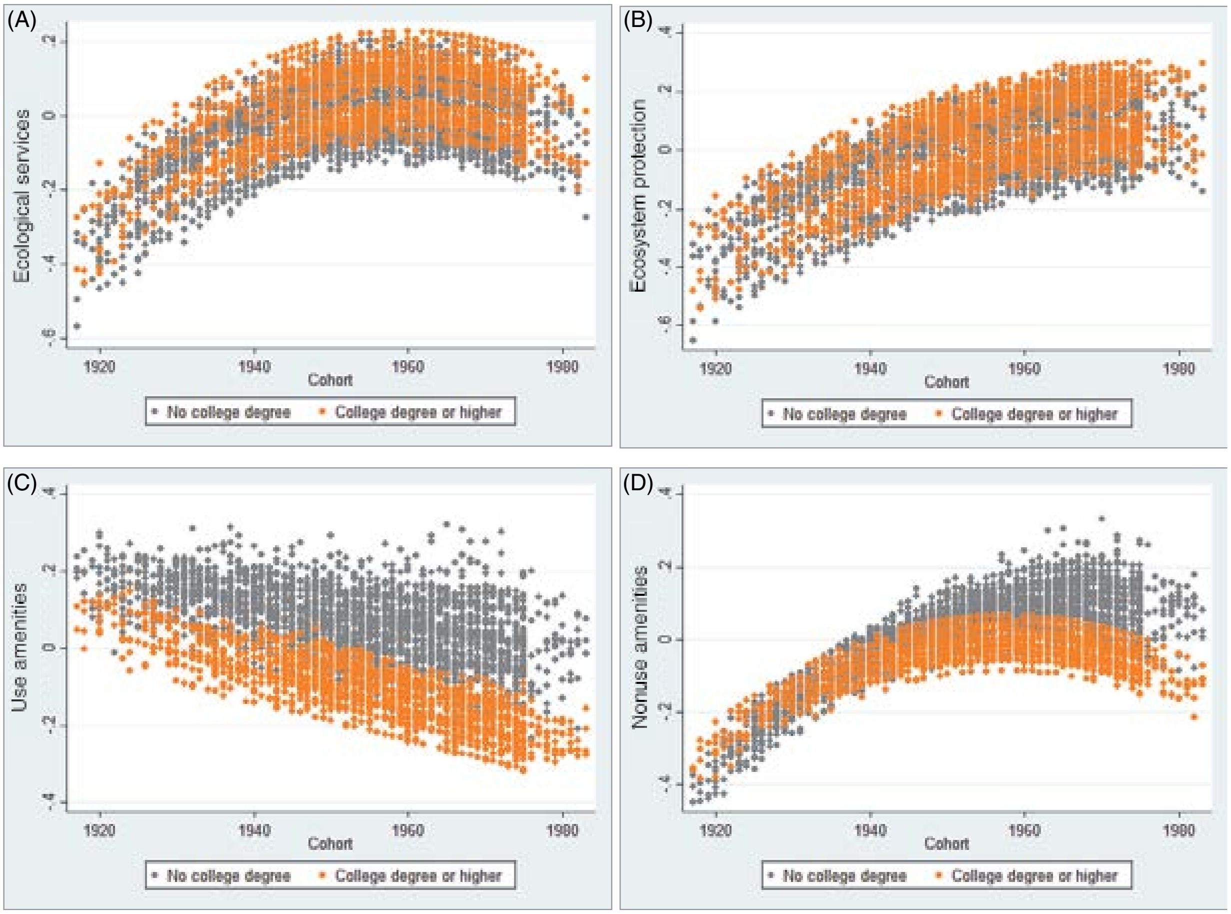

Figure 3.2—Predicted wilderness values by cohort for (A) ecological services, (B) ecosystem protection, (C) use amenities, and (D) nonuse amenities.

communication networks or acquired through personal experience with wilderness areas.

Conversely, in the case of ecosystem protection values, urbanization did play a role. Rasch found that people living in cities were more likely to have stronger ecosystem protection values, compared to those in rural areas. This finding lends support to the argument that ecosystem protection values, unlike ecological services, are being transferred through urban networks.

Rasch also found that those without a college degree held stronger use and nonuse amenity values, compared to those with a college degree. This finding may be related to the increased emphasis in higher education on the negative, human impacts to wilderness (Yung and others 1998) and the degradation caused by overuse. Another explanation could be the greater focus in higher education on science and the tangible values of natural areas such as biodiversity. Most college degree programs do not provide a wilderness studies curriculum or offer courses on the more esoteric values of wilderness championed in the late 1960s.

Conclusions

It appears that societal trends of urbanization, educational attainment, and technological embeddedness may be shifting wilderness values in younger generations, though not always in the expected directions. Ecosystem protection values are seemingly universal across generations, though more present in urban environments and in those with higher levels of formal education. Ecological services values (e.g., clean air and water) do not appear to have as much traction with those born in the 1970s and later. This could be related to possible declines in environmental literary curriculum at the K–12 level (Cortese 2003, NAAEE 2014). This finding may also be due to a lack of understanding of the ecological services that wilderness areas, in particular, provide. An analysis of ecological services values related to natural or/and protected areas in general may yield different results.

Nonuse values may also be losing their appeal for younger, technologically embedded cohorts who are less likely to value intangible processes or to have had firsthand experiences connecting with and/or being inspired by natural settings (Louv 2005). Younger generations may also be less familiar with nonuse values compared to baby boomers. These more ethereal values often stem from a previous phenomenological experience of communing with and assigning meaning to nature (Blumer 1986, Williams and others 1992). Louv (2005) warns that as younger generations spend less of their emerging adulthood years in nature, they will develop into adults who cannot perceive natural environments as valuable, in and of themselves.

Smith and Kirby (2015), in their study of whether or not the wilderness tradition still speaks to millennials, find that some millennials do value natural environments and wild places, yet they are conceptualizing wilderness differently than those in the baby boom generation. Some millennials identify more with a local version of wilderness, a place wild enough to immerse themselves in a natural environment, though it would not qualify as wilderness under the more stringent concept of an untrammeled wild place, completely devoid of any visible human impact. In fact, some millennials (and even some in older cohorts) find the untrammeled concept obsolete, given climate change and the level of development across the United States. Instead, they are happy to find awe and inspiration from small wild places, such as a nearby park (Smith and Kirby 2015).

Wilderness Management Implications

The sentiments captured by Smith and Kirby (2015), along with Rasch's (2018) finding that those born post-1970s are less likely to value wilderness for its mere existence, suggest that younger generations may be more in favor of active wilderness management, including restoration and intervention projects. If the concept of wilderness as pristine and untrammeled is considered a fallacy by some millennials, then they may believe that trammeling for the sake of restoration is acceptable, particularly with the increasing threats to vulnerable wilderness landscapes. Advocates of wildness and preserving the concept of "untrammeled landscapes" as a central tenet in the social construct of wilderness should take heed that unless there is greater effort to ramp up education around the untrammeled value of wilderness, this sentiment may very well be lost on future generations. If current observed trends continue, there may also be increasing pressure from the voting-age American public, not only for restoration in wilderness, but also for intervention activities which are designed to ensure a continued flow of habitat protection services, even if they come at the expense of some level of wildness.

Knowledge Gaps

A key challenge to understanding the current state of wilderness values, particularly in younger cohorts, is lack of data availability. The most recent NSRE survey data are more than 10 years old. Given the pace of demographic and technological change, it is likely that environmental values in general, and wilderness values in particular, are continuing to shift in American society. There is a clear need to collect more recent data on wilderness values to ensure that wilderness managers are keeping in step with newly emerging public values and attitudes toward wilderness preservation and management.

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4

Economic Effects of Wilderness on Gateway Communities

Evan Hjerpe

John Muir Wilderness (652,793 total acres) in California was designated in 1964 and is administered by the USDA Forest Service. (Bureau of Land Management photo by Bob Wick)

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KEY MESSAGES

- Wilderness recreation generates positive economic effects in gateway communities that provide services for nature tourists such as outfitting, lodging, restaurants, bars, and transportation.

- Regional expenditures by wilderness visitors spur economic contributions in terms of employment, output, and income.

- Wilderness gateway communities also provide the ideal location for some people to permanently relocate to these communities. These amenity migrants bring businesses, transfer payments, and income with them to the gateway communities.

- Rural Western U.S. counties containing wilderness have consistently generated greater in-migration than counties not containing wilderness. For in-migration from 1980 to 2010, rural Western U.S. wilderness counties have experienced an average in-migration increase of 8.2 percent, whereas rural nonwilderness counties have experienced zero migration growth (0 percent).

Introduction

Wilderness areas are destination spots for outdoor recreationists and for those looking to be close to natural areas and open spaces. Because wilderness is a unique outdoor attraction, it can have a positive economic effect on adjacent gateway communities. Wilderness gateway communities provide the services desired by visitors and recreationists that include outfitting, lodging, restaurants, bars, and transportation. The production of the services generates both local and national economic impacts, boosting regional output, income, jobs, and taxes. For surrounding wilderness gateway communities, providing services and outfitting out-of-region visitors can play a substantial role in their economy (Holmes and others 2016). Visitor spending on lodging, restaurants, and guide services has a positive impact on communities, resulting in ripple effects in terms of regional employment and income. Wilderness tourism has also been shown to be sustainable both ecologically and socially, making it a critical part of rural development portfolios (Hjerpe 2018).

But beyond nature tourism opportunities and their associated regional economic impacts, wilderness also offers unique recreational opportunities to nearby residents. The appeal of living close to a wilderness area can drive some people to relocate to a gateway community. People relocating to gateway communities surrounded by natural amenities is known as amenity migration. Amenity migrants bring businesses, transfer payments, and income with them and are an important part of local community development and growth.

Amenity migration rates increased, particularly in the American West, in the last decades of the 20th century, and associated research has been exploring this phenomenon since the 1970s and 1980s (McGranahan 1999). Many communities have begun to market and advertise their proximity to natural amenities, particularly mountains, snow, water, and sunshine. Communities also market their access to public lands and wilderness, creating a branding effect for economic development associated with both nature tourism and amenity migration. Prior research has illustrated that wilderness, along with public lands and climatic and geographic attributes of regions, are positively influencing rates of amenity migration. But the scale of this effect, and a focus on how wilderness and other protected lands have been driving amenity migration, have not been fully investigated.

Wilderness areas typically share common geographic and climatic attributes that contribute to their wildness and lack of previous development such as mountainous terrain or extreme temperature ranges. For example, Aycrigg and others (2013) showed that the most protected lands in the United States had the highest average elevation and the lowest average soil productivity as compared to all other lands. Common attributes of wilderness areas, such as varied topography, have been shown to be an important attractant to amenity migrants (McGranahan 1999), playing a role in the supply of amenities. Likewise, wilderness areas share a common administrative designation that limits recreation types and commercial activities. The resulting solitude and human-powered recreation attract visitors and people to relocate to adjacent communities. Having common geographic and designation attributes makes it difficult to distinguish whether the landscape characteristics or the official designations are the primary amenity attractions. We hypothesize that both play a role in benefitting wilderness gateway communities but acknowledge that it is difficult to disentangle geographic attributes and designation issues.

In this chapter, we synthesize the latest research on the economic impacts of wilderness, and we investigate the role of wilderness as an attractant for amenity migration. Despite the regional economic importance of wilderness for gateway communities, there has been little research investigating overall economic impacts and the effects of amenity migration. To investigate the economic impacts of wilderness on gateway communities, we conducted a literature review and synthesized the findings. We present descriptive statistics and discuss future research needs.

Wilderness Economic Impacts on Gateway Communities

Wilderness areas provide unique opportunities for outdoor recreation, especially for people seeking solitude, human-powered experiences, and independent exploration in nature and landscapes. The unique attributes of wilderness areas, as compared to other public and private lands, generate a market niche for nature tourists seeking particular forms of recreation. While on-site recreation in wilderness areas generates individual benefits and economic value to those who recreate in wilderness (Bowker and others 2005), the pursuit of wilderness recreation also generates economic impacts in surrounding gateway communities that have positive effects on community economic indicators (Morton 1999, Rosenberger and English 2005). These impacts include employment, income, and output generated by wilderness visitors.

The majority of wilderness economics research has been focused on nonmarket economic values that are different from economic impacts that illustrate how wilderness might affect jobs, income, and regional output. These nonmarket economic values are varied (Morton 1999) and include consumer surplus of wilderness recreationists and passive use values held by people that might be willing to pay to leave future generations opportunities to experience wild nature (i.e., bequest values). Wilderness case studies of nonmarket valuations (e.g., Gilbert and others 1992, Walsh and others 1984, Weber and others 2012) have illustrated the depth of these economic values for wilderness.

In contrast to the multiple nonmarket valuations of wilderness (see Bowker and others 2014), there have been few investigations of wilderness economic impacts and contributions. Two recent studies provide starting data points for synthesis of the economic impacts of wilderness. The first study (Hjerpe and others 2017) investigated the national economic impacts from wilderness areas using U.S. Department of Agriculture Forest Service National Visitor Use Monitoring (NVUM) visitor expenditures as a basis for extrapolating overall impacts. They found $700 million of annual economic output contributions from wilderness areas. A second recent study (Hjerpe 2018) examined the regional economic impacts of the Boundary Waters Canoe Area Wilderness (BWCAW), a high-profile wilderness area in Minnesota. Hjerpe (2018) found almost $80 million in total annual regional output in three surrounding counties.

Earlier research on wilderness economic impacts is scarce. Lichty and Steinnes (1982) estimated the economic impacts of nature tourism in Ely, MN, a gateway community to the BWCAW. They found $13 million (in year 1982 dollars) of regional tourism output, much of it from wilderness visitors. Keith and Fawson (1995) found expenditures of about $30 a day per wilderness visitor for three Utah wilderness areas. These Utah wilderness

Table 4.1—Total effects and multipliers for Boundary Waters Canoe Area Wilderness visitor expenditures (in year 2016 dollars)

Impact type	Employment	Labor income	Total value added[a]	Output
	number of jobs	----------	*million dollars*	----------
Direct effect	879	19.42	31.33	49.44
Indirect effect	101	4.00	6.30	13.61
Induced effect	126	5.01	8.56	15.70
Total effect	1,105	28.43	46.20	78.75
Multiplier effect	1.26	1.46	1.47	1.59

[a] Value added is the difference between an industry's total output and its intermediate inputs. It includes employee compensation, taxes, and surplus.

Source: Hjerpe (2018).

areas were not particularly well known or heavily visited and are likely representative of the typical economic impact associated with smaller wilderness areas. In contrast, the recent BWCAW study by Hjerpe (2018) highlights a showcase wilderness area. The BWCAW is estimated to be the most heavily visited wilderness area in the United States with approximately 150,000 annual visitors. Given the high visitation and unique outfitting opportunities, the economic impacts associated with the BWCAW should be considered at the high end of wilderness economic impacts.

Regionally, BWCAW annual visitation spurred some 1,100 full- and part-time jobs and generated almost $30 million of labor income (table 4.1). Multiplier effects ranged from 1.26 for employment to 1.59 for output, suggesting strong secondary effects especially for regional output. These multipliers, and regional per day expenditures, were on par with multi-day rafting trips in Grand Canyon National Park in Arizona (Hjerpe and Kim 2007) and in the Frank Church River of No Return Wilderness in Idaho (English and Bowker 1996).[1]

The interesting component of the BWCAW visitation is the export nature of the product being consumed. According to Hjerpe (2018), >97 percent of sampled BWCAW visitors were from out of the region, and many were from across the United States and from other countries (fig. 4.1). Outdoor recreation is different from traditional exports of harvested or mined raw materials. As opposed to shipping the product out for uses in other regions, visitors bring outside income into the

[1] English and Bowker (1996) used a State-level economy as the defined regional study area and found multipliers of 1.90–2.35 for Middle Fork boaters, whereas the BWCAW research used a three-county regional economy to determine multiplier effects. As multipliers increase with increases in the size of a regional economy, we suspect these multipliers are comparable.

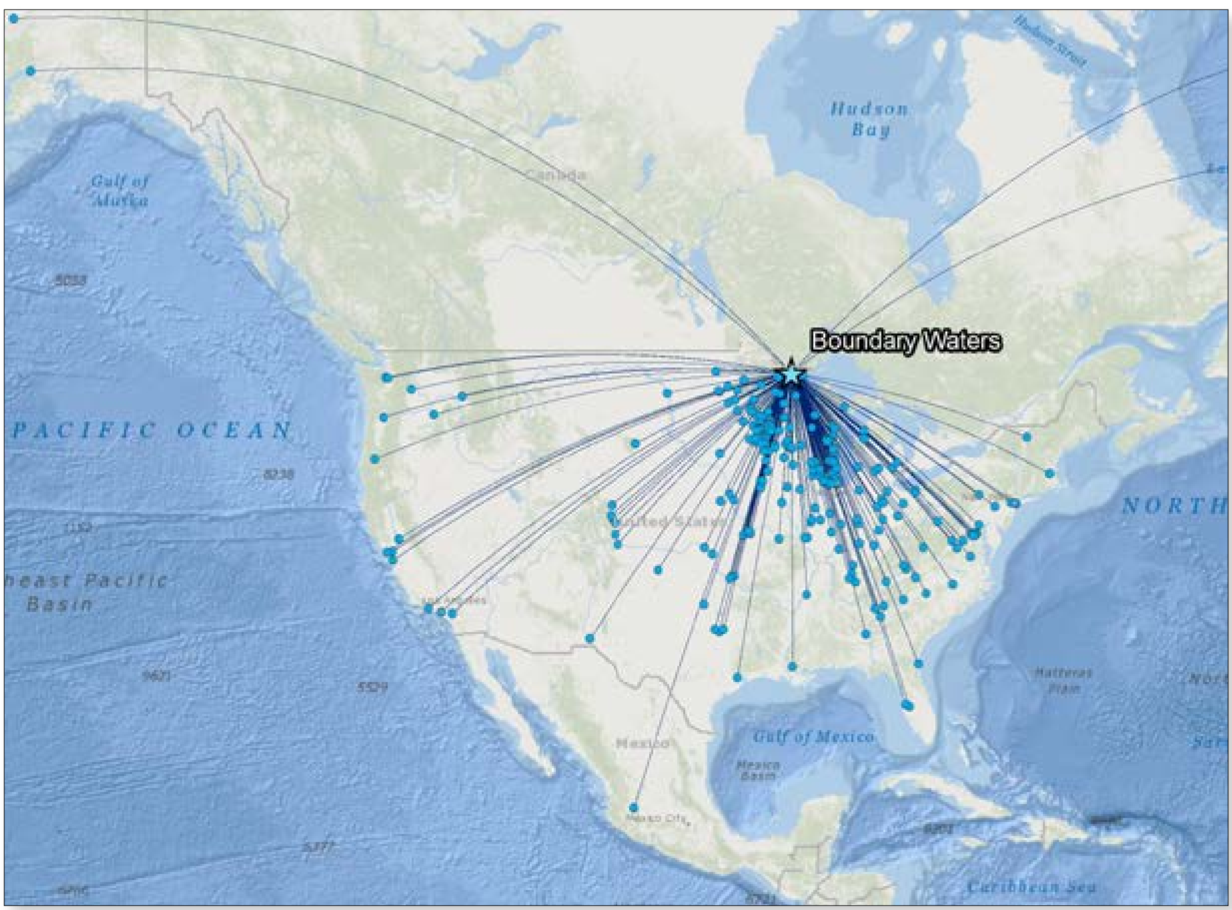

Figure 4.1—Sample visitor origin for Boundary Waters Canoe Area Wilderness (BWCAW). Visitor origins pictured only represent 2 percent of BWCAW annual quota permits (n = 505).

region to consume wilderness services on site. Despite the difference in shipping raw materials to other regions or having people in other regions travel to a wilderness area, economists technically treat nature tourism as an export industry.

Compared to other export industries based on natural resource utilization (i.e., logging and mining), wilderness outdoor recreation is the most sustainable land use option (Hjerpe 2018). While the overall expenditures of nature tourism will not always compete with output from resource extraction and wages from recreation service jobs can be lower than extractive industry jobs, outdoor recreation in protected areas provides substantial regional economic impacts largely without depleting the resource. Thus, outdoor recreation represents a renewable export, which can theoretically continue well into the future. This sustainability of primitive outdoor recreation should be acknowledged and incorporated into regional development planning. Currently, economic impact and contribution analyses do not account for the economic values associated with the sustainability of wilderness outdoor recreation; rather, economic impacts are modeled in the short term and rarely address the issue of resource depletion or natural capital loss. Wilderness visitation, as a sustainable export industry, should be part of any rural development program if possible.

Wilderness Gateway Communities and Amenity Migration

Gateway communities are not only an attraction for visitors, but also provide the ideal location for some people to permanently relocate to these communities. Noticeable increases in in-migration for nonmetro counties in the United States have been occurring for the last four decades, particularly in amenity-rich regions. The combination of visually pleasing views, public lands, and attractive natural features such as lakes, mountains, and sunshine provide for outdoor recreation opportunities and a quieter pace of life that has spurred many people to relocate to rural areas with natural amenities. This concept is termed amenity migration and has been documented in various fashions (e.g., Graber 1974, McGranahan 1999, Power and Barrett 2001, Rudzitis 1993).

Amenity migration has been most pronounced in the American West (Gosnell and Abrams 2011, Winkler and others 2007). Western amenity migration to rural areas has led to the New West (Power and Barrett 2001, Rudzitis 1996), where individuals are moving out of the city to improve their quality of life—a quality of life that includes outdoor recreation opportunities and access to protected public lands as even more influential than income and employment choices (Rudzitis 1999). These amenity migrants are often relocating to areas that were previously dependent on resource extraction such as logging, grazing, or mining but have shifted to more service-related industries such as financial, medical, and tourism industries (Power 1991). The new migrants are often retirees or footloose entrepreneurs with multiple income streams in search of ski resorts and public lands and requiring access to markets through infrastructure such as airports and highways (Rasker 2005, 2006). At the same time, advancing technology, global resource competition, and greater public lands conservation (e.g., related to the northern spotted owl [*Strix occidentalis caurina*]) have played a role in diminishing the importance of extractive industries in the rural West. Many Western U.S. amenity towns near wilderness have experienced a full economic restructuring where high-wage service industries have largely replaced logging, mining, ranching, and agricultural industries.

In terms of how big a draw wilderness is for amenity migrants, it is difficult to quantify an amenity migration-effect size for changes in employment or income for particular natural amenity attributes. The natural amenities that spur the relocation of investments and people are a broad set. That is, wilderness is one of a number of natural amenities that collectively attract migrants.[2] For example, research on U.S. migration patterns in general show the importance of warmer climates as a factor in recent shifts in population. For rural areas, climate explains almost half of the variance in natural amenity attributes associated with increases in some facet of rural growth (e.g., employment, income), but the type of land, presence of water, recreational facilities, and winter recreation opportunities also all contributed to overall variance of natural amenities (Deller and others 2001).

Further decomposition of the suite of natural amenities that combine to attract migrants can be illustrated from Deller and others' (2001) research. In their research, five broad natural amenity indices were further composed of numerous principal components. For example, the "type of land" variable was a composite of 16 significant individual variables such as mountains, land managed by the Bureau of Land Management, or a State park. One of the individual variables used was wilderness acres, and Deller and others (2001) found wilderness to be the second highest significant component in explaining variance related to type of land and positive natural amenity effects. For land types, wilderness was only behind National Forest System lands and ahead of all other types for explaining natural amenity attribute variance. While this suggests wilderness is an important part of natural amenities and their corresponding economic growth in rural communities, it also illustrates that wilderness is one among a number of amenity factors inducing rural community economic contributions.

The research of community contributions of wilderness via amenity migration effects is limited. Rasker and Hackman (1996) showed that wilderness counties (containing wilderness areas, national parks, and wildlife refuges) in the West outpaced resource-dependent counties in employment and real personal income growth in the 1980s and 1990s. Duffy-Deno (1998) looked at the effect of wilderness on rural county growth in the West and found no significant association with gains or losses in employment and population. Holmes and Hecox (2004) found that wilderness was associated with income, employment, and population growth for Western U.S. rural counties from 1970 to 2000. They attributed this growth largely to increased investment income and self-employed income. The positive associations of population growth and employment were also found for multiple types of protected Federal lands in the West (Lorah and Southwick 2003).

Through survey techniques of residents, wilderness has been confirmed as one of the factors playing a role in amenity migration in the American West (Rudzitis 1996, Rudzitis and Johansen 1991, Rudzitis and Johnson 2000). In terms of the role of wilderness in amenity migration, a few studies have looked at wilderness as a potential explanatory variable, generally finding wilderness to be positively related to amenity migration, but as one of many determining factors in migration (Deller and others 2001, Hand and others 2008, Izón and others 2010). However, recent research from Hjerpe and others (2020) examined the influence of broad sets of natural amenities, including protected areas, on migration rates from 1980 to 2010 for rural Western counties in the United States. They found that wilderness areas and national monuments were the most significant types of public lands associated with greater migration rates, on par with climatic and infrastructure explanatory variables.

In summary, there are structural economic changes occurring in the rural lands most likely to contain wilderness—a shift from extractive industries and manufacturing to services. Contributing to this shift in rural economies is documented relocation of migrants into these rural areas in pursuit of natural amenities. This amenity migration to rural areas has correlated with general increased population, employment, and

[2] The focus of this chapter is on natural amenities, despite overall amenity migration being composed of natural, cultural, social, and human-built amenities that often combine to attract migrants (Power 2005).

income, and wilderness has been determined to be a significant natural amenity contributor. But, with difficulties in isolating the effect of wilderness in amenity migration economic impacts, there is a need for greater research on how public lands and wilderness affect amenity migration rates.

Wilderness and Amenity Migration Trends

To investigate wilderness and amenity migration trends, we collated county-level data for the Western United States. Wilderness was identified in the U.S. Department of the Interior U.S. Geological Survey's (USGS) Protected Areas Database of the United States (PAD-US). Wilderness was spatially displayed over county borders to determine the presence of wilderness. In-migration data were pulled from Winkler and others (2013) for three decades: 1980s, 1990s, and 2000s.

Because the American West has been the most oft-cited example of high rates of population growth associated with amenity migration (Gosnell and Abrams 2009), we limit our investigation of wilderness and amenity migration to the Western United States. To isolate amenity migration from broader urban economic migration draws, we limit our comparison to 355 Western U.S. rural (nonmetro) counties (<250,000 people).

Results show a large disparity between rural Western U.S. counties with and without wilderness (fig. 4.2). Counties containing wilderness have consistently generated greater in-migration than counties not containing wilderness. Averaging three decades of in-migration from 1980 to 2010, rural Western U.S. wilderness counties have experienced an in-migration increase of 8.2 percent, whereas rural nonwilderness counties have experienced zero migration growth (0 percent).

The majority of amenity migration research has been focused on understanding variables that serve as an attractant to migrants. For natural amenities, these "supply" variables include the climatic, geographic, and land protection attributes. In contrast, little research has examined the "demand" variables that illustrate the outcome of amenity development. These "demand" variables include economic outcomes associated with amenity development such as percentage of seasonal and recreational home ownership and overall property values, alongside in-migration data. Looking at both supply and demand variables of amenity migration in regards to wilderness provides a deeper understanding of the influence wilderness has on migration while determining whether or not wilderness gateway communities are destination spots.

Winkler (2010) investigated the demand side of amenity migration by creating the Destination

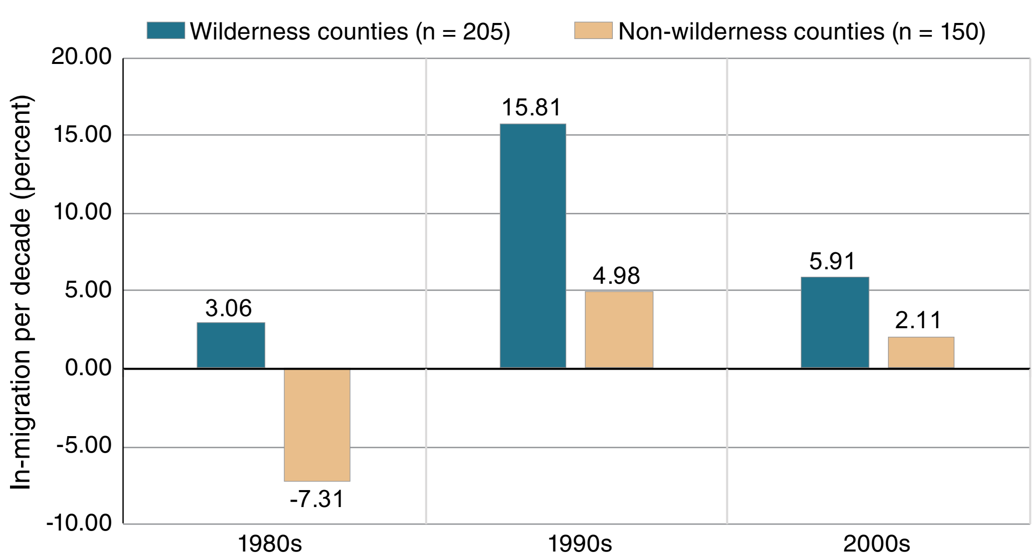

Figure 4.2—Wilderness and amenity migration in rural Western U.S. counties, 1980–2010.

Development Scale. She examined the demand for amenity migration utilizing three primary variables: percentage of seasonal housing, the percentage of houses >$200,000 in value (in year 2000 dollars), and the percentage of residents that relocated from an urban area in the past 5 years. According to Winkler (2010), the Destination Development Scale helps interpret the outcome of being a destination region, as opposed to the expected antecedents of why migrants are attracted to an area. The scale describes which communities are in demand as destinations, without making assumptions as to why the communities are in demand. Examining the demand for place allows for greater interpretation of amenity-based development.

Utilizing components of Winkler's Destination Development Scale, we compare the demand for living in wilderness gateway communities to the demand for living in Western U.S. rural regions without wilderness. As illustrated in figure 4.3, Western U.S. rural counties with wilderness are in much greater demand for amenity migrants than those rural counties without wilderness. Wilderness counties have almost twice as much seasonal and recreational housing, and housing >$200,000 in value (in year 2000 dollars) as compared to counties without wilderness. Likewise, in-migration from urban areas is substantially greater in wilderness counties. While there is a need to update recent trends, these descriptive statistics illustrate that if growth and development are desired, wilderness is likely a strong part of a region's destination marketing portfolio.

Future Research

Because amenity migrants are attracted to a suite of amenities that are often bundled together, such as mountains, lakes, and public lands, it is difficult to understand the full influence of wilderness as an amenity attribute. Previous research has illustrated that wilderness and protected public lands generally play a positive role in overall regional economic health, including being a factor in attracting amenity migrants. But questions remain concerning "designation effects" versus the landscape characteristics that epitomize wilderness and were in place prior to administrative designations. Further econometric investigations are needed for understanding the association between variables for amounts of in-migration, demand for amenity migration, wilderness, and other types of federally protected lands.

Concerning wilderness economic impacts and contributions, there is a need to better understand outfitter and guide impacts, especially for destination wilderness areas such as the Bob Marshall Wilderness Area in Montana or the Frank Church River of No Return Wilderness Area in Idaho. For example, outfitter and guide contributions to regional economies are not included in surveys of

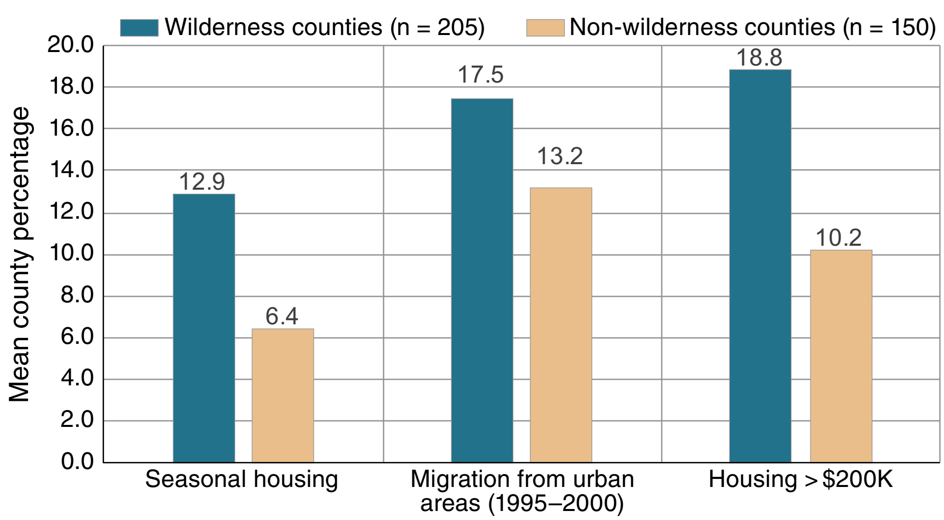

Figure 4.3—Wilderness and amenity development indicators for rural Western U.S. counties, 2000.

regional expenditures for outdoor recreationists in NVUM. Methods for estimating impacts should be focused on interviewing and surveying both wilderness users and the outfitters and businesses that provide access and guiding services for wilderness adventures. Additionally, basic visitation data are often missing or incomplete for numerous wilderness areas. Baseline monitoring of use and impacts is critically important for further economic analyses.

For both nature tourism impacts and amenity migration effects, there is also a need to investigate and acknowledge potential adverse effects on wilderness gateway communities. Unregulated nature tourism can lead to adverse ecological and social impacts (Howe and others 1997), and the provision of recreational services can lead to seasonal employment and result in lower wages as compared to extractive industries (Green 2001). Nature tourism can stress local infrastructure, emergency services, and resulting local tax burdens (Eagles and others 2002, Loomis and Walsh 1997). With high leakage rates of tourism expenditures in rural economies, the locally retained expenditures may not be sufficient to offset increased infrastructure and service maintenance (Hjerpe and Kim 2007). Understanding the full suite of economic impacts of wilderness tourism is paramount in deciding appropriate land use policy.

In terms of amenity migration concerns, being an attractive community for amenity migrants results in general increases in overall economic indicators, a positive outcome from the viewpoint of most city and county elected officials. However, rapid increases in amenity migration can also result in inequitable distribution of benefits, render property values unaffordable by many (Marcouiller and Green 2000), and result in environmental degradation common with general development (Abrams and others 2012). Examples of communities close to wilderness that have experienced rapid increases in per capita income, such as Aspen, CO, and Jackson, WY, illustrate some of the difficulties associated with too much amenity attraction—that is, the communities become the second homes and playgrounds strictly for the wealthy. While exceptionally high property values are a boon to local tax coffers, they result in disproportionate rates of financial access to these communities. These distributional concerns need further investigation.

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Wilderness Use, Users, Preferences, and Values from 2005 to 2014: A Case Study Using Forest Service National Visitor Use Monitoring Data

J.M. Bowker • Ashley E. Askew • Craig E. Landry • A. Hedges • Donald B.K. English

Haleakala Wilderness (24,719 total acres) in Hawaii was designated in 1976 and is administered by the National Park Service. (National Park Service photo by Tim Devine)

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KEY MESSAGES

- The National Visitor Use Monitoring (NVUM) program provides science-based information on visitation volume for recreationists on national forests, visitor and visitation characteristics, and satisfaction levels. Information specific to designated wilderness areas can be gleaned from the NVUM database.
- NVUM data show that visits to wilderness on national forests increased substantially between 2005 and 2014 from 6.5 million to 8.3 million site visits, an increase of 27.4 percent. This increase in visits is higher than for other national forest site types wherein recreation opportunities are provided.
- The large majority of the increase in wilderness visits has occurred in the western part of the country.
- The age distribution of visitors has increased marginally with those in the 50–59 age category producing the largest number of visits.
- The proportion of wilderness visits by non-Hispanic Whites has dropped while large upward shifts in wilderness visits by non-Hispanic Asian/Pacific Islanders, Hispanics, and those identifying as “others” were observed. Gender diversity also increased over the time period with the proportion of female visits increasing.
- The proportion of day use visitors increased over the time period, resulting in an increase in the share of visits with hiking as the primary activity as opposed to backpacking.
- The economic value (consumer surplus) per wilderness trip, estimated using travel cost demand models, exceeds the economic values estimated for other national forest recreation site types.

Introduction

In this chapter, we examine wilderness use (visits) and users (visitors) on national forest sites over a 10-year period from 2005 to 2014, segmented into two discrete periods. Wilderness areas occurring on national forests account for approximately one-third of the acreage and 445 of the 765 separate wilderness areas in the Federal National Wilderness Preservation System (NWPS). Thus, the average size of these wilderness areas is smaller than the NWPS average. These areas are administered across 113 different management units, ranging from the Tongass National Forest in Alaska with 19 separate wilderness areas to Minnesota's Superior National Forest containing only the Boundary Waters Canoe Area Wilderness. Some national forests, like the Wayne National Forest in Ohio, contain no designated wilderness (University of Montana 2018). Many wilderness experts would argue that these wilderness areas account for the majority of recreation visits given the relative convenience of visiting. Renowned wilderness scientist D.N. Cole estimated that recreation visits to wilderness sites on national forests accounted for >80 percent of all NWPS recreation visits (Cordell and others 2005: 174). Indeed, just under 80 percent of American cities with populations of 50,000 or more are within 100 miles of at least one wilderness (University of Montana 2018).

This chapter proceeds as follows. First, we discuss the National Visitor Use Monitoring program, the primary data source for all analyses in the chapter. Next, we describe recreation visits to wilderness sites managed by the Forest Service in terms of total numbers and demographics associated with these visits. These visit characteristics are compared over two 5-year periods from 2005 to 2014. We then explore visitor preferences through measures of perceived crowding, overall satisfaction, and ratings for attributes common to these wilderness recreation experiences. As with visits, comparisons are made through time. In addition, the samples are segmented into two distinct groups: day users and overnight users. The chapter concludes with an empirical examination of wilderness demand and net economic value of wilderness access. The approach applies revealed preference modeling to wilderness trip demand by ecoregion type. In closing, we note some caveats and potential future directions which could ensue from this work.

National Visitor Use Monitoring Data

The data source for our analyses was the U.S. Department of Agriculture Forest Service National Visitor Use Monitoring (NVUM) program (English and others 2002, 2020; Zarnoch and others 2011). The NVUM program has the primary objective of estimating visitation volume for recreationists on national forests. A secondary objective is to describe visitor characteristics, e.g., activity participation, visit duration, demographics, and satisfaction levels (USDA Forest Service 2016). NVUM sampling screens for last-exiting recreationists (LERs) at each site/forest, proceeding with an interview if screened affirmatively. This onsite screening ensures that (1) information is collected immediately after a visit; (2) responses are from those using the sites/forests for recreation, and (3) double counting is avoided. Respondents are asked about their current visit, as well as their visitation to the specific national forest over the previous 365 days.

The NVUM survey was initially implemented from 2000 to 2003 (round 1; R1). The methodology was significantly revised in 2004, with subsequent implementation in 2005. Because of the methodological change, R1 is generally not comparable with subsequent rounds; thus, the responses for R1 can be viewed as archival and descriptive for that period only. The methodological revisions improved the consistency of estimation and sampling procedures (English and others 2002, Zarnoch and others 2011). Sampling consists of 5-year cycles (rounds), where the end product is survey data collected from all national forests through appropriate prework and field work. Approximately 20 percent of forests are surveyed in a given year, producing a full set after a completed round. The years from fiscal year (FY) 2005 (October 1, 2004) to FY2009 (September 30, 2008) make up the round 2 (R2) sampling period, while FY2010 to FY2014 correspond to round 3 (R3). Data collection for round 4 (R4), comprising FY2015 to FY2019, is completed and will be available in summer 2020.[1] Starting with R2, a consistent and nationally available framework has been in place which can facilitate temporal trend comparisons as more data and time points become available. The strength of this survey process makes it valuable for temporal as well as spatial analyses, from individual national forests to regional and national levels.

The NVUM survey comprises three major variations: basic questionnaire only (asked of >35 percent of visitors) or basic questionnaire with a supplementary module containing either economics or satisfaction questions. The Basic Module focuses on the demographics, point of origin, visit purpose and frequencies, time on site, recreation choices by activity, and overall satisfaction with the just-concluded visit. Those who receive the additional Satisfaction Module are asked to rate satisfaction and importance levels for site attributes and perceptions of crowding, while those receiving the additional Economic Module are queried about trip expenditures, substitutes, and household income. Copies of the survey questionnaires are available from the authors or at https://cms.fs.usda.gov/about-agency/nvum/manager-tools.

The NVUM methodology employs stratified random sampling of site days on each national forest, considering use levels and site types (English and others 2002, 2020). There are four site types: day-use developed sites (DUDS), general forest areas (GFA), overnight-use developed sites (OUDS), and designated wilderness (WILD). Persons using DUDS or OUDS encounter facilities with moderate to high degrees of modification per the Forest Service's Infrastructure (INFRA) development scale. WILD consists of lands and waters under the jurisdiction of the National Wilderness Preservation System (NWPS). GFA includes any national forest components remaining outside these three classifications (English and others 2002). Analyses in this chapter focus on data collected from the WILD stratum during R2 and R3. Figure 5.1 shows the distribution of survey modules nationally for WILD in R2 and R3.

[1] A preliminary analysis similar to the present chapter but limited to subsets of national forests (present in all three rounds, R2–R4, representing approximately 60 percent of national forests) is presented in Bowker and others (2018).

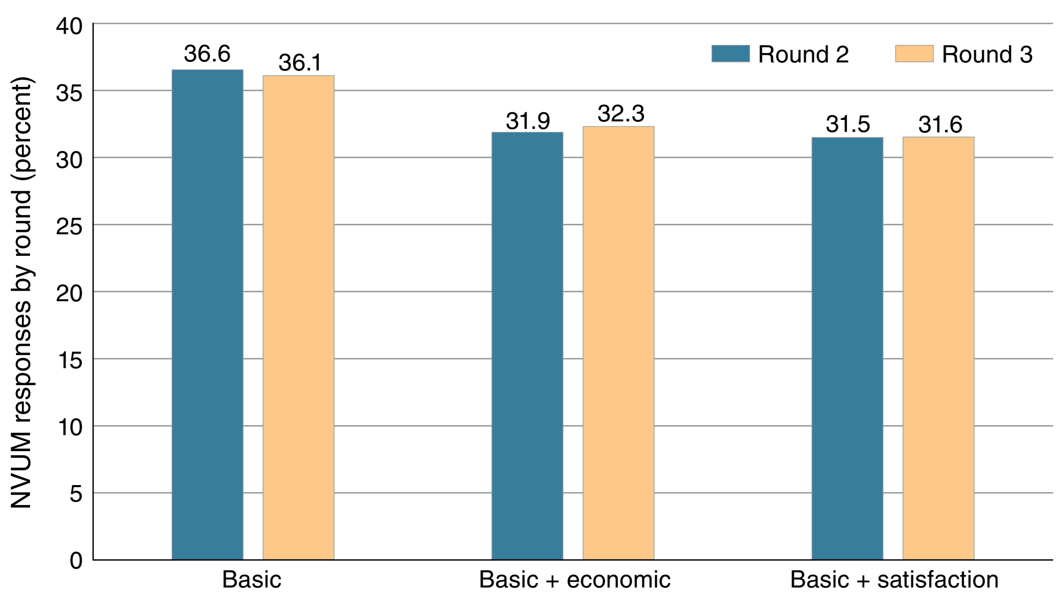


Figure 5.1—Unweighted percentages of National Visitor Use Monitoring (NVUM) responses by survey type in rounds 2 and 3.

The Basic Module was distributed to all respondents, with under a third receiving a supplementary Economic or Satisfaction Module.

Wilderness Visits

In this section, we present statistics on visits to all wilderness sites within national forest boundaries. Relevant estimates include annual visits to wilderness sites, visit demographics (age, race/ethnicity, gender, and household income), and visit characteristics (group size, visit duration, travel distances, and activity participation). We note that the statistics refer to the population of visits. The NVUM program does not directly estimate the number or characteristics of visitors (i.e., the set of people who make the recreational visits to wilderness). Thus, an adjustment is not needed to account for higher rates of annual visitation from certain types of individuals but is needed when describing the set of people who visit wilderness areas (Shaw 1988, Thomson 1991). The section's intent is to follow Cole's (1996) seminal work tracking changes in visits across the NWPS over time, here using NVUM R2 and R3.

For the contiguous United States plus Alaska and Puerto Rico, visitation to wilderness has increased considerably from an average of 6.5 million site visits annually during R2 to 8.3 million site visits annually during R3, an increase of 27.4 percent. Over the same period, the U.S. population grew by about 8 percent. Preliminary figures for R4 appear to indicate that wilderness visitation is continuing to increase, albeit at a slower rate than from R2 to R3 (Bowker and others 2018). Figure 5.2 depicts the annual wilderness site visit averages across Forest Service regions for R2 and R3. Contrary to the national trend, wilderness site visits to national forests in the Eastern and Southern Regions, together representing about 1.3 million visits in R3, each decreased from R2 to R3, by 18.2 and 2.2 percent, respectively. The other Forest Service regions showed wilderness site visit increases from R2 to R3 of >28 percent, with the Alaska Region showing the

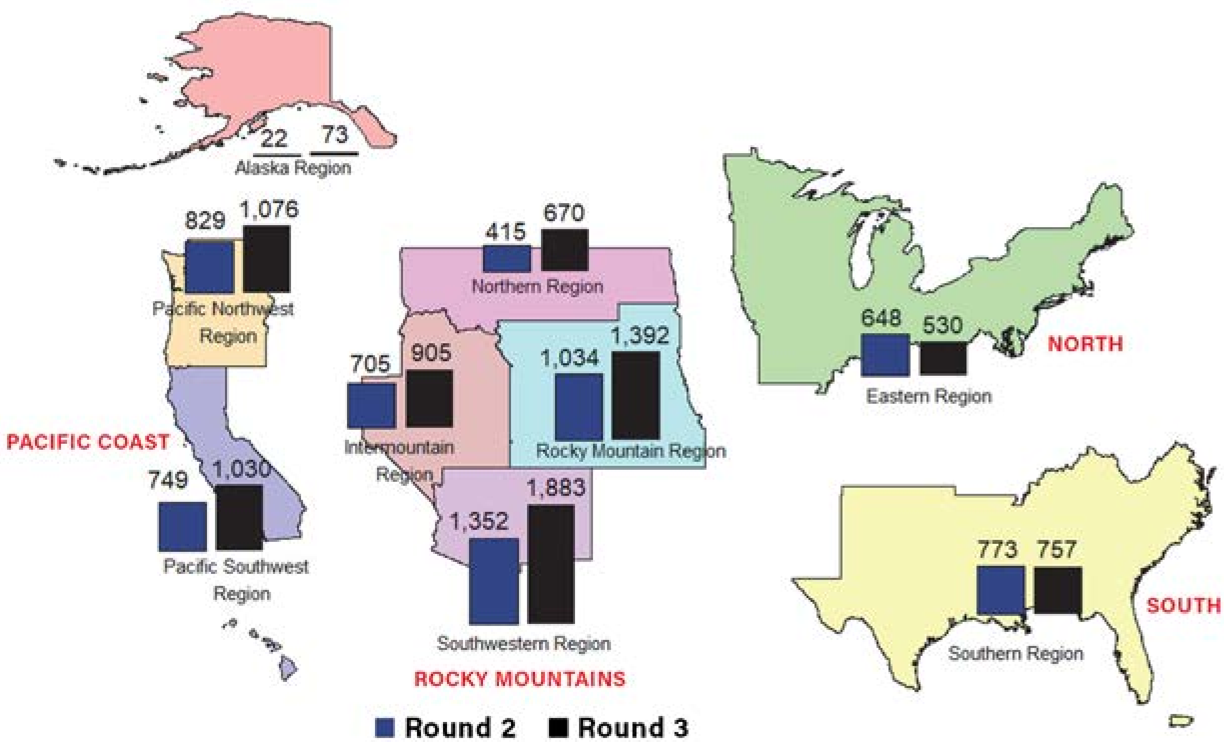


Figure 5.2—Average annual wilderness site visits (in thousands) by Forest Service region for the Nation.

largest percentage increase (232.5 percent) and the Southwestern Region showing the largest absolute increase in visits (531,000).[2]

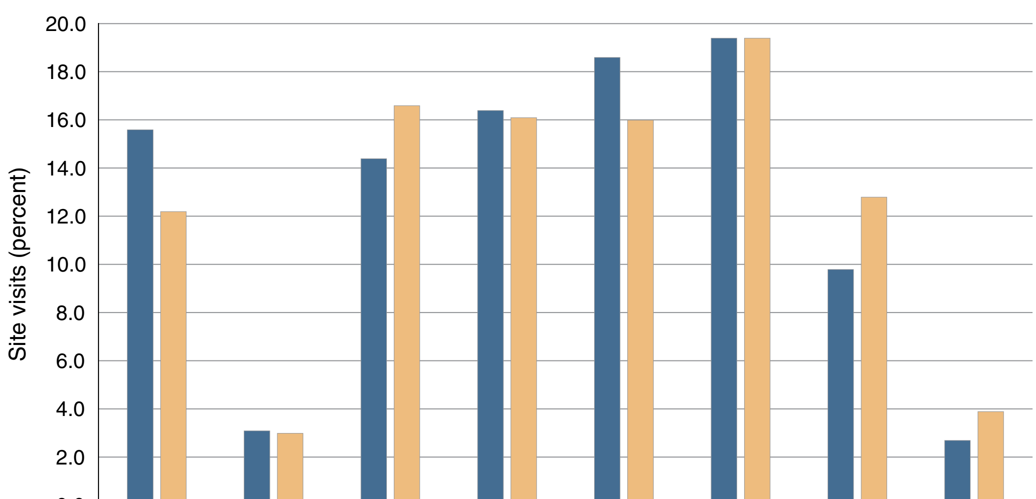
The age distribution across national forest wilderness visits has changed somewhat between R2 and R3 (fig. 5.3).[3] Despite the fact that the visit numbers by all age classes have increased, the percentage of visits represented by those in the under 16 years and 40–49 age groups have declined by about 3 percentage points, from 15.6 to 12.2 percent and from 18.6 to 16.0 percent, respectively. Visits in the 20–29, 60–69, and 70+ age groups have increased somewhat, while visits in the 16–19 and 30–39 age groups have remained static. The age group producing the most visits, 50–59 at 19.4 percent during R2 and R3, has remained constant as well. Overall, it appears that from 2005 to 2014, the age distribution for wilderness visits has shifted marginally to the right, suggesting a slightly older mean age for visitors. The aging of the visiting population is also evident in nonwilderness visitation. The 60+ age groups have accounted for most of the growth in total recreation visits across all Forest Service-managed lands over this same time period. In addition to changes in tastes and preferences, a number of factors could be contributing to this phenomenon such as declining retirement ages, increasing incomes, and amenity migration.

Racial/ethnic categories for wilderness visits include White (not Hispanic), Black (not Hispanic), Asian/Pacific Islander (not Hispanic), Native American (not Hispanic), Hispanic, and other (which includes identifying as mixed racial background or providing race[s] without Hispanic status). Non-Hispanic Whites made up the vast majority of wilderness visits on national forests, with a decline in proportion of site visits on average from 91 percent in R2 to 89 percent in R3, a decrease of 2 percentage points (fig. 5.4). The proportions of visits represented by Asian/Pacific Islanders (not Hispanic), Hispanics, and others rose by relatively large percentages, approximately 36, 35, and 39 percent, respectively.[4] However, as the R2

[2] Some of the differences could be from improvements in sampling procedures, although such procedural changes are unlikely to completely explain the differences.

[3] Statistics for visit characteristics are derived from NVUM data restricted to the contiguous 48 States.

[4] Note that there may be considerable rounding error in the figures due to reduction in significant digits.



	Under 16	16–19	20–29	30–39	40–49	50–59	60–69	70+
Round 2	15.6	3.1	14.4	16.4	18.6	19.4	9.8	2.7
Round 3	12.2	3.0	16.6	16.1	16.0	19.4	12.8	3.9

Figure 5.3—Age distribution of wilderness site visits for National Visitor Use Monitoring (NVUM) rounds 2 and 3.

A generally positive trend for site visits (percent) occurred across advancing age groups from the late teens to the 50s. Site visits (percent) declined from the recreationists in their 60s and onwards. In both rounds, the largest share of site visits came from those in the range of 50–59 years of age.

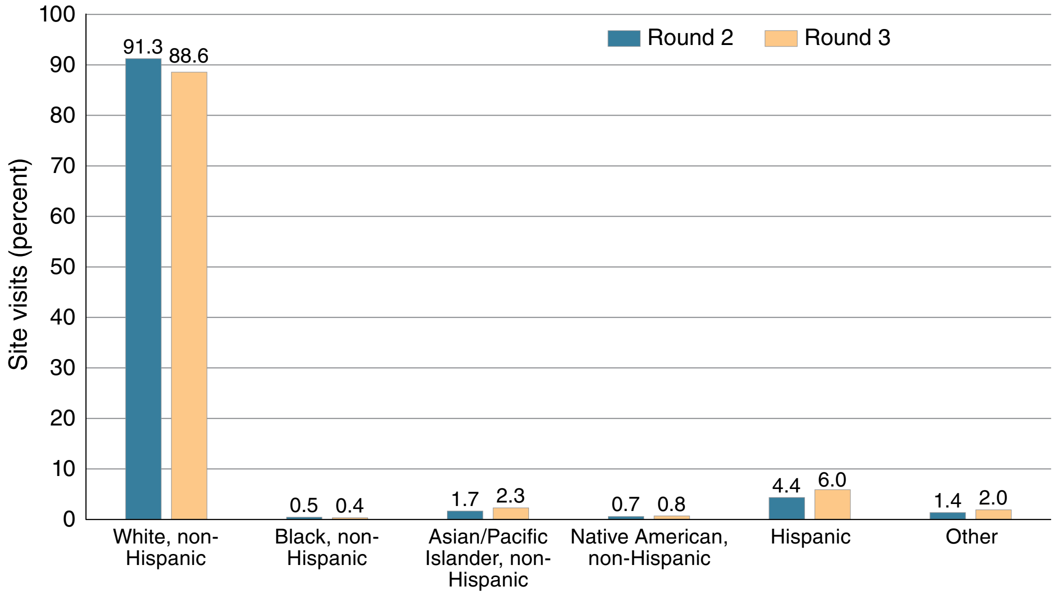


Figure 5.4—Race/ethnicity distribution of wilderness site visits for National Visitor Use Monitoring (NVUM) rounds 2 and 3.

The race/ethnicity distribution differs across rounds, indicating increased diversity driven mostly by Hispanics, Asian/Pacific Islanders, and others.

shares are relatively small to begin with, the changes in percentages could be somewhat misleading. The shares of non-Hispanic Black and Native American site visits remained practically unchanged across rounds, at about 0.5 and 0.7 percent, respectively. Based on these numbers, one may conclude that over the period of 2005 to 2014, the diversity of visits on national forest wildernesses increased. Statistical testing further confirms the significant shifts in racial/ethnic distributions across rounds, driven primarily by Hispanics, Asian/Pacific Islanders, and others (in order of largest contributors to the test statistic).

Adding to the apparent increase in diversity across racial/ethnic groups is a slight increase in female visitation from 39 percent in R2 to 41 percent in R3 (fig. 5.5). The differences in gender proportions across time are statistically significant, with females' distributional differences contributing more than males to the test statistic. This continues a trend reported by Cole (1996) where the percentage of female wilderness visits across the entire NWPS increased from 20 to 34 percent from 1964 to 1996.

Annual household income (in 2012 dollars) for national forest wilderness visits during R2 and R3 is presented in figure 5.6, demonstrating significant shifts across time points. Of those receiving the Economic Module, the nonresponse rates to the income question across the rounds were 15 and 19 percent, respectively. The percentages of site visits from the two lowest income categories, \$0–\$24,999 and \$25,000–\$49,999, have remained static at about 12 and 21 percent, respectively. However, wilderness site visits from household incomes of \$50,000–\$74,999 and \$100,000–\$149,999 have declined over the two rounds spanning 2005 to 2014. The \$50,000–\$74,999 category, producing the greatest percentage (23 percent) of wilderness visits in R2, averaged three percentage points less in R3 (21 percent). In contrast, the \$75,000–\$99,999 income category, which represented 14 percent of visits in R2, rose to 17 percent of visits in R3. Also, the \$150,000+ category increased by 29 percent, from 11 percent of the visits in R2 to 14 percent of the visits in R3. In statistical testing, the largest components of the test statistic come from the \$150,000+ category, followed by those with annual household incomes of \$100,000–\$149,999. These numbers suggest

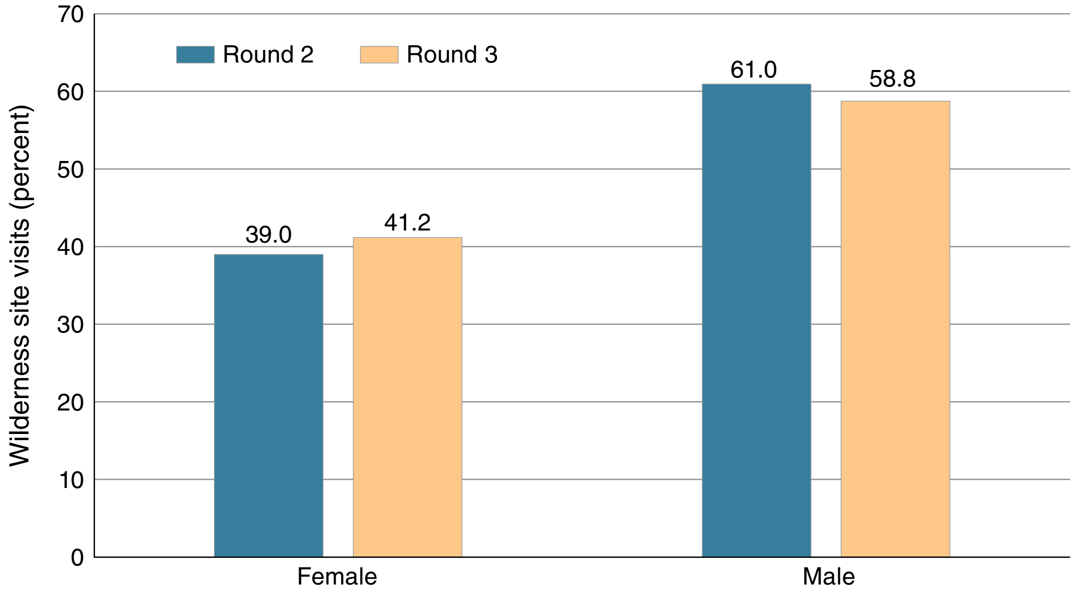


Figure 5.5—Gender distribution of wilderness site visits for National Visitor Use Monitoring (NVUM) rounds 2 and 3.

Statistical testing confirms that, from round 2 to round 3, the proportions of each gender differ significantly.

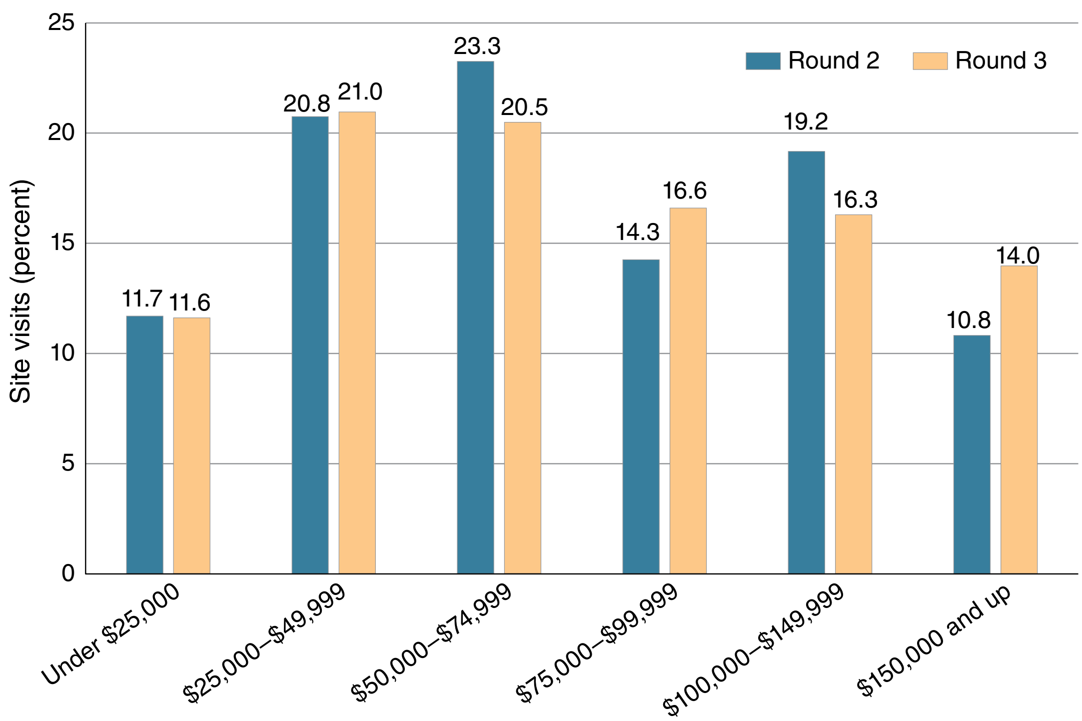


Figure 5.6—Annual household income distribution of wilderness site visits for National Visitor Use Monitoring (NVUM) rounds 2 and 3.

Statistical testing confirms distributional differences in income categories across rounds. The largest contributors to the test statistic are those in the $150,000+ group (on the rise), followed by those in the $100,000–$149,999 interval (a decline across rounds). The cells contributing the least to the test statistic are in the lower income intervals, under $25,000 and $25,000–$49,999, which is reflected graphically in the stability across rounds.

both an increased representation of higher income households among wilderness visits, and perhaps a shift toward a more uniform distribution across all income classes. This trend appears to be continuing with the subset of wilderness sites that Bowker and others (2018) used to compare R2 through R4. Moreover, the trend is consistent with the above finding that the 50–59 age group produces the most national forest wilderness visits.

Group size for wilderness visits has remained relatively constant from 2005 to 2014. Two-people units, by far the largest group size category, remained constant at just over 47 percent in both R2 and R3 (fig. 5.7). Similarly, groups of five or six represented about 5 percent of the visits, while groups of seven or more vacillated between 2 and 3 percent. Single-person groups accounted for just over 22 percent of wilderness visits in R2 and just under 20 percent of the wilderness visits in R3. Conversely, visits by groups of three or four increased from 23 percent in R2 to 26 percent in R3, an increase of 11 percent.

The duration of wilderness visits appears to have shifted from 2005 to 2014 (fig. 5.8). Visits in the 'under 3 hours' category represented 39 percent of all wilderness site visits in R2. That percentage rose to 44 percent of all visits in R3, an increase of 11 percent. The duration category with the next largest number of visits was '3–6 hours,' with a similar rate of change between rounds. R2 visits in the '3–6 hours' category represented 29 percent of site visits, rising to 32 percent of site visits on average in R3. Together, visits to national forest wilderness sites shorter than 6 hours rose from 68 percent in R2 to 76 percent in R3, an increase of 11 percent. Alternatively, visits lasting '6–12 hours' and '12+ hours' have declined in percentages of total visits. For example, visits lasting 6–12 hours, which are still likely day users, represented 12 percent of wilderness visits during R2, decreasing to 10 percent of the visits in R3. Similarly, visits to wilderness exceeding 12 hours declined from 19 percent in R2 to 14 percent during R3, a drop of 26 percent. In the case of wilderness visits, most likely any site visit of <12 hours in duration can be considered day use. Thus, it appears that the day use share of national forest wilderness site visits increased between 2005 and 2014 as visits <12 hours increased from 81 percent of all visits in R2 to 86 percent of all visits during R3. These findings are in sharp contrast to the percentage of day use reported for 10 wilderness areas in Hendee and others (1978: 296) wherein the day use visitation ranged from a low of 14 percent to a high of 67 percent. Cole (1996) identified a

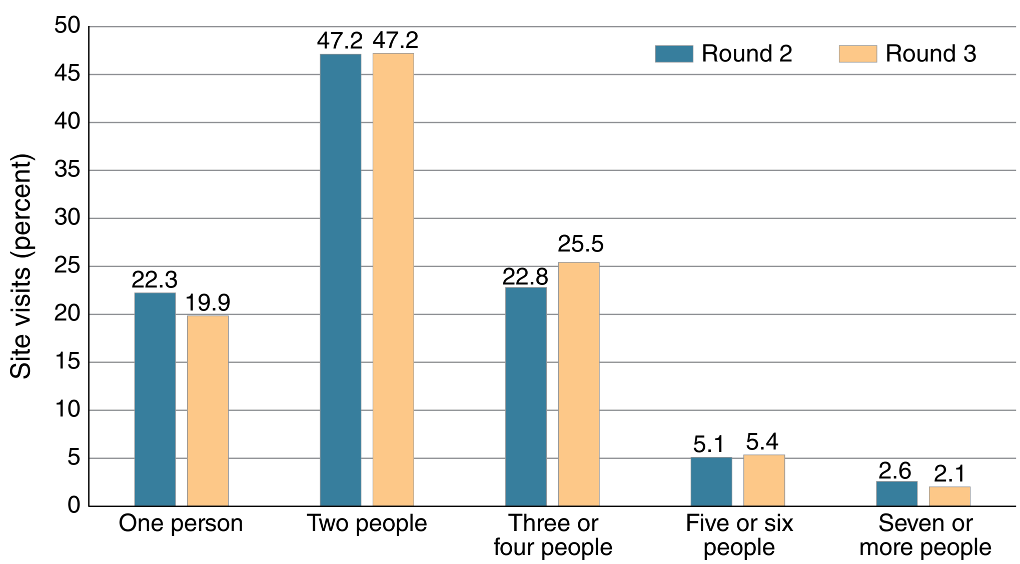


Figure 5.7—Group size distribution for wilderness site visits for National Visitor Use Monitoring (NVUM) rounds 2 and 3.

The distributions of wilderness visits over group sizes shift significantly across rounds. The largest contributors to this change in visit compositions are from single-person groups (on the decline) and groups of three or four people (increasing to round 3). The most stable group in terms of wilderness visits was that of two-people units.

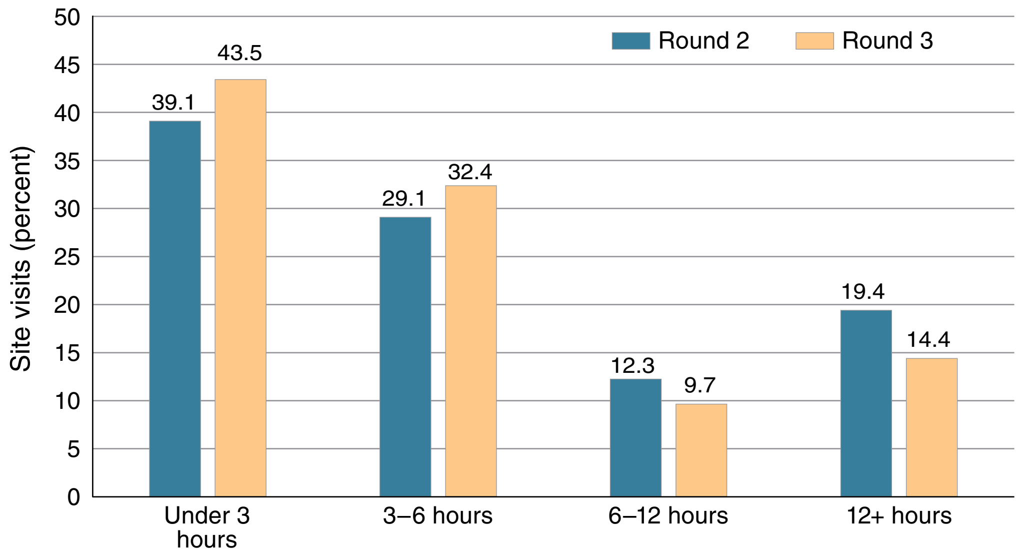


Figure 5.8—Site visit duration distribution for wilderness site visits for National Visitor Use Monitoring (NVUM) rounds 2 and 3.

The distributions by site visit durations shift significantly across rounds. Each grouping contributes largely to the test statistic, with the greatest from the '12+ hours' group and then the '6–12 hours' group, both on the decline.

potential trend of increasing day use based on limited data from the U.S. Department of the Interior National Park Service.

For the NVUM survey, onsite visitors to wilderness were queried about their activity participation. First, they selected from a list of activities in which they participated during their just-concluded national forest wilderness visit (https://cms.fs.usda.gov/about-agency/nvum/manager-tools). Then, they were asked to select their primary activity. Response rates for this question were nearly 100 percent; those who did not respond with a primary activity represented only 0.68 and 0.58 percent of the sample in rounds 2 and 3, respectively. The eight most popular primary activities during R2 and R3 are listed in table 5.1. These activities represented 88 percent of primary activities in R2 and 90 percent of the same in R3. By far, hiking/walking was the most popular main activity, accounting for 59 percent of R2's main activities and 66 percent of the main activities in R3. Moreover, hiking/walking increased as a primary activity from R2 to R3 by 11 percent. As an example of cultural change, Hendee and others (1978: 296) did not include hiking as an activity in their study of 10 wilderness areas managed by the Forest Service, but rather as a mode of

Table 5.1—Main activity distribution for national forest wilderness site visits for National Visitor Use Monitoring (NVUM) rounds 2 and 3

The most popular activity in both rounds by far is hiking, comprising a majority share of site visits. Statistical testing confirms the distribution of site visits (percent) across activity varying by round. All cells contribute to the test statistic, with the lowest from fishing and the greatest from hunting and hiking, respectively. Site visits from fishing appear to be more stable across rounds than for the other activities.

The nonresponse to main activity is quite low across rounds, at <2 percent for both time periods.

Main activity	Round 2	Round 3
	percent of site visits	
Hiking/walking	59.3	65.8
Backpacking	6.7	5.7
Relaxing	4.8	4.1
Viewing nature	4.5	4.1
Hunting	4.1	2.4
Fishing	3.5	3.8
Nonmotorized water	3.0	2.2
Other activities[a]	2.3	2.5
No main activity[b]	**0.7**	**0.6**

[a] The NVUM Basic questionnaire presents respondents with 28 total activities from which to select as the main activity, including the option of "other activity" for one not listed.
[b] These percentages indicate the site visits (percent) from respondents who did not respond affirmatively to any of 28 total activities.

transportation. Clearly, a major draw to national forest wilderness is hiking opportunities, which can be done on recreationists' own time or in conjunction with an overnight or multi-night trip. Notably, the second most popular main activity, backpacking or camping in roadless areas, declined slightly from 7 to 6 percent during the same time. Relaxing, viewing nature (viewing/photographing natural features, scenery, flowers, etc.), and hunting rounded out the top five most popular main activities in R2, while fishing surpassed hunting's popularity in R3. The patterns of activities and their percentages are consistent with apparent shifts to an increased proportion of day use on national forest wilderness noted above.

A final descriptor of wilderness visits is travel distance. In effect, this factor indicates the breadth and shape of the market spatially. The distribution of miles traveled for wilderness visits (with one-way distances of <3,000 miles) is depicted in figure 5.9 as a U-shape with the largest proportions of visits originating from ≤50 miles and >500 miles. For example, 37 percent of all visits originated within 50 miles during R2, whereas the percentage increased to 46 percent in R3. The increase in local visits would appear consistent with the previously reported increase in day use. Very long distance visits, i.e., originating >500 miles away from the wilderness site, accounted for 19 percent of visits in R2 and 17 percent of R3 visits. Without detailed followup questions to such visitors and subsequent analysis, it is difficult to discern the proportion of these visits which were day trips in conjunction with overnight stays in the general area or multi-day visits to the particular wilderness. Regardless, there appeared to be a shift of the distance traveled distribution for wilderness visits from right to left between R2 and R3.

Overall, it appears that a number of changes have taken place regarding wilderness visits on national forests from 2005 to 2014. First, wilderness visits on national forests have increased over the 10-year period by around 27 percent. This study made no attempt to identify the drivers of this change. But, if this rate of change continues for another 10 years or more, there is no doubt that understanding motivating factors will be paramount to managing wilderness in ways which sustains the resource's character. Other changes suggest that the concept of a wilderness trip is by no means homogeneous. Indeed, there

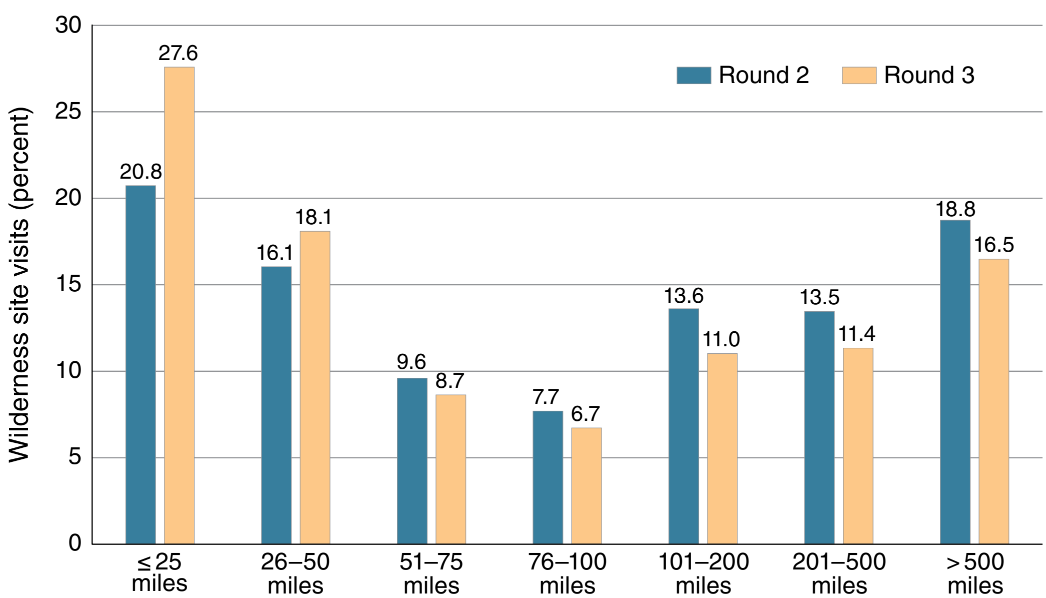


Figure 5.9—One-way travel distance distribution for wilderness site visits for National Visitor Use Monitoring (NVUM) rounds 2 and 3.

The distributions of wilderness visits by travel distances show significant differences across rounds. Examining the test statistic, the highest-contributing cells are those for the "25 miles and under" category. The visual confirmation above reflects the rapid change in visitation from that travel distance interval.

are multi-day overnight users, and there are day users, with the latter's share of all visits increasing from 2005 to 2014. Whether this observation is a trend is not discernable with just two 5-year periods of NVUM wilderness data as evidence. Nevertheless, it is clear that increasing shares of wilderness visits are of a day-use nature. This is corroborated by (1) a shift in the distribution of travel distances to the left, i.e., shorter distances representing more site visits; (2) an increase in the share of hiking versus backpacking as a reported primary activity; and (3) a relative increase in the share of visits that recreate <12 hours at the wilderness site.

Another change supported by these data is that wilderness visits are becoming more diverse from a racial/ethnic perspective. While minority wilderness visits remain considerably below population shares, a fact consistent with recreation visits in general to national forests (Flores and others 2018), there is nevertheless a noticeable increase in minority visits, particularly for Hispanics, Asian/Pacific Islanders, and those who choose to identify with the "other" self-identification category (i.e., multiple ethnicities or ethnicities without Hispanic status). There also appears to be an increasing share of visits represented by high-income households ($150,000 and up). This may or may not be correlated with what appears to be an upward shift in the age distribution of visits. Finally, visits by gender appear to be relatively stable over the relevant time periods, albeit with the proportion of females increasing slightly.

Wilderness Visitor Preferences

In this section, we examine visitor perceptions of factors generally relevant to outdoor recreation experiences at wilderness sites. We first evaluate two one-dimensional ordinal or Likert rating scales used to assess general visitor satisfaction during their wilderness experience, i.e., crowding and overall satisfaction. We also examine a number of individual site/forest attributes, considered components of overall satisfaction, using a popular two-dimensional assessment called importance-performance analysis (IPA). As in the previous section, data include NVUM R2 and R3 survey responses from wilderness sites in the continental United States. All visitors rate overall satisfaction in the Basic Module; however, data are further restricted to wilderness visitors receiving the Satisfaction Module with questions on crowding and attribute importance and performance. Given that the previous section identified day use as the larger percentage of wilderness visits and a growing share of all site visits, we partition the analyses in this section into those by day and overnight users. An overnight user is defined as a recreationist with a site duration of 18 hours or more. Here we focus on wilderness visitation with the primary purpose of recreating on the national forest.

The NVUM sampling procedure produces data that are endogenously stratified, i.e., the probability of a recreationist being sampled at a given site is related to the number of times he/she visits (Gill and others 2010, Shaw 1988, Thomson 1991). In survey prework, the NVUM sampling process allocates a certain number of sampling days within a period for each site/forest. More frequent visitors have higher probabilities of being sampled, which necessitates adjusting statistics on individuals' behaviors (as opposed to representation of visitation). The problem of bias resulting from endogenous stratification (or avidity bias) is rarely recognized or acknowledged in studies applying IPA to onsite data. Gill and others (2010) addressed this issue and offered a corrective procedure, weighting respondents' values by the inverses of their reported annual visits. Weighting by the inverse of annual visits equates all responses with respect to their probabilities of being sampled, thus mitigating the effects of avidity bias on estimates of individual visitor choices, preferences, and behavior. Askew and others (2017) applied Gill and others' IPA approach across multiple time periods and to one-dimensional crowding and satisfaction ratings across the multiple site types captured in the NVUM data.

Likert scales are commonly used to assess crowding at recreation sites (Fletcher and Fletcher 2003). For remote outdoor recreation or wilderness use, crowding or the perception thereof can be particularly important for managers (Shelby 1980). Generally, in wildland settings, increased crowding correlates negatively with the user's experience or satisfaction (Vaske and Shelby 2008). The NVUM survey uses a 10-point Likert scale in the Satisfaction Module for crowding, from "hardly anyone" (1) to "overcrowded" (10). The distributions of the weighted responses for crowding among wilderness site visitors, both day users and overnight users during R2 and R3, are displayed in figure 5.10.

For day users, the pattern between R2 and R3 indicates a decrease in those reporting "hardly anyone" and a decrease in those reporting "overcrowded." Except for the extreme category of overcrowding, there appears to be a somewhat rightward shift of the crowding response distribution over the 2005 to 2014 period, indicating a moderate increase in perceived crowding overall. For overnight visitors, there is also a more pronounced decline in the percentage of users reporting "hardly anyone" but also a small decline in those reporting the highest level of overcrowding. However, there is clearly a more pronounced shift in the reported crowding distribution to the right, indicating increased levels of perceived crowding than was the case for day users. This is interesting given the finding above which shows day use increasing and being by far the larger percentage of wilderness visits. One may infer that overnight users perceive, or sense, the aggregate increase in visits more strongly than day users.

All wilderness site visitors at national forests were also asked, using a 5-point Likert scale, to rate their overall satisfaction for the visit at which they were surveyed. The scale symmetrically spanned categories from "very dissatisfied" to "very satisfied" (fig. 5.11). The percentage of visitors reporting very satisfied exceeded 80 percent. In no case, for day or overnight users in either R2 or R3, did the sum of the lowest three satisfaction categories (dissatisfied plus neutral responses) exceed 3 percent of visitors, indicating that the vast majority of both wilderness user types were very satisfied. For day users, the distribution of responses is virtually unchanged from R2 to R3. For overnight users, despite the noticeable shift in the crowding distribution reported in figure 5.10, there appears to be a slight increase in the percentage of very satisfied visitors

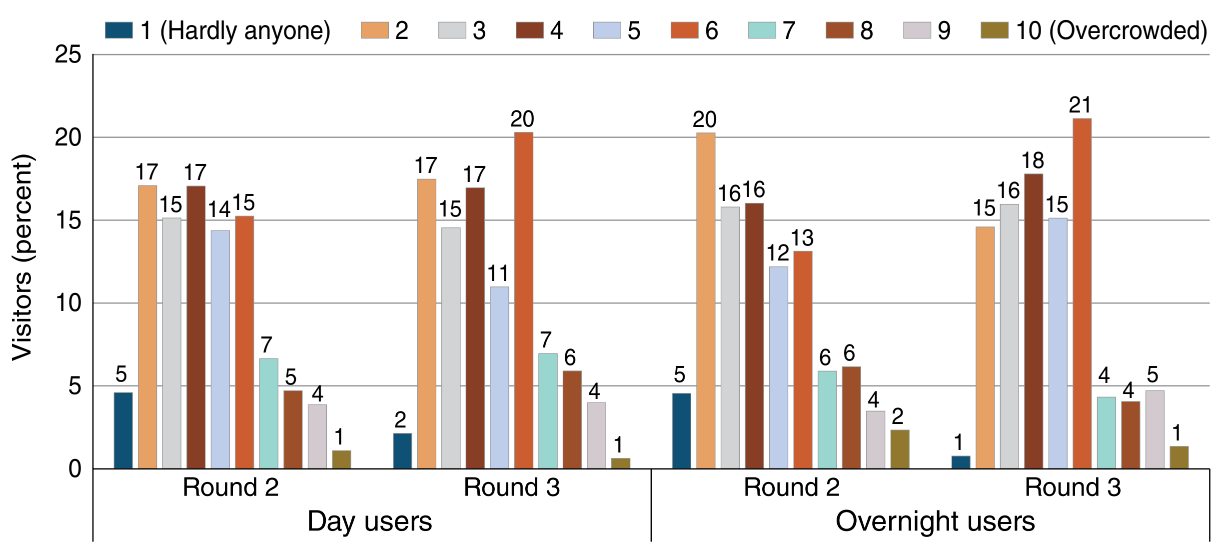


Figure 5.10—Distribution of crowding ratings (percentage of visitors) for wilderness day users versus overnight users for National Visitor Use Monitoring (NVUM) rounds 2 and 3.

The distributions of crowding ratings by visitors differ significantly across time within the two user groups. The largest shares of the test statistic come from visitors with ratings of 1 (on the decline) and 6 (on the rise)

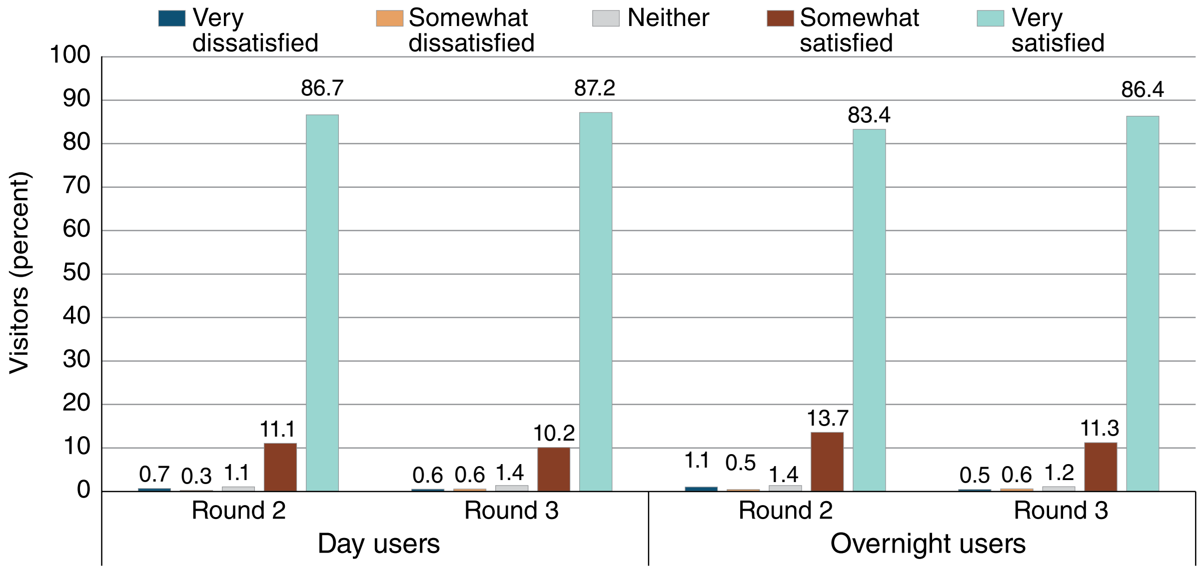


Figure 5.11—Distribution of overall satisfaction ratings (percentage of visitors) for wilderness day users versus overnight users for National Visitor Use Monitoring (NVUM) rounds 2 and 3.

The distributions of overall satisfaction ratings (percentage of visitors) are not significantly different across time within the two user groups. This could be due to the stable predominance of ratings of 5 ("very satisfied").

of about 3.6 percent from R2 to R3. Hence, despite perceived increases in crowding, which are consistent with the measured increase in total wilderness visits, the overall level of satisfaction among national forest wilderness visitors seems to have remained at least as good in R3 as in R2.

Importance-performance analysis is a simple yet informative technique for assessing consumer preferences where responses to perpendicularly juxtaposed Likert scales are contrasted in a two-dimensional analytical framework, jointly examining importance and satisfaction ratings. Martilla and James (1977) are generally considered the originators of this form of analysis, developed in the context of auto sales and consumer satisfaction. It has been used and extended by a number of researchers to assess various aspects or attributes of recreation and tourism experiences (Askew and others 2017, Gill and others 2010, Lai and Hitchcock 2015, Lee 2015, Leeworthy and others 2004, O'Leary and Adams 1982, Sörensson and von Friedrichs 2013, Ziegler and others 2012). Though the methodology is now nearly four decades old, applications are ongoing.

Martilla and James (1977) formulated an approach for attributes, where thresholds established for importance and performance define four quadrants (fig. 5.12A):

1. **High importance, high satisfaction:** A quality or attribute which is deemed highly important and performing well means to "keep up the good work" (GW).
2. **High importance, low satisfaction:** A highly important quality or attribute which is not performing well suggests that management "concentrate here" (CH).
3. **Low importance, high satisfaction:** This is a potential indicator of "possible overkill" (PO), where shifting resources to maintaining or improving another quality or attribute could lead to an overall improvement in the recreation experience.
4. **Low importance, relatively low satisfaction:** Though recreationists may not be as satisfied, the low importance attached to this quality or attribute indicates that this is an item of "low priority" (LP), and that limited resources may be better allocated toward another quality or attribute.

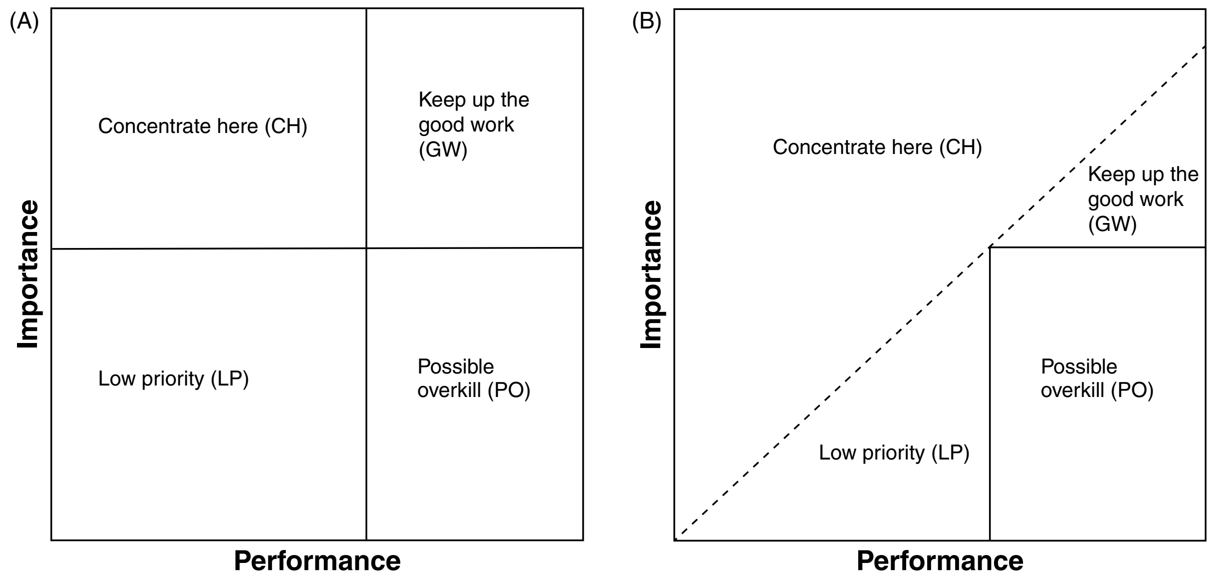


Figure 5.12—Traditional importance-performance analysis (IPA) with thresholds (A) versus the hybrid using the iso-priority line (B), shown as dashed, where the importance and performance are equal (Abalo and others 2007).

The differences between the thresholds and the attribute indicate positive or negative deviations. Items performing very highly may appear in the extreme reaches of the GW quadrant, while those far into the CH quadrant require attention. Attribute scores close to the thresholds are inconclusive. In a temporally adapted IPA, movement of attribute means over periods suggests potential trends. Threshold placement is "a matter of judgment," with options being scale-based (e.g., centers or arbitrarily chosen Likert-scale values) or data-based (e.g., attribute score medians or means) (Martilla and James 1977). While final choice is left to researcher judgment, research continues on threshold establishment (Lai and Hitchcock 2015).

An alternative to quadrants and thresholds is the iso-priority line approach (Lee 2015). This is a diagonal line on which performance equals importance. This diagnostic indicates which items are of highest concern, using pairwise differences of satisfaction and importance as the measures for a more sensitive test (Ziegler and others 2012). In other words, the iso-priority approach reduces the dimensions of analysis from two to one (Albayrak 2015). A downside is that the test is less informative, using a division of only two spaces rather than the four classifications seen in traditional IPA (Sever 2015). A hybrid approach can also be formulated by overlaying an iso-priority line on the conventional IPA based on either scale- or data-centered thresholds. This method expands the potential area of concern (fig. 5.12A and B). The distances can then be used to gauge how strongly an attribute falls into a quadrant.

When applied to wilderness recreation on national forests, the methodology occurs in three phases: selection of qualities or attributes relevant to the wilderness recreation experience (in advance), rating of attributes by respondents (survey process), and computing means and thresholds for a two-dimensional plot (data analysis). We follow Askew and others (2017) and Leeworthy and others (2004) by introducing a temporal aspect to compare R2 and R3.

If an original survey is part of the IPA study, then attributes can be customized to the researchers' or managers' needs. Otherwise, secondary data can be used if relevant attribute information is obtained. The Satisfaction Module of NVUM contains 16 importance and satisfaction Likert scale attribute questions for the various site types on national forests (Askew and others 2017). For wilderness, we selected a subset of four attributes closely related to recreation at the wilderness site including: NATENVR (condition of the natural environment), SCENERY (scenery at this site/area), SAFETY (feeling of safety), and TRAILS (condition of forest trails). We also included five attributes which essentially occur outside the wilderness boundaries and relate to accessing the wilderness site: SIGNAGE (adequacy of signage to this site), TOTALSIGNS (adequacy of signage on this forest as a whole), PARKING (available parking), PARKINGLOT (condition of parking lot), and TOTALROADS (condition of roads on this forest as a whole). The NVUM attributes not considered relevant to our analysis included CLEANLINESS (cleanliness of restrooms), DEVFACILITIES (condition of developed facilities), HELPFULNESS (helpfulness of employees), DISPLAYS (availability of interpretive/educational displays), VALUE (value for fees paid), and RECINFO (availability of information about this site).

The IPA diagrams for national forest wilderness day users and overnight users are presented in figure 5.13. Consistent with the high overall satisfaction ratings discussed previously, most attributes rate near or above 4 ("somewhat important," "somewhat satisfied") on a five-point Likert scale during both R2 and R3. As we are interested in tracking ratings by user subgroup over two periods, the axis for each user type is based on respective subgroup mean scores calculated for R2 which serves as a baseline. Furthermore, two-sample t-tests are used to determine statistically significant changes across time points at levels 0.05 and 0.10, shown in table 5.2.

For both day users and overnight users, the attributes ranking highest for importance and satisfaction are those directly related to the wilderness recreation experience, i.e., NATENVR, SCENERY, SAFETY, and TRAILS (fig. 5.13). For day users, all four of these attributes unambiguously appear in the GW quadrant indicating relatively high importance and satisfaction or performance, with the former two attributes at the upper reaches of the quadrant. For overnight users, the results for these attributes are similar except that TRAILS falls into the CH quadrant, indicating managerial attention could be needed. Day and overnight users attach greater importance to SCENERY in R3, with increasing satisfaction driving the attribute farther into the GW quadrant (especially for overnight users). For both user groups, as NATENVR approaches the iso-priority line from R2 to R3, an improved outcome is realized, driven by increasing satisfaction over static importance. For day users, the attribute of TRAILS becomes increasingly more important in R3, though still in the GW quadrant due to static (and relatively high) satisfaction. If the trails used by both groups are the same, then there is clearly a difference in expectations across groups. Otherwise, it could be that the quantities or conditions of the likely more remote trails used by backpackers are a concern. Another possibility is that since remote trails likely receive both less use and less maintenance, they could be more subject to natural disturbances. Both user groups perceive SAFETY to be performing well across time. From R2 to R3, the attribute becomes more important to day users with unchanging satisfaction levels. The perception of safety improves on satisfaction for overnight users (with static importance), driving the attribute farther into the GW quadrant.

For both user groups, SIGNAGE, TOTALSIGNS, and TOTALROADS rated consistently lower in satisfaction and toward the middle in importance over the two periods (fig. 5.13). Moreover, all three attributes are rated in the LP quadrant for R2, indicating that despite the relatively lower satisfaction levels, the importance of these attributes may be insufficient to merit additional managerial attention. However, attributes related to signage for both groups show increases in importance relative to satisfaction. For SIGNAGE, both day user and overnight user ratings display a move from LP to CH in R3 motivated by increasing importance. As well, concern is demonstrated as the signage scores for both groups move above the iso-priority

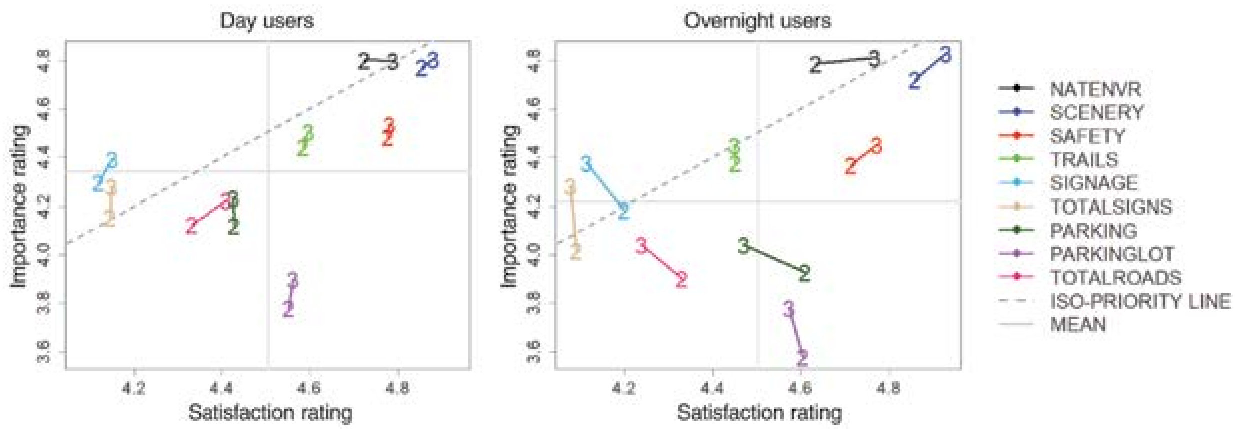


Figure 5.13—Importance-performance analysis (IPA) for wilderness users for National Visitor Use Monitoring (NVUM) rounds 2 and 3.

The highest performing attribute is SCENERY, which is very important to the wilderness experience. NATENVR also performs very well from the quadrant approach, but the iso-priority line indicates that satisfaction does not always match or exceed attached importance. Lastly, SAFETY is a high performer in both the quadrant and iso-priority approaches.

The least important attributes correspond to PARKINGLOT, TOTALROADS, and PARKING. However, the increasing importance could signal a worrisome trend, depending on the means at the next time period. The lowest (relatively) levels of satisfaction occur for SIGNAGE and TOTALSIGNS, with importance in the middle.

Table 5.2—Changes between importance and satisfaction ratings from National Visitor Use Monitoring (NVUM) rounds 2 to 3

Increasingly important items with stable satisfaction include the following: TOTALSIGNS (day and overnight users), SAFETY (day users), TRAILS (day users), SIGNAGE (day and overnight users), PARKING (day users), and PARKINGLOT (day and overnight users). Items increasing in both importance and satisfaction include TOTALROADS (day users) and SCENERY (day and overnight users). Overnight users indicate declining satisfaction for TOTALROADS and PARKING, with importance increasing in the former and steady in the latter. Satisfaction increases in conjunction with static importance for NATENVR (day and overnight users) and SAFETY (overnight users).

	Change in rating means, round 2 to round 3			
	DAY USERS		OVERNIGHT USERS	
Attribute	Importance	Satisfaction	Importance	Satisfaction
	----------------------------percent----------------------------			
Forest-level				
TOTALSIGNS	3.0[a]	0.5	6.6[a]	-0.5
TOTALROADS	2.4[a]	1.7[a]	3.5[a]	-2.6[b]
Site-level				
NATENVR	-0.1	1.4[a]	0.5	3.2[a]
SCENERY	0.7[b]	0.6[a]	2.3[a]	1.8[a]
SAFETY	1.1[b]	0.2	1.9	1.3[b]
TRAILS	1.4[a]	0.4	1.7	0.5
SIGNAGE	2.2[a]	0.9	4.6[a]	-1.7
PARKING	2.6[a]	0.1	2.9	-2.3[b]
PARKINGLOT	3.1[a]	0.2	5.6[a]	-0.4

[a] Difference statistically significant at 0.05 level.
[b] Difference statistically significant at 0.10 level.

line in all cases, suggesting that signage is potentially a growing concern of national forest wilderness users and that managers should consider addressing this issue. Both user groups attach increasing importance to TOTALSIGNS, but the larger shift in overnight users reclassifies the attribute as needing work per the quadrants. The attribute is above the iso-priority line for both user groups, indicating possible concern. For both user groups, the attribute of TOTALROADS is of low concern, though shifts may warrant monitoring in the next survey cycle, especially for overnight users. The attribute becomes more important for both user groups, but while satisfaction increases for day users, it declines for overnighters.

The remaining attributes are PARKING and PARKINGLOT. Despite wilderness being restricted to nonmotorized activities, the great majority of visitors access wilderness sites via motorized travel. Thus, parking availability and, to an extent, the condition of the parking lot can influence the quality of a wilderness recreation experience. With the reported increases in wilderness visits discussed previously in this chapter, it is not difficult to imagine that parking facilities, particularly at high-impact day use areas, could become an issue. As shown in figure 5.13, for both day users and overnight users, parking is toward the middle of the ratings for satisfaction but at the bottom for importance. Not surprising, the condition of the parking lot is the least important attribute for both user groups appearing in the PO quadrant. However, parking attributes become increasingly important: condition for both user groups and amount for day users. Also potentially concerning is the decline in satisfaction for overnighters' experience with amount of parking. If this becomes a trend correlated with increased visitation, then parking, especially parking availability, could become a serious management concern in the future. Using preliminary data for R4, Bowker and others (2018) indicate that this may well be a major concern for wilderness managers in the future, particularly in wilderness areas that experience high concentrations of day users during peak periods.

Overall, it appears that wilderness users, both day and overnight, are highly satisfied at the aggregate level, despite an uptick in perceived crowding associated with the experienced increase in visitation. It also appears that the fundamental aspects of onsite use, i.e., scenery, natural environment, trails, and safety, are rated as the highest and best functioning attributes, although trails could become an issue, especially for overnight users. Signage, offsite but essential to accessing the wilderness site, appears to be the most pressing issue over the 2005 to 2014 period. Moreover, parking availability is likely to become an emergent management issue.

Economic Value of Wilderness Recreation Access

Wilderness is a source of economic value to visitors as well as those who will never visit (Bowker and others 2014, Holmes and others 2016). An important economic value for wilderness, and perhaps the least abstract, is use value resulting from recreation access. In most cases, while access at the site is free because user fees are not charged, visitors invest significant time, effort, and money in researching recreation opportunities and gaining experience (investments in human capital), acquiring necessary gear and supplies (investments in physical capital), traveling to recreation sites, and engaging in activities onsite (Parsons 2017). Household welfare losses could be considerable if access to wilderness sites were limited, either through closure or a change in designation. Consequently, visitors have a positive willingness to pay for continued access to wilderness areas, and estimates of this value are useful in assessing the economic value and impacts of Forest Service operations.

We employ the travel cost method (TCM) to NVUM wilderness visitation data in order to assess the determinants of demand for trips to wilderness areas and to estimate consumer surplus, or net willingness to pay, associated with access. The TCM is also discussed in the context of a different sample of wilderness visitors in Holmes and others (this volume, ch. 6). The TCM focuses on household choice of the desired number of trips to wilderness sites on national forests based on enjoyment (i.e., utility) received from such trips and the cost of access, subject to budget and time constraints. The utility function for individual i is a function of the number of visits taken to a specific wilderness site (x) and the consumption of a composite good (q), accounting for all other consumption activities: U(x,q). Normalizing the price of the composite good (q) to equal 1 (through use of a cost-of-living index [Landry and others 2016]), the individual's budget constraint is given as: $px + q \leq y$, where p is the cost of travel to the site (discussed below) and y is household income. Constrained optimization of utility leads to the standard Marshallian demand function for site visitation [$x = f(p,y)$], which is often estimated using the travel cost method (Parsons 2017).

Estimation of recreation demand models permits assessment of visitor response to price changes (price elasticity of demand), which could result from user fees, parking fees, or an increase in travel costs and the influence of household demographic characteristics on visitation. Each of these can aid in understanding the nature of wilderness visitation and its relationship to other recreational opportunities, and in forecasting future demand. Demand models can also be used to examine the effect of wilderness area characteristics (i.e., surrounding population density, size of wilderness, and trail miles) on recreation choice and intensity. Models can also be tailored to allow different price responses by visitors to different wilderness characteristics or ecotypes, as well as by different kinds of primary activity, e.g., hunting, backpacking, and hiking. Classifying wilderness areas by ecoregion permits a comparison of demand across ecologically distinct settings.

As described above, we employ NVUM data, collected onsite across wilderness areas on national forests. The sampling design is meant to approximate population proportions at wilderness sites (important for site-choice analysis). The sample, however, suffers from truncation of nonusers (potential users that might visit wilderness areas under different conditions—e.g., lower gasoline prices) and endogenous stratification. We apply the Thomson-correction (Landry and others 2016, Thomson 1991) to estimate unbiased group and site descriptive statistics.

To assess recreation demand for wilderness, we estimated pooled single-site recreation demand equations for all wilderness areas in the NVUM dataset (R2 and R3). This approach accounts for all 445 designated wilderness areas across 113 administrative units within the National Forest System (University of Montana 2018) within a single recreation demand model framework (Bin and others 2005), including wilderness site characteristics to account for heterogeneity. We incorporate the theoretical framework of incomplete demand systems in order to produce estimates of economic welfare that are consistent with microeconomic theory (LaFrance 1990, Landry and others 2016, von Haefen 2002), and we account for onsite sampling, which gives rise to endogenous stratification and truncation of recreation demand data (Englin and Shonkwiler 1995, Landry and others 2016, Shaw 1988, Shi and Huang 2018). Our regression framework is given by:

$$\ln(x_{ij}) = \beta_i + \beta_p p_{ij} + \beta_y y_j + \gamma' H_j + \delta' Z_i$$

The dependent variable x_{ij} indicates trips taken by household j to wilderness in forest i; the intercept term for site i is β_i, and price and income effects are given by β_p and β_y, respectively. Household descriptors are captured by the vector H_j, while site characteristics are captured by the vector Z_i. We follow standard protocol and estimate the hours spent traveling to wilderness areas by dividing the distance traveled (from centroid of ZIP code point of origin to point of onsite interview) by a presumed speed of transit. For those traveling <100 miles, we assume a speed of transit of 45 miles per hour to account for time spent on secondary and back roads;

for those traveling ≥100 miles, we assume a speed of transit of 55 miles per hour to account for interstate travel. Travel costs are approximated as operating costs for a medium sedan according to the American Automobile Association's "Your Driving Costs" (AAA 2004–2015), which range from \$0.141 to \$0.2109 per mile (nominal dollars). We account for opportunity cost of time as one-third of the survey respondent's household hourly wage rate (or the minimum wage if we have no data on wage rate). Travel cost (p) is the sum of round-trip monetary and time cost. Household income is measured as the mid-point of the income category indicated by the respondent, with the upper income approximated by the Pareto Distribution (Hout 2004). An estimate of the upper income level is given by:

$$\overline{Inc}\,\frac{1}{2} - L_{upper}\left(1 + \frac{V}{V-1}\right)$$

where

$$V = \frac{\ln\left(f_{upper-1} + f_{upper}\right) - \ln\left(f_{upper}\right)}{\ln\left(L_{upper}\right) - \ln\left(L_{upper-1}\right)}$$

For the Pareto approximation, L_{upper} is the lower bound on the upper income category, $L_{upper-1}$ is the lower bound on the penultimate income bracket, and f_i are the corresponding frequencies for $i = upper - 1, upper$. All prices and income are divided by the numeraire price (represented by an inflation-adjusted cost-of-living index derived from the C2ER [2015] data).[5, 6] The vector H_j includes respondent gender, age, and inflation-adjusted price indexes for housing, transportation, and food at the household's origin; Z_i includes

[5] We use geospatial techniques in order to interpolate data for the household ZIP codes outside of the core-based statistical areas (CBSAs).

[6] The coefficient on price of a substitute site is restricted to zero to preserve symmetry of the Slutsky Substitution matrix (LaFrance 1990, Landry and others 2016, von Haefen 2002).

Table 5.3—Descriptive statistics for National Visitor Use Monitoring (NVUM) recreation demand data

Variable	Definition	Raw data	Thomson correction	Inverse trips weight
trips	Trips to wilderness area for primary purpose of recreation	11.4138 (29.4388)	1.9585 (.0639)	1.9585 (4.3034)
tc	Travel cost of wilderness trip (2014 dollars)	97.7174 (182.918)	142.7886 (11.9957)	142.7886 (217.3082)
distance	Distance to wilderness area	282.2921 (527.649)	412.7474 (34.6346)	412.7474 (626.7216)
pden	Persons/m^2 (thousands)	3.9835 (4.4952)	3.9738 (.0268)	3.9738 (.5059)
hec	Wilderness size (thousand ha)	189.6299 (223.290)	178.7834 (11.0287)	178.7834 (212.0822)
trails	Trail miles (hundreds)	3.5618 (3.4820)	3.4733 (.1818)	3.4733 (3.4601)
male	Indicator male sex	.6558	.6485	.6485
age	Years	43.9857 (14.5264)	43.1629 (.7669)	43.1629 (14.4968)
p_h	Housing Price Index (normalized 2014 dollars)	1.0449 (.1935)	1.0532 (.0112)	1.0532 (.2088)
p_f	Food Price Index (normalized 2014 dollars)	.9899 (.1879)	.9833 (.0104)	.9833 (.1970)
p_t	Transportation Price Index (normalized 2014 dollars)	.9796 (.1366)	.9769 (.0079)	.9769 (.1477)
realhhinc (n = 5,295)	Household income (normalized 2014 dollars)	97.2652 (69.2501)	99.5314 (6.5647)	99.5314 (69.9315)

Numbers in parentheses are standard deviations.

population density surrounding the national forest, wilderness area size (in hectares), wilderness trail miles, and Level 1 ecoregion dummy variables. See Omernik (1987) for more information on ecoregions (https://www.epa.gov/eco-research/ecoregions).

Summary statistics for our travel cost dataset are presented in table 5.3. We present raw descriptive statistics, mean and standard deviation corrected via Thomson (1991) to produce unbiased population moments, and mean and standard deviation using the inverse of trips as a weight in estimation (Gill and others 2010, Landry and others 2003). Consistent with many onsite recreation samples, the corrections indicate significant upward bias in trips (raw mean of 11.4 trips compared, much larger than the corrected means of 1.95). This is consistent with avidity bias (endogenous stratification), as oversampling of frequent visitors introduces upward bias into the mean of trips.[7] The corrections also indicate downward bias in raw mean of travel distance and travel cost (consistent with avidity bias); means of other site and household characteristics (e.g., trail miles, age) are roughly consistent across the descriptive statistics calculations, except for household income. Raw household income is around $97,000, while the corrected means are around $99,000. Notably, corrected estimates of standard deviation vary quite a bit, with the weighted approach indicating greater dispersion.

We use U.S. Environmental Protection Agency Level 1 ecoregion descriptions to classify the wilderness areas by type and illustrate how wilderness visits to different ecoregions may vary in value. Note that due to the size and distribution of U.S. wilderness areas, the classifications are not mutually exclusive. Figure 5.14 depicts the distribution of wilderness area ecoregions in the NVUM data. The most common ecoregion is Northwest Forest Mountain, followed by North American Desert, East Temperate Forest, and Great Plains. The remaining ecoregions represent 10 percent or less of the NVUM sample.

Building on recent recreation demand literature with an endogenously stratified sample, we explored both regression models

[7] The Thomson correction suggests that trips are under-dispersed (standard deviation < mean), whereas the weighted correction suggests over-dispersion (standard deviation > mean).

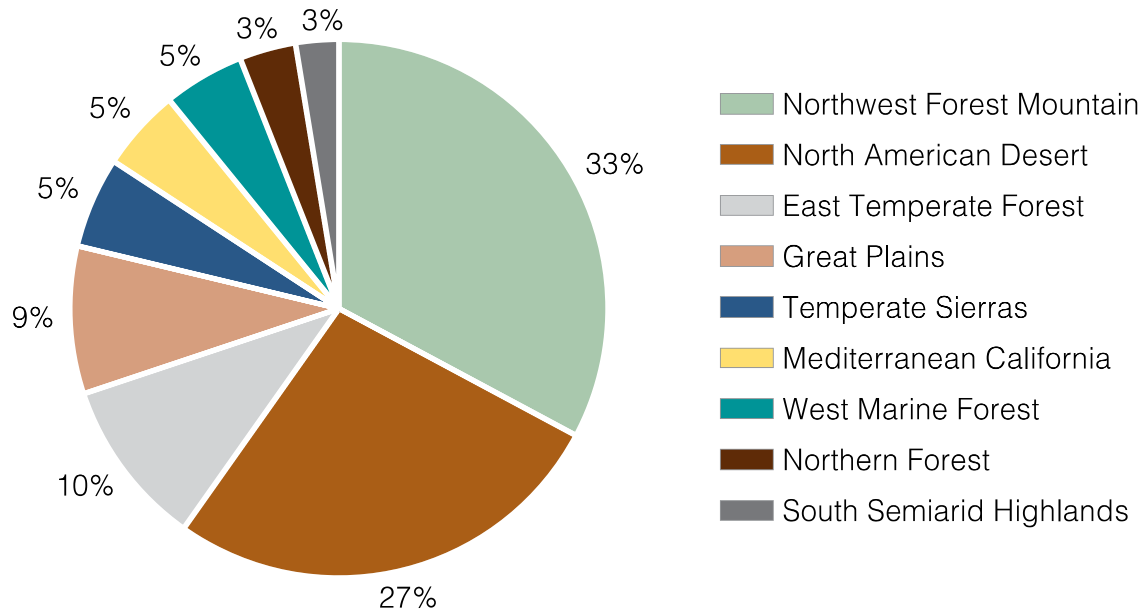


Figure 5.14—Distribution of U.S. Environmental Protection Agency Level 1 ecoregions in the National Visitor Use Monitoring (NVUM) wilderness visitation data.

Table 5.4—Count data travel cost demand regression models for full and restricted samples

Variable	Poisson		Negative binomial	
tc	-0.0051[a] (0.0001)	-0.0056[a] (0.0003)	-0.0039[a] (0.0001)	-0.0041[a] (0.0003)
pden	-0.0034 (0.0234)	0.0067 (0.0452)	0.0303 (0.0537)	0.0363 (0.1045)
hec	0.0001[c] (0.0001)	0.0001 (0.0001)	0.0006[a] (0.0002)	0.0007[b] (0.0003)
trails	0.0120[a] (0.0031)	0.0143[b] (0.0058)	0.0151[b] (0.0071)	0.0178 (0.0138)
male	0.0479[b] (0.0198)	0.0285 (0.0382)	0.0651 (0.0447)	0.0559 (0.0871)
age	0.0105[a] (0.0006)	0.0102[a] (0.0013)	0.0132[a] (0.0015)	0.0142[a] (0.0031)
p_h	-0.1508[b] (0.0650)	-0.1601 (0.1239)	-0.4274[a] (0.1385)	-0.4417[c] (0.2638)
p_f	-0.0664 (0.0620)	0.0071 (0.1164)	0.0669 (0.1635)	0.0864 (0.3085)
p_t	0.5334[a] (0.0961)	0.5483[a] (0.1813)	0.5430[b] (0.2225)	0.6901 (0.4262)
NorthernForests	-0.3262[a] (0.0572)	-0.3523[a] (0.1164)	-0.1874[c] (0.1067)	-0.1759 (0.2149)
NorthwesternForestedMountain	-0.1833[a] (0.0500)	-0.0987 (0.0982)	0.0603 (0.1157)	0.1845 (0.2259)
MarineWestCoastForest	0.1463[a] (0.0382)	0.0916 (0.0745)	0.2602[a] (0.0905)	0.2195 (0.1779)
EasternTemperateForests	-0.1860[a] (0.0513)	-0.0863 (0.1010)	-0.0764 (0.1077)	0.0841 (0.2096)
GreatPlains	0.2739[a] (0.0274)	0.2846[a] (0.0525)	0.3925[a] (0.0662)	0.3975[a] (0.1298)
NorthAmericanDeserts	0.1415[a] (0.0242)	0.1550[a] (0.0466)	0.1655[a] (0.0552)	0.1937[c] (0.1068)
MediterraneanCalifornia	-0.1314[a] (0.0507)	-0.1148 (0.0924)	-0.1696 (0.1035)	-0.1179 (0.1945)
SouthernSemiAridHighlands	0.2084[a] (0.0493)	0.2055[b] (0.0977)	0.6789[a] (0.1410)	0.7491[a] (0.2825)
TemperateSierras	-0.0774 (0.0512)	-0.0726 (0.1009)	0.1779 (0.1283)	0.2075 (0.2529)
ln(*realhhinc*)		-0.0701[b] (0.0278)		-0.1189[c] (0.0633)
Constant	0.0280 (0.1575)	0.2074 (0.3178)	-19.7724 (69.1098)	-22.8271 (30.8345)
ln(*alpha*)			19.6948 (69.1089)	22.9522 (30.8263)
Observations	**19,681**	**5,295**	**19,681**	**5,295**

Numbers in parentheses are standard errors.

[a] $p < 0.01$
[b] $p < 0.05$
[c] $p < 0.10$

that modify the underlying population distribution directly in the likelihood function (Englin and Shonkwiler 1995, Landry and others 2016, Shaw 1988), as well as decouple truncation and endogenous stratification (Shi and Huang 2018). The former approach will be more efficient if the model is correctly specified, while the latter approach permits greater flexibility in model selection and is more robust to mis-specification. Given the flexibility and robustness of Shi and Huang's (2018) weighting approach, we chose to focus on these sets of results.

Table 5.4 presents regression results for weighted and truncated Poisson and negative binomial models (Shi and Huang 2018), with and without real household income (which is available for only a sub-sample of the data, thus reducing sample size for regression analysis). The negative binomial model nests the Poisson, permitting tests of over-dispersion (fitted mean < fitted variance) and the appropriateness of Poisson. Consistent across all count-data recreation demand models, we find a negative travel cost coefficient (*tc*) and positive impact of respondent age (*age*). Notably, the dispersion parameters [ln(*alpha*)] are not statistically significant in the negative binomial models. As such, we focus primary attention on the Poisson models (first two columns of table 5.4) but utilize the entire set of estimates in our welfare analysis.

The Poisson regressions indicate that wilderness recreation demand is greater for areas with more wilderness trail miles (*trails*) and for larger wilderness areas (*hec*), the latter only statistically significant in the main equation (table 5.4, column 1). Surrounding population density (*pden*) has no estimated effect on recreation demand.

The main Poisson equation (table 5.4, column 1) indicates that males (*male*) take more wilderness trips, all else being equal. Regarding the prices of other commodities, we find a negative effect of housing costs (*p_h*) in the respondent's home region and a positive effect of transportation costs (*p_t*) in the home region. The effect of real household income [ln(*realhhinc*)] is negative and statistically significant, suggesting that wilderness trips are an inferior good amongst the population of visitors, with households with greater income taking less trips, all else being equal. We find greater demand for trips to Great Plains, Southern Semi-arid Highlands, Marine West Coast Forests, and North American Deserts. We find lower wilderness area recreation demand for Northern Forests, East Temperate Forests, Northwest Forested Mountains, and Mediterranean California.

Since real household income is transformed by the natural logarithm, the coefficient indicates the income elasticity; E_I is defined as the percentage of change in group visits for a 1-percent change in household income. Thus, a 1-percent change in household income is expected to decrease wilderness trips by 0.07 percent. The travel cost parameters are -0.0051 (full sample) and -0.0056 (income sub-sample). Price elasticity, E_p, defined as the percentage of change in group visits divided by the percentage of change in travel cost, are thus E_p = (-0.0051 * \$142.79) = -0.72 and E_p = (-0.0056 * \$142.79) = -0.80, respectively; these results indicate that wilderness demand is not particularly responsive to travel cost. Thus, we would not expect large changes in demand for wilderness due to changes in, for example, gasoline prices or entrance/parking fees. Integrating under the recreation demand curve

Table 5.5—Economic welfare estimates for access (group) to wilderness on national forests

Sample	Population Poisson model	Weighted negative binomial model
Entire	\$196.11 (\$191.85–\$205.70)	\$256.41 (\$251.51–\$274.17)
Income subsample	\$178.35 (\$164.55–\$184.90)	\$243.90 (\$231.66–\$274.81)

95-percent confidence intervals are in parentheses; all values in 2014 dollars.

for wilderness areas produces an estimate of group-level (i.e., household or traveling party) consumer surplus:

$$CS = -\frac{1}{\beta_{tc}}$$

This indicates per-visit consumer surplus values of $CS_{entire\text{-}sample}$ = - 1/(-0.0051) = $196 per group and $CS_{sub\text{-}sample}$ = - 1/(-0.0056) = $178 per group. These are indicators of economic value over and above what travelers pay to access wilderness areas. Based on a sample average group size of 2.71, we find average consumer surplus per-visit measures of $72.32 to $65.68 per person, respectively. Turning our attention to the negative binomial regression estimates, we find lower price elasticity of demand: E_p = (-0.0039 * $142.79) = -0.56 and E_p = (-0.0041 * $142.79) = -0.59, for the entire sample and income sub-sample, respectively. Corresponding per-visit consumer surplus estimates are of $CS_{entire\text{-}sample}$ = - 1/(-0.0039) = $256 per group and $CS_{sub\text{-}sample}$ = - 1/(-0.0041) = $243 per group, which correspond with per-visit, per-person measures of $90 to $95, respectively. Group consumer surplus measures and 95-percent confidence intervals (based on the Krinsky and Robb [1986] procedure) are depicted in table 5.5.

Our results are comparable to Sardana and others' (2016) finding of $87 per person per trip using data from an earlier version of NVUM (R1) for the wilderness areas in the national forests of the Southern Region. The per-person, per-trip value for a wilderness recreation visit is very similar to the average value of $84 reported by Bowker and others (2014) across 31 previous studies. Sardana and others (2016) found that wilderness access value was the highest of four site types in national forests, e.g., DUDS ($62), GFA ($63), and OUDS ($50).

Access value, or consumer surplus per visit, is but one component of the total economic value of wilderness which includes passive use value, scientific value, and the amenity value of wilderness capitalized into nearby residential properties (Holmes and other 2016). Moreover, a complicating factor is that these values are dynamic and most likely increasing in real terms with time (Holmes and others 2016). Nevertheless, the above example is one way to assess the question of whether wilderness access values differ by ecosystem types. Such information could be used as a component of a benefit-cost analysis addressing potential designation of additional wilderness to the Federal system where ecosystem types differed among competing areas. Alternatively, the same numbers could be used to assess de-designation across different ecosystem types. The results above could also be used in conjunction with projections of relevant covariates to assess potential changes in future visitation, facilitating the development of long-term adaptive or anticipatory management, as opposed to more reactive management plans.

Conclusions

This chapter described visits and visitors to wilderness areas over the course of 2005 to 2014 using data available from the Forest Service NVUM program. The first, and perhaps the most important, finding is that visits to wilderness sites located within national forests increased substantially over the beginning of this century from 6.5 million to 8.3 million site visits, an increase of 27.4 percent. This increase in visits is higher than that for the other national forest site types (DUDS, GFA, OUDS) wherein recreation opportunities are provided. Moreover, preliminary analyses suggest that the increase in wilderness recreation visits has persisted through 2018, albeit at a slower rate. Regionally, the large majority of the increase in wilderness visits has occurred in the western part of the country. The only noticeable decline in visitation occurred in the Eastern Region. While the time window is not long enough to reliably establish the existence of an upward trend in visits to wilderness or a downward trend in the East, the findings suggest visitation is likely to grow nationally. Therefore, dealing with this visitation growth, particularly in highly attractive and easily accessible areas, may become an important concern for management.

Change is taking place among the visitors to wilderness, perhaps mirroring society in general. For example, the age distribution has increased marginally with those in the 50–59 age category producing the largest number of visits (19 percent). A larger change has occurred with respect to the ethnic diversity of visits. While non-Hispanic White males have long been the primary recreation visitors to wilderness areas, the proportion of visits by non-Hispanic Whites has dropped about 3 percentage points. The shift is correlated with large upward shifts in non-Hispanic Asian/Pacific Islanders (36 percent), Hispanics (35 percent), and those identifying as "others" (39 percent). Gender diversity also increased over the time period with female visits increasing from 39.0 to 41.2 percent. The changes in age and diversity are consistent with American society at large and suggest a gradual acculturation to wilderness recreation (Johnson and others 2005). With Asian/Pacific Islanders and Hispanics among the fastest growing segments of the population, increasing diversity appears consistent with the growth in visitation noted above. Finally, and more likely correlated with the increasing age distribution than with the increased diversity, the share of visits from higher income households, i.e., those above $150,000 annually, has increased over the relevant time period.

A second major finding about the composition of wilderness visits is that the proportion of day use visitors has increased over the 2005 to 2014 time period. This change is correlated with a leftward shift in the distribution of visits across travel distances and an increase in the share of visits with hiking as the primary activity as opposed to backpacking. A number of potential explanations for this development could exist and merit further research. For example, with increasing settlement in the West being driven by amenity migration, higher income individuals are attracted to areas closer to wilderness and are thus traveling shorter distances and visiting more often for shorter, perhaps more intense, visits. Another factor is that even in an urbanizing America, wilderness areas, particularly in the 48 contiguous States, are increasingly known and accessible to diverse urban populations. In conjunction with the shorter visits and associated increase in hiking, this might suggest that management will be faced with congestion issues on trails in areas close to the wilderness periphery, as well as parking areas proximal to wilderness trailheads.

Visitor expectations, as indicated by preferences and satisfaction levels, for the current inventory of wilderness areas within national forest boundaries appear to be generally well met and stable, despite the increase in visitation potentially serving as a threat to the wilderness experience. Over the 2005 to 2014 period, there were no significant changes to either perceived crowding or to overall satisfaction levels, with visitors rating their overall experience at the highest level >80 percent of the time. This result could suggest that expectations regarding the "wilderness experience" are changing and that visitors are simply adapting to the same. For example, day users might find the peripheral areas still less congested than their potential alternatives, or they have little problem adapting to the increasing visit numbers. For backcountry users, the increased congestion may not be an issue because the areas important for their wilderness experience may be beyond the limits for the day visitors. We also emphasize that our findings are system-wide and would not necessarily be applicable to an individual wilderness within a given national forest.

The IPA results, albeit highly aggregated, suggest that visitors are generally very satisfied with the natural conditions, essential to a fulfilling wilderness experience. However, the results for trails indicate definite differences in importance and performance ratings for day versus overnight visitors, with the latter indicating the need for managerial attention. For all users, access issues like parking, access roads, and signage are also areas for management to focus on in the near term. These could be even more critical if visitation continues to increase, particularly at areas with highly desirable features and at areas that are seasonally dependent.

The final section of the chapter demonstrated the use of economic models to describe wilderness demand and to estimate the economic value associated with access to wilderness. The models and results presented showed that older respondents take more wilderness trips and that trips are greater for the Great Plains (including Colorado, Montana, and Wyoming), Southern Semi-arid Highlands, Marine West Coast Forests, and North American Deserts, and for wilderness areas with greater magnitudes of trail miles. The recreation demand models found evidence of price-inelastic demand (E_p = -0.72) suggesting that increasing future access costs (e.g., entrance fees, travel related costs) will have a less-than-proportional effect on visitation. We found real household income to have a statistically significant and negative effect on group trip demand. This suggests that wilderness visitation can be considered an inferior good, but the magnitude of the income elasticity was rather small at 0.07 percent. The model and results presented showed that the economic value derived from 2005 to 2014 visitors to wilderness is consistent with previous studies (Bowker and others 2014, Sardana and others 2016) at about $66–95 per person per visit. This value is the highest among the general site types provided in the national forest recreation inventory.

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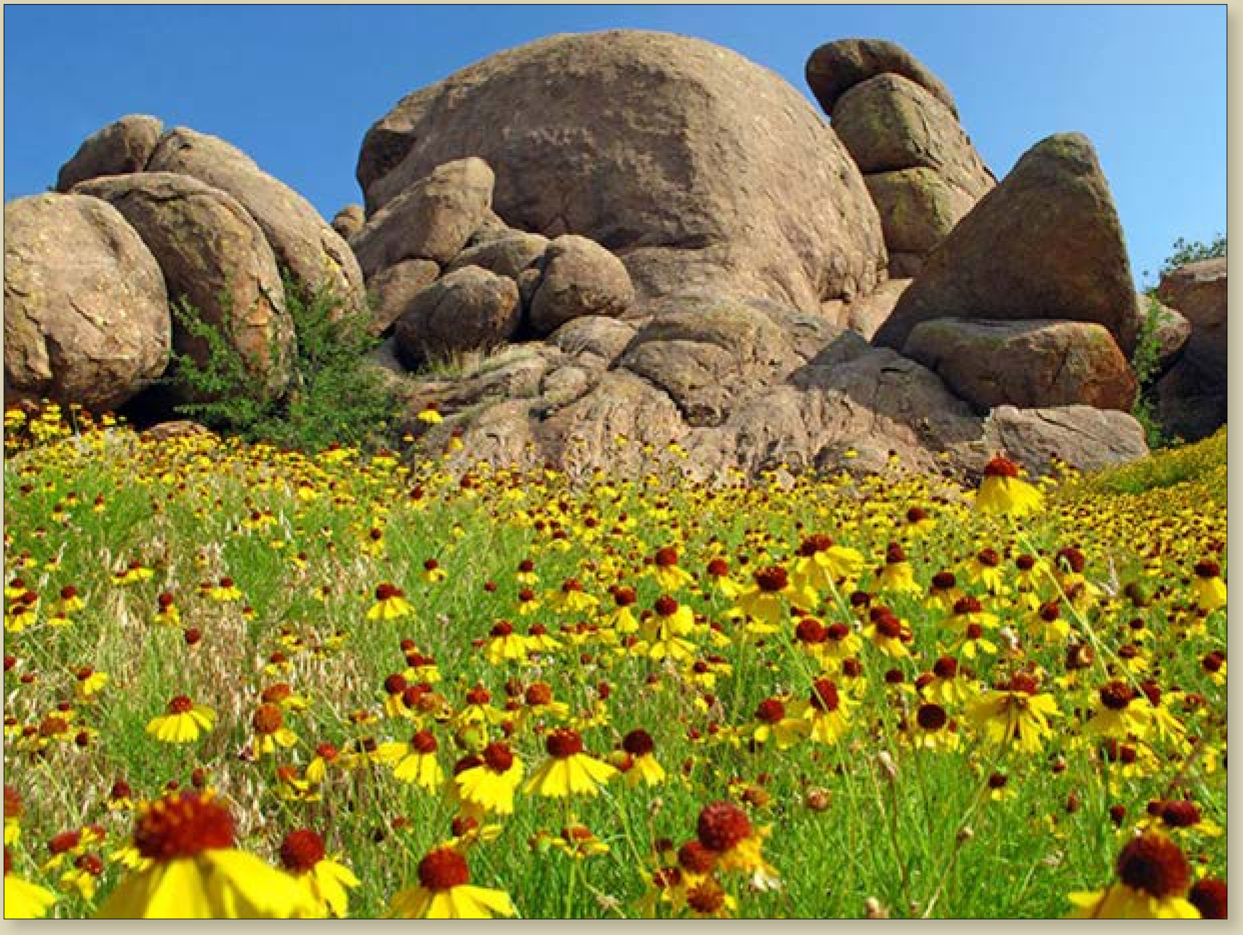
6

The Potential of Recreation Permit Data To Understand Wilderness Use and Value

Thomas P. Holmes • Jeffrey E. Englin • Octavio Valdez-Lafarga



Wichita Mountains Wilderness (8,570 total acres) in Oklahoma was designated in 1970 and is administered by the Fish and Wildlife Service. (Courtesy photo by wilderness.net)

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KEY MESSAGES

- Administrative wilderness permit data collected by the four wilderness management agencies contain information suitable for estimating wilderness use and value and forecasting the future demand for wilderness recreation. By augmenting permit data with information describing demographic characteristics of the places where trips originate, as well as ecosystem characteristics of the places that people choose to visit, economic methods of analysis can be used to understand how many people are taking wilderness trips, who is taking those trips, and why they are taking those trips.

- The historical prerogative for, and use of, wilderness permit and voluntary registration data by wilderness agencies is reviewed.

- Economic models using wilderness permit data are reviewed. These models reveal how recreational use and value are altered by changes in demographic variables, such as age and income, and natural disturbance events such as wildfires, as well as showing how "shocks" affecting the recreational use of individual wilderness areas are transmitted to other wilderness areas.

- Researchers affiliated with the Aldo Leopold Wilderness Research Institute, with support from wilderness managers in the four wilderness management agencies, have collected, compiled, and archived a globally unique dataset consisting of historical wilderness permits and voluntary registrations. These data are publicly available to researchers interested in investigating a variety of issues related to wilderness recreation and management.

Introduction

The framers of the Wilderness Act (Public Law 88–577) recognized the importance of sustaining both the ecological integrity and the recreational quality of lands set aside under this unique legislation, stating that wilderness areas are to be established and administered "for the use and enjoyment of the American people in such a manner that will leave them unimpaired for future use and enjoyment" (Sec. 2a).[1] Furthermore, the act recognized that a key element of wilderness enjoyment is derived from "land retaining its primeval character and influence," thereby providing "outstanding opportunities for solitude or a primitive and unconfined type of recreation" (Sec. 2b). This orientation, recognizing both biophysical and human elements, emerged from concerns raised during preceding decades by rapid growth in primitive forms of outdoor recreation and the resultant impacts on the condition of natural environments and the psychometric quality of recreational experience (Wagar 1964, 1974).[2] The special report issued by the Outdoor Recreation Resources Review Committee succinctly summarized the issue: "Retention of the opportunity for a wilderness recreation experience – freedom from crowds and evidences of recreation overuse – is equally important to maintenance of wilderness land character, and probably more difficult" (ORRRC 1962: 15). A few sentences later, the report goes on to state that "The total value of wilderness seems sufficiently valid to justify wilderness reserves without heavy use." In order to protect wilderness values, the Commission recommended that wilderness management agencies consider limiting recreational use within high-use zones and pursue means for distributing use from zones where capacities are exceeded to other, less frequented zones. More than a half-century later, these concerns remain valid.

Efforts by wilderness management agencies to attain the joint goals of natural resource protection and visitor satisfaction set into motion widespread activities to monitor and regulate wilderness use by instituting systems of wilderness permits and voluntary trail registers. The earliest uses of mandatory wilderness permits were begun by the U.S. Department of Agriculture Forest Service in 1966, when permits were required to enter the Boundary Waters Canoe Area Wilderness (BWCAW), and by the U.S. Department of the Interior National Park Service in 1968, when a backcountry camping permit system was established for Rocky Mountain National Park (Hendee and Lucas 1973).[3] Permit data allowed managers to better understand how ecological impacts were correlated with wilderness use, and, during the 1970s, some wilderness areas began using permanent photo points along popular trails to record evidence of resource degradation (Hendee and others 1978: 318). Since that time, the discipline of recreation ecology rapidly developed, and dozens of studies have been conducted using descriptive surveys, comparisons of used and unused sites, before-and-after natural experiments, and other methods to quantify recreation impacts on the landscape (Leung and Marion 2000).[4]

During the early 1970s, it became apparent that congestion within the more popular wilderness areas was affecting the quality of wilderness trips. Research conducted in four study areas

[1] Concern with sustainable recreation has not diminished on Federal lands. For example, the U.S. Department of Agriculture Forest Service recently established a framework for sustainable recreation to facilitate the goals of connecting people with the natural world and promoting healthy lifestyles (USDA Forest Service 2010). As wilderness comprises substantial proportions of lands managed by the Forest Service (19 percent) and the U.S. Department of the Interior U.S. Fish and Wildlife Service (22 percent) and National Park Service (55 percent), this land class provides unique opportunities for outdoor recreation and is an essential component of the Nation's wellness infrastructure.

[2] It has been estimated that wilderness use increased fifteenfold between the late 1940s (when wilderness was administratively designated) and 1972 (Lucas 1974). In this chapter, federally designated wilderness is simply indicated as wilderness.

[3] National forests in California began issuing mandatory wilderness permits in 1971 at five study areas (Desolation, Marble Mountain, San Gorgonio, San Jacinto, and Ventana). By 1974, mandatory permits were being issued for 21 areas including Forest Service wilderness and primitive areas, National Park Service backcountry areas, and the Pacific Crest Trail. These data are on file with chapter authors.

[4] One of the major findings of this research has been that visitor impacts at wilderness campsites increase rapidly even at modest levels of use, with further degradation becoming marginally less pronounced as the intensity of use increases (Marion 2016).

(Bob Marshall Wilderness, BWCAW, Bridger Wilderness, and High Uintas Primitive Area) revealed an inverse relationship between the satisfaction received by visitors to these areas and the number of encounters with other parties (Stankey 1973). Building upon this path-breaking study, and recognizing that the economic concept of willingness to pay (WTP, or consumer surplus) provides a cogent measure of consumer satisfaction, visitor surveys collected in the Spanish Peaks Wilderness provided economic estimates of the value of solitude as a function of trail and campsite encounters (Cicchetti and Smith 1973). The results of this study confirmed the Stankey (1973) findings and demonstrated that at some point, as the number of visitors to a wilderness area increases, the gain in aggregate WTP is more than offset by the loss in value due to congestion effects and, therefore, the aggregate value of trips will decrease. These seminal studies provided a foundation for later efforts that modelled the optimal social carrying capacity of wilderness areas (Fisher and Krutilla 1972) and the development of travel simulation models allowing managers to distribute the numbers of people entering a wilderness area across trails and campsites (Smith and Krutilla 1974, 1976).

Economists were also quick to realize that information provided by wilderness permits could be used to estimate travel cost demand functions using models described by Clawson and Knetsch (1966) and applied to low-density recreation such as found in wilderness areas (Krutilla and Fisher 1975, Smith 1975). These pioneering studies of wilderness recreation demand were instrumental in providing a conceptual and econometric basis for what soon became a rapidly growing body of analysis directed towards understanding how the economic value of wilderness trips is affected by trip quality (congestion), socioeconomic characteristics of visitors, and biophysical variables. For nearly 50 years, wilderness permit data have provided an essential source of information for conducting studies on the magnitude and scope of benefits received by the American public from having access to wild landscapes. As described further below, new econometric techniques, combined with new sources of data, now provide unique opportunities for analyzing interconnected management and policy issues across multiple units within the National Wilderness Preservation System (NWPS), as well as for conducting traditional analysis of individual wilderness areas.

In this chapter, it is argued that the value of visitor monitoring activities instituted by wilderness management agencies could be enhanced by instituting a systematic transfer of information from visitor management systems to agency research systems composed of databases and analysts. These databases and analysts should enable translating patterns of use into indicators of wilderness enjoyment under a wide range of wilderness conditions, visitor characteristics, and recreational behavior. This argument is pursued in the following sections, first by summarizing the ways in which wilderness permit data have been used to monitor wilderness use. This summary is followed by a review of the economic literature addressing the demand for wilderness trips based upon the analysis of wilderness permit data. Recognizing the possibilities for developing new data and new analytical tools, the next section describes efforts by members of the Wilderness Economics Working Group (WEWG) at the Aldo Leopold Wilderness Research Institute (ALWRI) to collect, process, and archive historical and current wilderness permit data. Examples of ongoing and future analyses of WEWG wilderness permit data are described next, and conclusions are presented in the final section of the chapter.

Monitoring Wilderness Use with Permit Data

Attempts to manage the quality of wilderness experience have been largely built upon two conceptual frameworks: recreation carrying capacity and the Recreation Opportunity Spectrum which sought to create standards of quality that could be maintained over time (Manning and Lime 2000). In addition to these conceptual underpinnings, Section 6 of the National Forest Management Act of 1976 (16 U.S.C. 1600) requires carrying capacity assessments for wilderness areas. However, agencies were slow to assess wilderness carrying capacities, with only about 15 percent of areas having completed assessments by 1979, contributing to a lack of reliable use data. This data/information gap was seen as an obstacle to assessing acceptable use levels within units of the NWPS (Washburne 1981).

Determining the number of people using specific wilderness areas and zones is complicated by the fact that areas typically have many access points, are remotely located (even from Ranger Stations), and have highly variable use (Hendee and others 1978). Initial efforts to quantify numbers of wilderness users focused on the use of self-registration stations. However, it was soon recognized that some users (such as horsemen, hunters, lone visitors, and people making short trips) were less likely to provide registration information. As a result, mandatory wilderness permits were suggested as a necessary management tool "for efforts to ration or modify use and control overuse" (Hendee and Lucas 1973: 207). Despite the fact that survey research conducted at heavily used wilderness areas generally indicated support for rationing use via mandatory permitting systems (Bultena and others 1981, Fazio and Gilbert 1974, Stankey 1979), limiting permit numbers is controversial, and some have argued that rationing should only be used as a solution of last resort (Behan 1974).[5]

The implementation of wilderness permit systems also creates administrative burden contributing to the total number of wilderness areas with any sort of (limited-use or non-limited-use) permit systems shrinking by about 25 percent between 1980 and 1995 (from 69 to 50) (Watson and Niccolucci 1995). However, during this period, wilderness use grew rapidly from roughly 11 million visitor days in 1980 to 17 million visitor days in 1994 (Cole 1996), and the number of wilderness areas implementing limited-use permit systems grew from 17 to about 25 (nearly 50 percent) during this period (Watson and Niccolucci 1995).

The use of computerized systems for analyzing data provided by wilderness mandatory permits, self-issued permits, and voluntary registration cards has evolved as a wilderness management tool. Within the Forest Service, the VIPER (Visitor PERmit) system replaced the older WILD (wilderness permit) analysis system in 1980 and provided for a single-permit format for use on all areas where permits were required (wilderness, river use, campgrounds, etc.) (Feuchter 1980). Among the information generated by the new system were reports on group size, primary method of travel, travel mode impacts (e.g., pack and saddle stock numbers), travel zone codes, travel plan nights, dates of visit, entry and exit points, number of times visitors used the area in the past 10 years, and permit issuance workload by administrative unit.[6]

Rapid changes in computing technology allowed the Forest Service to update their system for tracking wilderness usage with the implementation of the Visitor Use Permit System (VUPS) in the year 2000 as part of the INFRA system used for tracking Forest Service infrastructure (Suter 2003). This computer system provided operators the ability to track quotas, issue reservations and permits, and calculate fees, and also allowed users to generate customized reports in Microsoft® Excel® or Access® databases. A data quality assessment of the full spectrum of wilderness data entered into INFRA (WILD-INFRA) was undertaken in 2013 and indicated that wilderness permit data were entered accurately

[5] Behan (1974) argued that the problem of overcrowding could be solved by either increasing the number of wilderness areas or by increasing wilderness capacity by expanding the number of trails and campsites.

[6] Data for VIPER were entered on punch cards and analyzed at the centrally located Fort Collins Computer Center (FCCC). The FCCC was established in the early 1970s, used a UNIVAC system, and provided access via "dumb terminals" and a slow-speed data communication network (Hartgraves 1991). A distributed computer system (Data General), allowing local analysis and communication between locations, was installed on more than 900 computers in the National Forest System by the mid-1980s.

and completely in about 94 percent of the wilderness areas included in the study (WIMST 2014). Despite the apparent success of VUPS, the system was terminated in 2015. Since that time, the quota system used for assigning mandatory, limiting permits has been automated and implemented using an online reservation system (Recreation.gov). Under the new system, the number of Forest Service wilderness areas with a quota system appears to have been reduced.[7]

Economic Analysis of Wilderness Permit Data: Historical Applications

Although the primary Federal agency use of wilderness permits has been for operational considerations, such as monitoring and managing recreational use, permit data can be used more broadly for research into factors that influence the demand for recreational visits. A fundamental economic principle is that the choices people make reveal information about their preferences, given the constraints they face when attempting to satisfy those preferences. Thus, behavioral evidence of wilderness trips, as recorded by wilderness permits and voluntary registration data, provides information on choices to pursue wilderness-based experiences.

Economic theory argues that the demand for goods and services depends upon their price as well as the preferences of consumers, which typically vary across socioeconomic factors such as age, education, and income. In response to a query from the Director of the National Park Service regarding how the economic value of national parks might be measured, Harold Hotelling provided a creative solution in a 1947 letter arguing that people typically need to travel a significant distance to access parks, and that costs money. Economic theory predicts that people will make park visits up to the point that the satisfaction value of an additional trip equals the travel-related costs. Thus, people living nearer to a park will gain satisfaction above and beyond the associated travel costs, and these values can be computed by using travel cost to represent the price of recreational access (Arrow and Lehman 2005). This idea was subsequently developed analytically by Marion Clawson (1959) and, a few years later, articulated in the first general treatment of the economics of outdoor recreation (Clawson and Knetsch 1966). The basic Hotelling-Clawson-Knetsch (HCK) model for estimating recreation demand is to regress the rate of visitation to a recreation site on the round-trip cost of travel between trip origins and the site. A suite of demand shift variables are also included that control for differences in socioeconomic characteristics of visitors, indicators of site quality, and costs for visiting substitute sites. In recent years, the basic model has been extended to include analysis of choices among alternative sites with varying quality (random utility models, RUM) and the use of count data (integers truncated at zero) both for single sites and for systems of recreational demand (Englin and others 2003). Examples of these models are described below.

Received Travel Cost Model of Wilderness Demand Using Permit Data

Wilderness permits typically include information on the origin (ZIP code) of the person obtaining the permit, as well as the wilderness area visited. In some cases, the specific trailhead where the wilderness trip commences is included on the permit, as well as the anticipated travel route.[8] Therefore, computation of the distance between trip origins and destinations is possible, as are the

[7] As of 2015, 20 Forest Service wilderness areas were listed as having a quota system requiring mandatory, limiting permits. These areas accounted for 6.6 million acres or about 18 percent of Forest Service wilderness area. (Personal communication. 2016. Steve Boutcher, Information Manager, Wilderness and Wild and Scenic Rivers Staff, U.S. Department of Agriculture Forest Service [retired]). Further, an additional 33 Forest Service wilderness areas were listed as requiring mandatory, nonlimiting permits. However, it is not clear whether mandatory (limiting and nonlimiting) permit systems were fully functional under the VUPS system. Under the new online reservation system, 10 Forest Service wilderness areas have implemented a quota system.

[8] A study conducted in 1979 in Yosemite National Park (California) wilderness found that mandatory permit compliance rates were about 92 percent and that, if these rates were maintained, then trailhead quotas could be reasonably set so that it would no longer be necessary to require visitors to provide detailed itineraries (van Wagtendonk and Benedict 1980).

computation of travel costs, thus allowing estimation of travel cost demand models.

Early examples using zonal travel cost models—The first study the authors are aware of using wilderness permit data to estimate travel cost models of wilderness demand was conducted at Desolation Wilderness in California (Smith 1975). In this study, permit data were aggregated into 64 origin zones (counties), and travel costs were estimated from the site to the approximate population center in each county. [9] Three different demand model specifications were estimated (linear, semilog, and log-linear). Results of the linear model specification were considered inadequate. However, both the semilog and log-linear (double-log) specifications indicated that wilderness demand was both price elastic (that is, a 1-percent increase in travel cost resulted in a >1-percent decrease in visitation rate) and income elastic (a 1-percent increase in income resulted in a >1-percent increase in visitation rate). Because the visitation rate data were for an entire season, subsets of recreational data could not be analyzed to investigate whether perceived congestion influenced measures of WTP for recreational access.[10] As noted below, such tests are eminently possible given data recently compiled by WEWG economists.

One of the decisions that must be made in estimating recreation demand from wilderness permit data concerns the spatial extent of the market. A method for determining the spatial limits of travel cost recreation demand models was presented by Smith and Kopp (1980) using data contained on permits collected in the Ventana Wilderness (California) during 1972. Of the 100 origin zones used for analysis, 64 are counties surrounding the site from California, Oregon, Nevada, and Arizona. The remaining 34 origin zones were from more distant States. Wilderness demand was specified using a log linear form, and the estimates of price and income elasticities were very similar to the values reported by Smith (1975), indicating a similarity in preferences for wilderness recreation at different sites in California. A comparison of model estimates derived using only California origin data (n = 64) versus all origins data (n = 100) showed that the same qualitative demand structure was exhibited, in terms of price and income elasticities, across samples. However, estimates of the average visitor WTP per trip for access to the Ventana Wilderness differed substantially across samples. Including all origin zones in the analysis resulted in a WTP per trip estimate of $14.80 (in 1980 dollars, or $45.10 in 2018 dollars), while only including California origins reduced the WTP per trip estimate to $5.28 (in 1980 dollars, or $16.09 in 2018 dollars). While the reduction in WTP is not surprising, given that origin zones at greater distances are eliminated in the smaller sample, the results of this study point out the importance of testing the stability of a model's estimated parameters as a means for establishing spatial limits to travel cost models.

Innovations using count data models—Linear models used for estimating travel cost models of recreation demand treat trip counts as continuous variables that are unbounded and, consequently, predicted values may be <0. Recognizing that trip counts are (often small) integers bounded at zero, a new class of econometric models was introduced during the 1980s for analyzing recreation demand, popularly referred to as count data models (count data model applications to forest recreation demand are reviewed in Englin and others [2003]). Preliminary efforts to adapt count models for analysis of onsite recreational surveys needed to account for truncation at zero (people taking zero trips are not observed) and the likelihood of over-sampling people who visit often (endogenous stratification)

[9] "Zonal" travel cost models typically used ordinary least squares to regress visitation rates to a site—computed as observed visits from each origin zone divided by population in the zone—on the estimated travel cost from each zone plus other explanatory variables such as median education and median family income in the zone. During the period of the Smith (1975) study, national forests in California reported wilderness use via computer printouts containing county-level data on the number of permits, number of people, and number of visitor days.

[10] This point was further expanded upon in a later study suggesting that information regarding individual expectations of congestion would be needed in order to model the impacts of congestion on wilderness demand (Smith 1981).

(Shaw 1988). Although the Poisson distribution was initially used to estimate travel cost models using count data, the negative binomial distribution provided a generalization (relaxing the restriction that the mean must equal the variation in counts) and was later adapted to account for truncation and endogenous stratification to analyze onsite surveys of hikers in the Cascade Mountains (Englin and Shonkwiler 1995).

Recognizing that count data models could be applied to aggregate data available from wilderness permits (as opposed to individual data obtained using onsite surveys), Poisson and negative binomial models were used to analyze the demand for overnight canoe trips at the BWCAW (Hellerstein 1991). Data for this study were aggregated to the county level (using ZIP code information contained on permits) for the 1,396 counties within 1,000 road miles from the BWCAW. In contrast to onsite data, analysis now explicitly included observations of origins where zero-demanders were included. The study concluded that the aggregate WTP for wilderness trips taken in 1980 ranged from about $1.3 million (in 1980 dollars, or about $4 million in 2018 dollars) to $1.7 million (in 1980 dollars, or about $5.2 million in 2018 dollars). It is important to note that these WTP estimates represent the predicted expected value of WTP, which include expected values for counties where positive-demanders and zero-demanders were observed, thus accounting for the underlying (latent) demand for trips from all origins considered to be in the market area.

Combining wilderness permit data with stated preferences—Advances in economic methods have provided approaches to economic analysis that can enhance the value of information contained in wilderness permits by combining trip route data with supplementary information provided by visitor surveys. A novel study conducted during 1993 at three formally designated wilderness canoe routes within Ontario's Provincial Park system (Quetico, Killarney, and Algonquin Provincial Parks) posed the hypothesis that the value of solitude varies across specific segments of a wilderness trip (Boxall and others 2003).[11] To test the hypothesis, questionnaires were provided to canoeists taking at least a 2-day trip that asked respondents to report the number of groups they encountered during each of four different activities: (1) the first and last day of a trip; (2) while paddling; (3) while portaging; and (4) while camping. Additionally, participants in the study provided answers to contingent valuation questions regarding their WTP for small changes from the number of actual encounters during the four different activities. In general, results of the study showed that increases in congestion are more costly than decreases are valuable, and that the value of solitude varies across the four activities (congestion while camping had, by far, the largest impact on value). This study is important for illustrating how wilderness permit data can be used to leverage the knowledge gained regarding the value of solitude experienced in wilderness settings by combining revealed and stated preference data.

Understanding wilderness recreation behavior after wildfires—During the past few decades, a new understanding has begun to emerge regarding the ecological role that wildfires play in maintaining healthy forest ecosystems. Forest managers are now seeking innovative ways to integrate wildfires, prescribed burning, and other fuel treatments into land management planning, and understanding the impact of wildfires on recreation behavior is a necessary component of such plans. Lightning-caused fires are permitted to burn in wilderness areas when conditions are acceptable (otherwise, they are suppressed), and prescribed fires are sometimes set in wilderness to mimic natural disturbance regimes (Geary and Stokes 1999). Postfire activities such as salvage logging and tree planting are not allowed in wilderness, thus allowing visitors the opportunity

[11] Backcountry permits for these wilderness canoe areas detail the specific routes consisting of campsites, or lakes, which will be visited on specific nights.

to observe natural ecological dynamics following a wildfire.

Economists recognize that the quality of recreational environments affects trip-taking behavior and, therefore, economic values. Research concerning the impacts of wildfires on recreation use and value requires stated or revealed preference data. Stated preference (e.g., contingent behavior) data relate contingent trip behavior to burn patterns across a landscape. Revealed preference data rely on the occurrence of natural experiments containing sufficient variation so that the effects of burn patterns on actual trip behavior can be estimated. Among the first studies to evaluate the impact of wildfires on recreation behavior and economic value was a revealed preference study conducted using backcountry canoeing registrations obtained from Nopiming Provincial Park in Manitoba, Canada (Englin and others 1996). In this park, backcountry registrations require canoeists to provide details of the route they will paddle and contain information that allows computation of travel costs from trip origin to the canoeing put-in. Integrating canoe route data with spatial information on locations where wildfires had occurred during the past decade (and would be visible from canoe routes actually taken) allowed travel cost models to be estimated.[12] The results of this study found that wildfires reduced the recreation value (WTP) of canoe trips, and it was suggested that WTP would return to preburn values as the forest regenerated.

Two problems arise when estimating the change in recreational values arising from wildfires or other natural disturbances that affect the quality of recreational settings. First, processes of natural succession will alter the appearance of landscapes for many decades after a disturbance. Second, recreationists have the opportunity to substitute alternative sites both across time and space, allowing choices to be made that reveal preferences for alternative levels of recreational quality. Recognizing the significance of these issues, a novel dataset was constructed by collecting >180,000 permits from seven wilderness areas in mountainous regions of California, spanning the years 1990–2002 and encompassing about 2.7 million acres with roughly 2,739 miles of trails (Englin and others 2008).[13] Spatially referenced wildfire data were also collected, spanning years from 1908–2001, that allowed burns of different vintages (relative to the trip year) to be computed and integrated with data on travel costs and (ZIP code-level) demographic variables. The large temporal and spatial scale captured substitution behavior across time and space and, further, wildfire patterns used for analysis reflect actual occurrences on the landscape, rather than a simulated pattern of fires imposed by the research team.[14]

Analysis of the California wilderness permit and fire data was undertaken using fixed effect count data models that controlled for stable, unobserved variables related to the trip origins (such as geographical features). Results indicated that wildfires 1–3 years prior to the observed wilderness trip had little impact on the number of wilderness trips, while fires occurring 4–9 years prior were positively correlated with a steep rise in the number of trips. This result suggests that hikers may be motivated to observe patterns of fire succession (flowers, low vegetation) after the initial impacts of fires (soot, debris, hazard trees) had subsided. Further results showed that, during the subsequent two decades following fires, there was little impact on recreational behavior, although burned-over areas with 40–60 year vintages appeared to reduce recreation demand. The authors suggest that this may be due to an increasing density of forest vegetation which would restrict panoramic views of the surrounding landscape.

[12] Travel cost, presence of wildfires, and other biophysical attributes were entered into a random utility model that permitted economic values to be estimated based upon the choices made among alternative canoe routes.

[13] The wilderness areas included three managed by the National Park Service (Lassen, Sequoia-Kings Canyon, and Yosemite) and four managed by the Forest Service (Ansel Adams, Golden Trout, John Muir, and Hoover).

[14] Simulated fire data were used in a contingent behavior model of recreation value under a suite of wildfire scenarios (Englin and others 2001). Results of the study indicated that annual recreation values vary dynamically following a wildfire and that the intertemporal path of values is highly nonlinear.

In a further study of the impact of wildfires on wilderness recreation, permit data were collected for two trails in the Enchantment area of Alpine Lakes Wilderness (Washington), which experienced the 40,000-acre Rat Creek Hatchery fire in 1994 (Hilger and Englin 2009). Mandatory permit data were available 7 years prior to the fire, during the fire year (up to the time of the fire), and a few years after the fire. Count data models were estimated using a utility theoretic demand system, which allowed correlation among the equations in the demand system, to isolate the impact of the wildfires on recreation visits. Results of the analysis indicated that 2 years after the fire (the area was closed the year after the fire), recreational values per trip dropped by about 75–80 percent relative to the prefire values. After 3 years, however, when wildflowers and other small vegetation had begun to take hold, recreation values had recovered and perhaps exceeded prefire levels.

Using wilderness permits to model recreation demand systems—Wilderness recreationists have opportunities to choose alternative areas to visit, and several recreation sites could be substitutes, suggesting that wilderness demand be specified using a system of demand equations. As mentioned above (regarding analysis of the Rat Creek Hatchery fire), count data modeling approaches have been developed that explicitly account for substitution effects in a utility theoretic fashion. Basically, these methods require that restrictions be placed on parameters estimated in the system so that they conform to economic theory. The first study we know of that applied this methodology used self-registration and permit data collected at four backcountry provincial parks in Canada (Englin and others 1998). Demand systems allow predictions to be made of how recreational visitation and value will change as prices or quality attributes change. In the Canada models, the researchers were interested in modeling the impact of changes in exchange rates between Canada and the United States (as the permit data showed that Americans constituted a substantial proportion of total trips). The results were informative, indicating (for example) that increasing exchange rates from the prevailing level (US$0.70 per Canadian $1.00) to the level at which the two currencies become equal would reduce visitation in one of the parks by nearly 25 percent.

In studying the demand for wilderness recreation using permit data, the possibility of two types of data generation processes should be recognized. First, in any given year, wilderness permit data show that some origins (ZIP codes) generate zero wilderness trips. Thus, a first stage of analysis should evaluate why this is so. Second, of the origins that generate positive numbers of trips, some locations produce greater levels of wilderness trips than other locations. Integrating analyses across these two processes helps to explain why some people never take wilderness trips, and why some people take substantially more trips, resulting in a two-part model (these are generally known as hurdle models).

Innovative methods continue to be developed for estimating recreation demand systems using wilderness permit data. A unique hurdle model demand system was estimated for the BWCAW which spans >1 million acres in northern Minnesota and contains about 1,175 lakes and >1,200 miles of canoe routes (Valdez-Lafarga 2017).[15] There are 71 entry points into the wilderness. Travel costs were estimated from each origin (ZIP code) in the lower 48 States to each access point, resulting in >24 million observations. The large number of observations used to estimate the demand system resulted in failure of standard likelihood-based parameter estimates to converge and consequently,

[15] The BWCAW lies within the Superior National Forest in the Rainy River Watershed. A lengthy public debate regarding proposals to mine resources within the watershed, and adjacent to the BWCAW, recently resulted in a decision by the U.S Department of the Interior to overturn an Obama administration directive that would have withdrawn the area from mining leases for 20 years (USDA Forest Service 2018). The decision, rendered on September 6, 2018, now permits Federal mineral leases on about 234,000 acres in the Superior National Forest. Economists have argued that "Over time, the economic benefits of mining would be outweighed by the negative impact of mining on the recreational industry and on in-migration" (Stock and Bradt 2018), and it is anticipated that this decision will result in further litigation.

Bayesian methods utilizing Markov Chain Monte Carlo simulation were used to obtain parameter values. Data analysis was very computer intensive—a 20-million-draw Bayes procedure took about 6 weeks to run with the BWCAW data.

WEWG Wilderness Permit Data Collection and Compilation Efforts

Initial efforts to collect, compile, and analyze wilderness permit data were undertaken by two of the authors of this chapter in order to model recreation behavior following wildfires (Englin and others 2008). This Phase I effort was labor intensive and required visiting Forest Service and National Park Service Ranger Stations in the Sierra Nevada Mountains (California) and Lassen Volcanic National Park (California) to obtain paper copies of wilderness permits. As a result, approximately 227,000 electronic records were created and archived, forming a unique historical database of wilderness visits to these regions. Recognizing that wilderness permit data contain tremendous amounts of information about who is visiting wilderness and where they are going, and that these data might subsequently be lost as Forest Service procedures change, data collection and compiling efforts were continued by members of the newly formed WEWG at the ALWRI in 2014. Beginning that year, Phase II efforts recovered about 482,000 electronic wilderness permit records from the VUPS database and continued the development of a systematic process for integrating wilderness permit data with secondary data that could be used for economic analysis. Data compilation and archival procedures, allowing the integration of Phase I and Phase II datasets, are described in a detailed manual (available from the authors upon request).

Overall, the procedures used for creation of a pooled dataset from the original Phase I and Phase II wilderness permit datasets involved six steps (fig. 6.1):

1. Consolidate the original dataset spreadsheets into a single file for input and analysis using STATA statistical software.
2. Obtain and interpolate demographic data provided by the U.S. Department of Commerce Census Bureau for each origin ZIP code in the contiguous United States (CONUS). As Census data are decadal, interpolation of these data is necessary to account for annual changes in demographic variables.[16] For each ZIP code, the following demographic variables are included in the database: total population, percentage of Whites, average annual income, average household size, average educational attainment, and age distribution by age cohorts. These data are available to be used as demand shift variables in econometric analysis.
3. Obtain precise (latitude and longitude) locations for each trailhead contained in the permit records.[17]
4. Estimate travel distance, travel time, and travel (mileage) cost from every CONUS ZIP code to every trailhead using PC*Miler|BatchPro software. The travel cost variable used to estimate wilderness demand functions is then specified to include mileage cost plus the opportunity cost of time (using data on household income).
5. Obtain U.S. Environmental Protection Agency (EPA) ecoregion denomination for each location within the permit data (also required for statistical modeling purposes when combined with permit data).
6. Create a count dataset of all trips (including zero) from each CONUS ZIP code to each trailhead location within the permit data and combine this with demographic, travel-related, and ecoregion data in order to generate the final pooled dataset for statistical modeling purposes.

[16] For the year 2011, demographic data were obtained from the American Community Survey (ACS).

[17] Note that locational information contained in Phase I data is based upon the geographic center of each wilderness area. Phase II data include trailhead latitude and longitude.

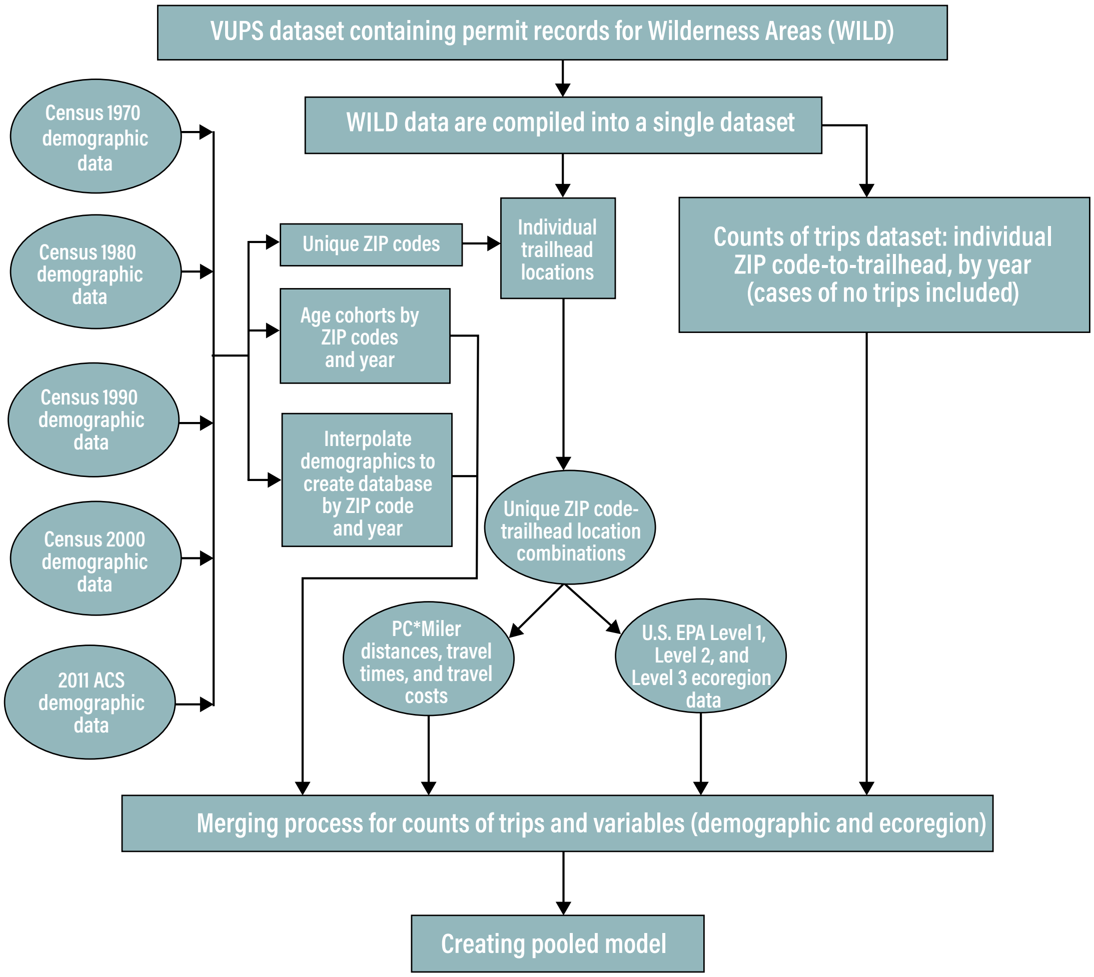

Figure 6.1—Flowchart showing the integration of Visitor Use Permit System (VUPS) wilderness permits data, census data, ecosystem data, and information on travel distances and travel times.

Given that VUPS data only pertain to Forest Service wilderness areas and the VUPS system was discontinued in 2015, a further (Phase III) effort was undertaken to collect all wilderness permit and voluntary registration data that may be held by other agencies or by Forest Service partners that were not included in the VUPS system. A call letter from ALWRI to wilderness managers was sent in April 2016 requesting any and all permit and registration data that they would be willing to submit for processing and analysis. This effort resulted in the collection, compilation, and archiving of about 305,000 additional wilderness permit records.

A further source of wilderness permit records is the Recreation.gov system, which includes data for wilderness areas that are managed using a quota system. Data obtained from this source (Phase IV), spanning the years 2012–2017, have added approximately 311,000 permit records to the WEWG database. The spreadsheet format of Phases III and IV differs from data records in Phases I and II and, consequently, these data are archived in a relational database format that allows for the creation of datasets for various types of statistical analyses.

Taken together, the WEWG data collection effort has compiled and archived a globally unique database of >1 million observations of trip-taking behavior by recreationists seeking a wilderness experience.[18] These data span broad geographical areas and ecosystems, primarily represented by Western U.S. wilderness areas (fig. 6.2). Further, although permit records have been collected, processed, and archived from

[18] These are numbers of "raw" permits prior to processing steps that remove observations with missing fields for variables such as date or ZIP code.

all four wilderness management agencies, most records to date have been recorded for Forest Service wilderness areas (78 percent), followed by the National Park Service (19 percent) and U.S. Department of the Interior Bureau of Land Management and U.S. Fish and Wildlife Service wilderness areas (3 percent). In addition, 4 years of permit data (2013–2016), representing approximately 15,600 data records, have been obtained for the 2,650-mile-long Pacific Crest Trail, which passes through 48 wilderness areas in California, Oregon, and Washington.

Ongoing Analyses of WEWG Wilderness Permit Data

The globally unique database of wilderness recreation decisions represented in the WEWG wilderness permit and voluntary registration data offers multiple research opportunities. Recreation economists can explore novel questions throughout the NWPS by analyzing wilderness value and use as demand systems that capture substitution among areas as environmental and social conditions change. Additionally, these data are useful for traditional types of analyses regarding management issues at individual wilderness areas (such as understanding the impact of recreational use on environmental degradation and the value of solitude). Here we describe some ongoing projects currently being undertaken at ALWRI utilizing these data.

Long-Run Evolution of Wilderness Values

Soon after the signing of the Wilderness Act, as decisions regarding expansion of the NWPS were coming to the forefront of American environmental policy, it was hypothesized that the value of wilderness trips would increase over time due to two fundamental forces (Krutilla and Fisher 1975). First, as the U.S. population grew, it was naturally expected that the demand for trips would likewise increase. Second, it was hypothesized that as income and education levels increased within the United States, the value of trips would likewise

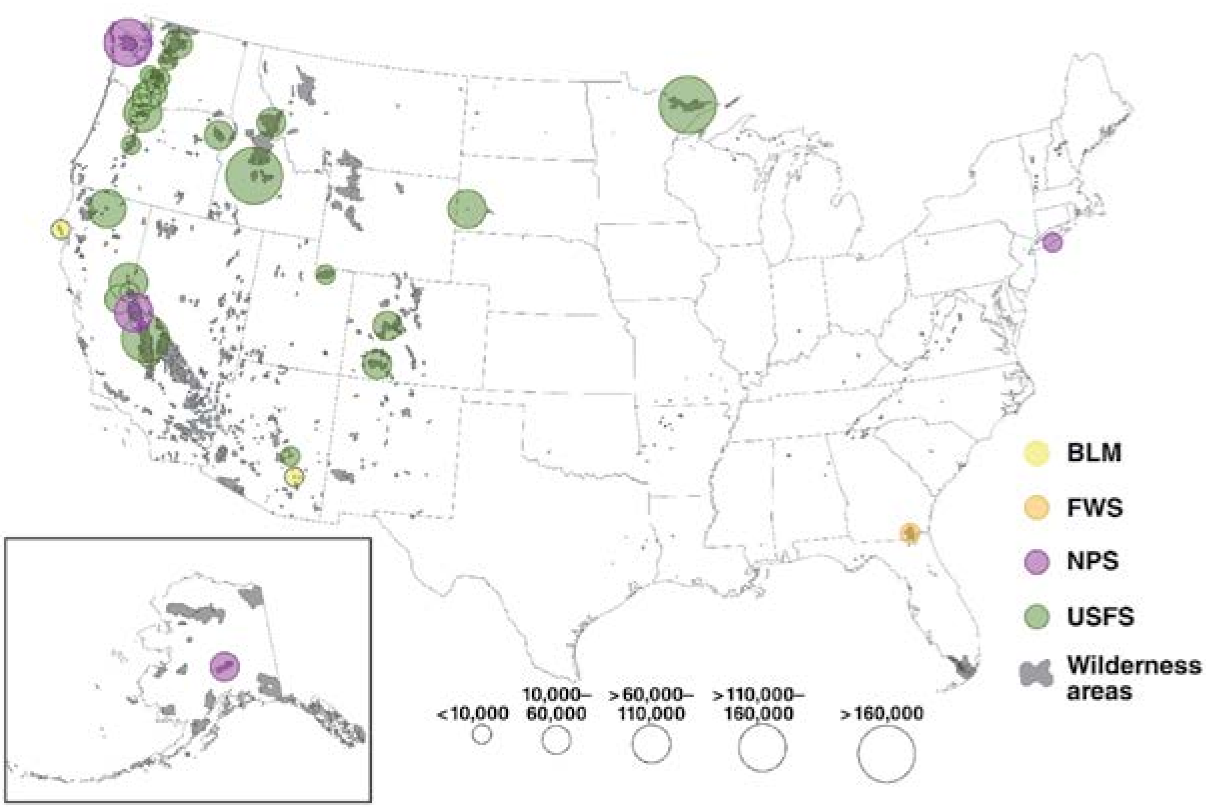

Figure 6.2—Wilderness areas currently represented in the Wilderness Economics Working Group (WEWG) permit and voluntary registration database, by agency, showing approximate location and relative number of permits.

increase. Willingness to pay for wilderness trips reflects individual preferences for those recreational opportunities versus other goods or services that could be consumed, given individual budget constraints. Since the signing of the Wilderness Act, technological changes have produced more and cheaper consumption goods throughout many sectors of the American economy. However, the supply of wildlands cannot be physically increased. Therefore, the increasing scarcity of wildlands relative to other goods and services could increase WTP for wilderness trips over time, and the WEWG permit database provides a unique opportunity to test the Krutilla-Fisher hypothesis (Krutilla and Fisher 1975).

It has recently been argued that there has been a "… pervasive and fundamental shift away from nature-based recreation…" (Pergams and Zaradic 2008: 2299) since the mid-1980s and that this trend may be explained, in part, by the explosive growth in time spent using electronic media (Pergams and Zaradic 2006). Such a trend, if as fundamental and pervasive as argued, could have dramatic implications for the funding of natural resource conservation and recreation management programs in the years and decades ahead. Despite the significance of this research, it is critical to understand that these studies do not address long-term trends in wilderness use nor broader questions related to benefits of wilderness recreation.

The WEWG permit data span roughly 4 decades and 40 wilderness areas and are uniquely suited to testing hypotheses about long-term trends in wilderness use and values. Although anecdotal evidence suggests that wilderness values have been increasing over time (Holmes and others 2016), this hypothesis has never been rigorously tested.[19] Further, a common criticism leveled at wilderness preservation is that "… celebrating wilderness has been an activity mainly for well-to-do city folks" (Cronon 1996: 15). Tests of this assertion have been very limited, as only a few wilderness demand studies report information that can be used to compute the income elasticity of demand (e.g., Smith and Kopp 1980), and these studies are too limited to conclude anything about the trend in income elasticity over time. A long-term analysis of recreation expenditures in the United States concluded that income elasticity had fallen from about 2 (indicating a luxury good) at the beginning of the 20th century to about 1 (indicating a normal good) in 1991 (Costa 1997). The WEWG permit data provide a unique opportunity to test whether a similar trend in income elasticity of demand has occurred for wilderness trips.

Generational Differences in the Demand for Wilderness Recreation

As highlighted in chapter 1 of this report, cultural changes occur gradually as the formative experiences of younger generations provide new cultural orientations which, over time, are capable of transforming prevailing worldviews. Understanding cultural perspectives of cohorts is thus a natural means for studying social changes (Ryder 1965). The idea that wilderness values are cultural values, and that these values evolve over time, has been clearly articulated: "Far from being the one place on earth that stands apart from humanity, [wilderness] is quite profoundly a human creation – indeed the creation of very particular human cultures at very particular moments in human history" (Cronon 1996: 7). Thus, it seems natural to consider the hypothesis that the values associated with wild landscapes differ across generational cohorts (see ch. 3 of this report).[20]

The structure of the data included in the WEWG permit database provide the opportunity to test this hypothesis regarding

[19] It is critical to note that wilderness permit data can only address the recreational use value associated with access to these lands. Passive use values, such as knowing that wilderness exists even if one never intends to access those lands, may be more significant than use values and may change more rapidly with increasing scarcity.

[20] Research suggests that preferences and values for wild places may also vary according to racial/ethnic backgrounds (Johnson and others 2004), which has implications for aggregate demand and values for wilderness trips in the future as the demographic characteristics of the United States change over time. These trends are also being evaluated using the WEWG wilderness permit data.

the recreational preferences of multiple generations regarding wilderness use. In particular, the demographic information in the database includes numbers of people residing in each CONUS ZIP code that belong to specific age cohorts, which allows estimates of generational cohorts to be computed. Analysis of preference differences across cohorts is a particularly powerful tool for estimating future levels of wilderness use and value as, once established, cohort preferences are thought to be relatively stable over time. For example, understanding how wilderness demand is changing now that the population of the millennial generation exceeds the population of baby boomers can help wilderness managers anticipate the number and types of wilderness experiences that a new generation of outdoor enthusiasts will be seeking.

Impact of New Wilderness Designations on Wilderness Demand

During the late 1960s, plans for open pit mining in the Boulder-White Clouds Mountains created a major controversy between those arguing for economic development of the region and those arguing for protection of natural amenities. The debate gained national attention, as well as analyses of the economic tradeoffs (Krutilla and Fisher 1975). Partial protection of the area came in 1972 when the area was designated as the Sawtooth National Recreation Area (Idaho). This designation allowed multiple forms of recreational use, including the use of motorized vehicles. Interest in preserving the area as wilderness continued through the 2000s, and the Central Idaho Economic Development and Recreation Act, which proposed the creation of wilderness areas in this region, was introduced into the U.S. Congress six times without passage. Finally, in 2015, three wilderness areas were created by Congress: the Cecil D. Andrus-White Clouds Wilderness, the Hemingway-Boulders Wilderness, and the Jim McClure-Jerry Peak Wilderness.

These three new wilderness areas lie across the Sawtooth Valley, and Salmon River, from the Sawtooth Wilderness (Idaho; established in 1972). The close proximity of the three new wilderness areas to previously existing wilderness provides an opportunity to understand the impact of wilderness designation on recreational use. Permit data provided by the Sawtooth National Forest were made available to WEWG for the years 1998–2015. Analyses of these data will shed light not only on trends in the use and value of the Sawtooth Wilderness, but can identify how use and value change with the designation of new, nearby wilderness areas.[21]

Use of Social Media Data To Monitor Wilderness Use and Value

The Forest Service has begun efforts to develop a sustainable recreation research agenda (USDA Forest Service 2010). The significant role played by wilderness within the Forest Service recreation portfolio, as well as continuing concerns regarding the ecological and psychometric impacts of increasing levels of wilderness use, provide the opportunity to investigate concepts of recreation sustainability within wilderness settings. Although wilderness permit data provide essential information on who is visiting wilderness areas, what wilderness characteristics they are seeking, and how demographic changes are influencing wilderness recreation demand, permit data are only available for a small proportion of the entire NWPS. A new project currently being undertaken by economists at WEWG is exploring the possibility of using social media data to model wilderness demand at locations where permit data are unavailable. This project builds upon previous research demonstrating the feasibility of using crowd-source photographs to measure recreational visitation at U.S. national parks (Sessions and others 2016). These approaches are currently being extended to Forest Service wilderness areas where mandatory permit data have been archived (the Maroon Bells-Snowmass in

[21] In cooperation with the University of Montana, a project is also underway using wilderness permit data to evaluate how recreational use is impacting campsite degradation in the Sawtooth Wilderness.

Colorado and the Sawtooth Wilderness areas in Idaho) so that crowd-sourced data can be validated using records of actual visitation. If crowd-sourced data provide reliable estimates of wilderness use in these two settings, use of this methodology may be extended to obtain wilderness use numbers more broadly.

Conclusions

Wilderness permit and voluntary registration data contain information about actual decisions to take wilderness trips. When permit data are combined with information describing demographic characteristics of the places where trips originate, as well as ecosystem characteristics of the places that people choose to visit, economic methods of analysis can then be used to understand how many people are taking wilderness trips, who is taking those trips, and why they are taking those trips. Economic models using wilderness permit data have been typically used to answer these types of questions for one or a few wilderness areas analyzed together. However, the wilderness permit database compiled and processed by members of the WEWG now permit economic analyses of much larger constellations of wilderness areas within the NWPS. A greater understanding of both small-scale and large-scale patterns of wilderness use decisions will provide a basis for more reliable forecasts of future use and value of wildlands, thereby helping wilderness managers and policymakers design programs that protect the ecological integrity of wilderness while sustaining the physical and psychological benefits provided by these Federal lands.

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7

Carbon and Carbon Storage in the National Wilderness Preservation System of the Conterminous United States

Daniel W. McCollum • Michael H. Hand • Pamela M. Froemke • Christopher Huber

Joseph Battell Wilderness (12,336 total acres) in Vermont was designated in 2006 and is administered by the Forest Service. (Courtesy photo by wilderness.net/Ken Norden)

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KEY MESSAGES

- While not a typical management or policy objective, one of the benefits accruing from wilderness areas is the contribution of these areas to national carbon sequestration.
- During the period 2002–2005, the amount of carbon sequestered annually in wilderness areas was roughly equal to that in nonwilderness areas managed by the U.S. Department of Agriculture, Forest Service and the U.S. Department of the Interior, Bureau of Land Management, National Park Service, and U.S. Fish and Wildlife Service on a per-acre basis.
- Annual carbon sequestration amounts on Federal lands vary depending on the type of vegetation (forest, wetland, grassland, etc.). Within forest ecosystems, which is the most common ecosystem type within the NWPS, sequestration amounts are affected by the age class distributions of trees and the influences of a variety of natural disturbances including wildfires and forest insect outbreaks.
- Based upon recent (2015) values for the social value of carbon (in 2017 dollars using a 3-percent discount rate), the average annual economic value of carbon sequestered within NWPS areas in the conterminous United States, based on the 2002–2005 baseline period, amounted to $2.2 billion.

Introduction

Wilderness areas are, by design, unique landscapes managed to minimize human impacts and maintain functioning wild ecosystems. One important ecosystem service that wilderness areas may provide is a contribution to climate regulation, which is influenced by carbon sequestration. Many designated wilderness areas in the United States—including some of the largest—can be characterized as forest ecosystems. But wilderness areas are heterogeneous in ecosystem type, size, and ecological functions. They include wetlands, grasslands, islands and coastal areas, and marine ecosystems. The degree to which wilderness areas provide climate regulation services may vary substantially between areas and, potentially, in comparison to other publicly managed lands.

The focus of this chapter is on estimates of annual carbon flux,[1] the amount of carbon exchanged between Earth's carbon pools (i.e., atmosphere, oceans, crust, and terrestrial ecosystems), in U.S. wilderness areas. Understanding carbon flux in wilderness areas may be important for two reasons. First, wilderness areas may provide the closest approximation to "nature's own" carbon flux (or carbon flux without management interference) in ecosystems represented in wilderness areas; knowing more about ecological functions in places minimally affected by humans may improve understanding of the carbon cycle. Second, comparing wilderness area carbon flux to that on other public lands is a first step toward understanding management impacts on the carbon cycle; public land managers may benefit from knowledge about carbon flux in landscapes without management interventions typically practiced on nonwilderness public lands.

The chapter begins with a brief introduction to carbon and carbon flux. Following that, the literature on public land carbon sequestration is reviewed. Some basic information about the extent of the National Wilderness Preservation System in the United States is presented in the next section. Data and methods used to estimate carbon flux are then described, followed by an explanation of the social cost of carbon used to place values on the amounts of carbon sequestration in wilderness areas. Results are presented for carbon flux, CO_2 equivalent flux, and social value of sequestered carbon in wilderness areas by management agency. Results by State, agency, and individual wilderness area are presented in the appendix (available at https://www.srs.fs.usda.gov/pubs/gtr/gtr_srs254/gtr_srs254_supplement.pdf). The discussion section begins with some comparisons between carbon sequestration in wilderness areas and that on all public lands by management agency, and proceeds into a discussion of how growth and disturbance events affect carbon sequestration. The latter, paired with projections of future climatic conditions, can provide insight into what might be anticipated for the future of carbon sequestration in wilderness areas. While this discussion is an overview, we believe it will add value to readers' understanding of interactions of weather, climate, disturbance events, and ecological processes—the "behind the scenes" influences on carbon storage.

Carbon and Carbon Flux

Carbon accounts for approximately half the total dry mass of living things (Ollinger and Sallade 2011). Those living things, and carbon-containing nonliving things, are found in the Earth's carbon pools, namely its atmosphere, oceans, crust, and terrestrial ecosystems. Continuous exchange (or cycling) of carbon between those four pools occurs as a result of natural processes including photosynthesis, respiration, and decomposition. Photosynthesis transfers carbon from the atmosphere to

[1] A reviewer correctly pointed out that we focus only on carbon when, in reality, carbon dioxide (CO_2) is just one of the greenhouse gases influencing climate regulation. While carbon sequestration is not the only ecosystem function relevant to planners, managers, and policymakers, it is one that is widely reported and, arguably, is representative of climate issues to segments of the public. Further, ecosystem services like climate regulation interact with management and other ecosystem services to reinforce, mitigate, or otherwise affect ecosystem conditions. Such interactions, and our incomplete understanding of their effects, contribute to uncertainty related to natural resource management and future conditions.

terrestrial ecosystems where it is captured and stored by living plants. Not all carbon captured by trees and other plants ends up as stored carbon, however. Approximately three-quarters of the carbon fixed by photosynthesis is quickly released back to the atmosphere through ecosystem respiration as plants grow and carbon is stored in living plant material (Malmsheimer and others 2011).[2] When plants die, they begin to decompose. Some carbon is released to the atmosphere from microbial respiration used to produce energy needed by microorganisms to decompose plant (and other organic) material. In forests, about half the respiration comes from growth in aboveground (living) vegetation; the other half comes from the forest floor and forest soils (decomposition). Respiration from the forest floor and soil is proportional to the amount of woody debris and forest litter decomposition on site (Malmsheimer and others 2011). Carbon not released to the atmosphere through respiration in the growth or decomposition process gets incorporated into soils where it can remain for many years, thus being stored or sequestered.[3] At any point in the process from life to decomposition, plant material can be consumed by fire, quickly releasing carbon to the atmosphere (Ollinger and Sallade 2011).

Whether a carbon pool acts as a sink or source is determined by the change in carbon stored within the pool over a period of time as measured by net carbon flux per unit area over the time period. A net uptake of carbon by the ecosystem results in a carbon sink or carbon being sequestered. A net emission of carbon by the ecosystem results in a carbon source. Carbon flux is measured in grams of carbon (gC) per time period over a specific area. When carbon is released to the atmosphere (or absorbed from the atmosphere), it is generally in the form of carbon dioxide (CO_2). Hence, carbon flux is often expressed in grams of carbon dioxide equivalent (gCO2e) per time period. *By convention, negative net carbon (CO_2e) flux indicates a net uptake of carbon (CO_2e) by the terrestrial ecosystem, and positive net carbon (CO_2e) flux indicates a net emission of carbon (CO_2e) (Malmsheimer 2011). For ease of presentation and intuition from the perspective of carbon moving in and out of the terrestrial ecosystem (both in the body of this chapter and in the appendix), we reversed the signs on carbon and CO_2e flux so a positive number indicates net sequestration by the terrestrial ecosystem and a negative number indicates net emission.*

It is very important to understand the units being expressed. Units of CO_2e are calculated by multiplying units of carbon by 3.667 (or 44/12, which is the ratio of the molecular weight of CO_2 to the molecular weight of carbon—one unit of carbon is contained in 3.667 units of CO_2). It is also important to be aware of whether an estimate or discussion is based on carbon stock or carbon flux (the change in carbon stock in an area over a time period). Carbon sequestration is a dynamic process—a flow. Carbon stock does not represent the dynamics of sequestration. It is the addition or subtraction of carbon to/from the stock, or carbon flux, which is of primary interest in discussions of carbon sequestration. Because of the dynamic nature of carbon sequestration, it is also important to understand the time period over which the flux is measured. When a disturbance or management action occurs that affects the balance of carbon in a particular land area, the effects of that event are not necessarily immediately evident. Some effects do occur immediately—a wildfire can quickly release large amounts of CO_2 and other greenhouse gases into the atmosphere. Other effects play out over a period of years, maybe decades, e.g., releases of CO_2 from decomposition of dead and downed trees. Carbon flux in any given

[2] Photosynthesis is the process by which plants and some microorganisms use carbon dioxide (CO_2) and water, along with energy from sunlight, to produce glucose (a carbon-containing compound) and oxygen. Respiration is the process by which cells in plants, animals, and microorganisms combine glucose and oxygen to produce CO_2, water, and the energy cells need to function. While photosynthesis uses CO_2 and releases oxygen, aerobic cellular respiration uses oxygen and releases CO_2.

[3] There is a subtle difference between storage and sequestration. Carbon sequestration refers to the process of removing carbon from the atmosphere and depositing it in a reservoir, while carbon storage refers to the quantity of carbon stored in a reservoir.

year, therefore, is the result of both current and past events that occurred on the land and comprises large carbon exchanges that occurred very quickly (e.g., wildfire) and others that occurred slowly and over a longer period of time (e.g., decomposition).

Carbon flux varies naturally over time depending on a host of factors including weather and disturbance events. This is illustrated by the four maps (in fig. 7.1) of annual net ecosystem carbon balance (or flux) in the United States for 2002–2005 (USGS 2019). The point of figure 7.1 is not which areas are carbon sinks or sources, but to visually illustrate that net ecosystem carbon balance (resulting from carbon flux over the time period) changes from year to year.

Literature on Public Land Carbon Sequestration

This section presents existing estimates of carbon stock and carbon flux for different land management units across the United States. To put them in perspective and provide some context, total carbon stock in terrestrial ecosystems (all vegetated lands) of the conterminous United States in 2005 was about 48,400 teragrams of carbon (TgC),[4] and average annual carbon flux for the period 2001–2005 ranged from 238 $TgCO_2e/yr$ in the U.S. Great Plains to 319 $TgCO_2e/yr$ in the Western United States to 1,023 $TgCO_2e/yr$ in the Eastern United States (Zhu 2011; Zhu and Reed 2012, 2014). Once again, recall that we reversed signs on carbon flux so a positive number indicates net sequestration.

Heath and others (2011b) used U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) program data (Smith 2002, USDA Forest Service 2010) to estimate forest carbon stocks and changes in those stocks in the conterminous United States and coastal Alaska for public and private owners of forested lands. National forest lands were estimated to contain an average of 192 metric tons of carbon per hectare (tC/ha) and a total

[4] The units used in the literature on carbon stocks and fluxes may be unfamiliar to some readers. A metric ton (t) is equal to 1 megagram (Mg) or 1 million (10^6) grams (1000 kilograms [kg]). For comparison, this equals 1.1 U.S. tons (T). A teragram (Tg) is equal to 1 million Mg (or 1 million t or 10^{12} grams).

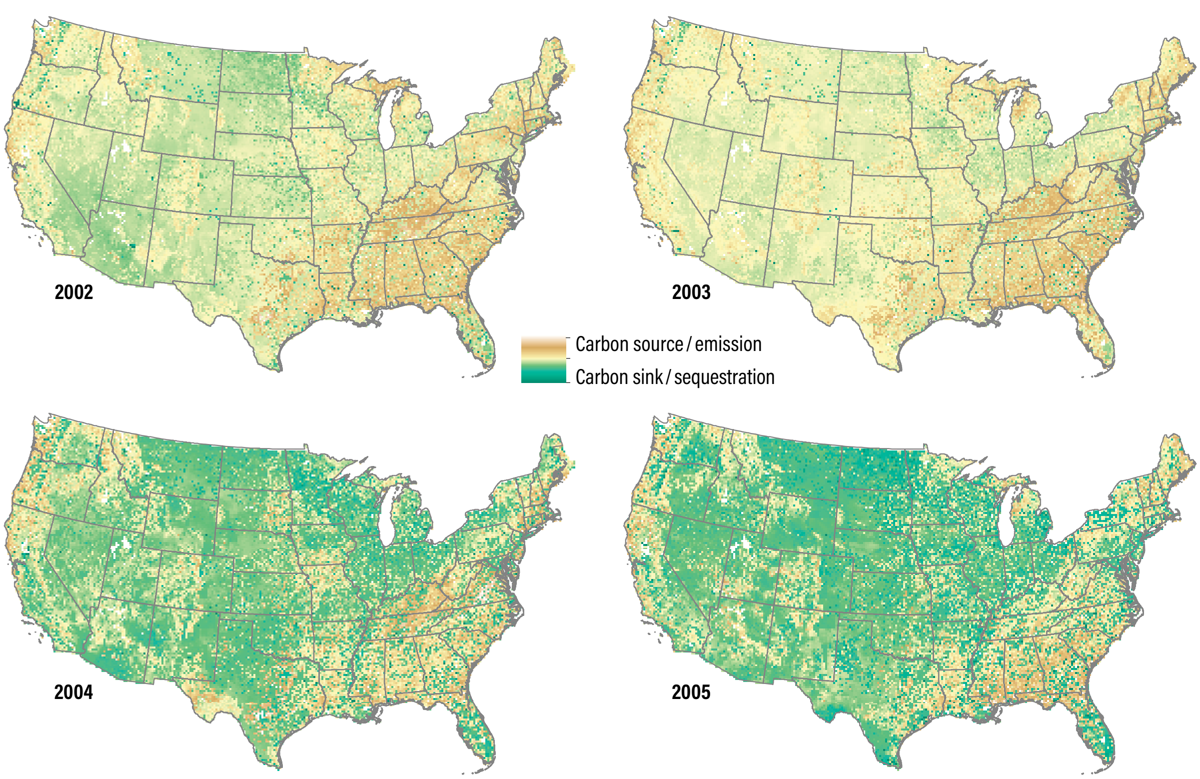

Figure 7.1—Annual U.S. net ecosystem carbon flux, 2002–2005.

of 11,604 TgC in the year 2005. "Other public" forest land (e.g., State and county forest land) and privately owned forest land were estimated to contain 169 tC/ha and 150 tC/ha with totals of 7,268 TgC and 26,058 TgC, respectively. Those three land ownerships comprised 22, 15, and 63 percent, respectively, of forest land in the conterminous United States and coastal Alaska. In addition to their estimates of total carbon stock by land ownership, Heath and others (2011b) estimated carbon stocks (but not carbon fluxes) by Forest Service region and by individual national forest. Those estimates appeared in an appendix to their paper.

Carbon fluxes, using FIA data from 2000–2008, were reported as 147.3 $TgCO_2e$/yr, 184.6 $TgCO_2e$/yr, and 149.2 $TgCO_2e$/yr for forested lands managed by the Forest Service, other public land managers, and private land managers, respectively, all indicating carbon sequestration. An additional 92 $TgCO_2e$/yr were sequestered in products made from timber harvested from private lands and 3 $TgCO_2e$/yr in products made from timber harvested from Forest Service managed land (Heath and others 2011b). More about carbon sequestration in harvested wood products can be found in Skog (2008).

Heath and others (2011b) estimated carbon stocks using all forest carbon pools (aboveground living and dead material plus belowground living and dead material). Changes in carbon stock (i.e., carbon fluxes) were estimated using only aboveground living and dead carbon pools (i.e., excluding soil and anything belowground). Their reason for excluding soil from carbon fluxes was that changes in land use can result in transfers of large amounts of soil carbon to other land uses which will (falsely) appear as losses to or gains from the atmosphere (Heath and others 2011b: 5).

Other studies used the same FIA data as Heath and others (2011b) but with different survey years (e.g., Wear and Coulston [2015] used 2007–2012 data, Woodall and others [2015] used 1990–2016 data, Heath and others [2011a] used 1990–2008 data, Smith and Heath [2008] used 1990–2005 data) to derive forest land carbon stocks and fluxes at national, regional, or State levels, and for different tree species and stand size classes. Heath and others' (2011b) paper is the only one in which national forest-level results were reported.

Richardson and others (2014) presented estimates of carbon sequestration and values of sequestration on lands managed by the U.S. Department of the Interior National Park Service (NPS) in the conterminous United States. Data for their study came from digital spatial maps produced by the U.S. Department of the Interior, U.S. Geological Survey (USGS) for the years 2001–2005 (Zhu 2010), showing net ecosystem carbon flux that were then overlaid with a spatial map of NPS boundaries. At the national level, average annual carbon flux on NPS lands was estimated to be 14.5 $TgCO_2e$/yr. The net present value of that carbon sequestration, using the social cost of carbon (SCC—more on that below) was estimated to be $582.5 million per year in 2013 dollars. In addition to the average annual sequestration and social value, Richardson and others (2014) estimated sequestration and social values for each individual NPS unit.

A similar study on carbon sequestration on NPS lands in the conterminous United States (Banasiak and others 2015) used the same 2001–2005 USGS data as Richardson and others (2014). Instead of using the digital map overlaid by NPS boundaries, however, Banasiak and others used data from underlying USGS reports on carbon sequestration rates by ecoregion and ecosystem type, and then applied those to the relevant proportions of ecoregions and ecosystem types found on each NPS unit. In total, Banasiak and others estimated average annual carbon sequestration on NPS lands to be 17.5 $TgCO_2e$/yr, valued at $707 million in 2013 dollars using the same SCC used by Richardson and others (2014). Like Richardson and others, Banasiak and others presented their results for each individual NPS unit in an appendix.

Banasiak and others took the analysis a step further and looked at future carbon sequestration on NPS lands using USGS projections of average carbon sequestration rates for the period 2006–2050. Their results suggested that "absent any changes in land management (such as invasive species removal or fire management) carbon sequestration in NPS managed lands is predicted to fall by 31 percent to an average of 12.0 $TgCO_2e$ sequestered annually, due to factors such as a warming climate and increased fire hazards" (Banasiak and others 2015: 2). Similarly, Wear and Coulston (2015) projected a gradual decrease in carbon sequestration on all forested land over the next 25 years, from 634 $TgCO_2e$/yr to 411 $TgCO_2e$/yr (a decrease of 35 percent).

Carbon stored in National Wildlife Refuges (NWR) (administered by the U.S. Fish and Wildlife Service [FWS] of the U.S. Department of the Interior) was the subject of a study by Patton and others (2015). They reported on the quantity and economic value of carbon stored in wetland ecosystems on five NWRs in four case studies. Refuges selected for the study were: (1) Arrowwood NWR in North Dakota, (2) Blackwater NWR in Maryland, (3) Okefenokee NWR in Georgia, and (4) Sevilleta NWR and Bosque del Apache NWR, both in New Mexico. Using data from the FWS Cadastral Geodatabase for refuge boundaries, the FWS National Wetlands Inventory to identify types and boundaries of wetlands within the NWRs, and a review of the literature for data on carbon and biomass by land cover type and carbon pool, Patton and others derived estimates of carbon stocks in each of the four wetland case study areas. Carbon stocks (as opposed to carbon fluxes) in wetlands of the Arrowwood, Blackwater, Okefenokee, and (combined) Sevilleta and Bosque del NWRs were estimated to be 0.4 $TgCO_2e$, 7.676 $TgCO_2e$, 133 $TgCO_2e$, and 0.018 $TgCO_2e$, respectively. Those stocks were valued at $5.2 million, $100 million, $1.726 billion, and $2.32 million, respectively, in 2010 dollars. These numbers are conceptually different than those estimated in the studies on Forest Service and NPS lands (above) in that they are values of carbon stocks and not values of carbon fluxes. They do not represent carbon sequestration, only the amount of total carbon present.

Sleeter and others (2017) modeled annual ecosystem carbon stock and fluxes at the Great Dismal Swamp NWR, in southeastern Virginia and northern North Carolina, for the period 1985–2015 using age-structured forest growth curves and known data for disturbance events and management activities. Total net ecosystem productivity (NEP) for the 30-year period was estimated to be a net sink (indicating carbon sequestration) of 0.97 TgC for the temperate forested wetland. The NEP reflects annual growth minus heterotrophic respiration without factoring in disturbances or management activities. When a hurricane and 6 historic fire events were included in the 30-year simulation, the Great Dismal Swamp NWR became a net source of 0.89 TgC (indicating carbon emission).

Ingraham and Foster (2008) used a benefit transfer procedure to estimate the value of five ecosystem services provided by NWRs in the conterminous United States. Carbon sequestration was among the ecosystem services considered in the study. To account for the spatial variability of ecosystem services in terms of the ecological productivity of different ecoregions, Ingraham and Foster used a net primary production (NPP)-based gradient to transfer scaled economic values from one ecoregion group to other unstudied ecoregion groups. Using this ecoregion productivity adjustment, Ingraham and Foster estimated the value of carbon sequestration services provided by the National Wildlife Refuge System in the conterminous United States to be $3.3 billion per year in 2004 dollars. Values were also estimated for "disturbance prevention," "freshwater regulation and supply," "habitat provision," and "nutrient removal/waste assimilation." Total annual value of the five ecosystem services was $26.9 billion. Because of the unproven nature of their NPP-based adjustment method, Ingraham and Foster (2008) also estimated the total value of the five ecosystem services without the NPP-based adjustment factors to be $24.8 billion per year.

The paper contained no further discussion of the NPP-based adjustment factors other than to suggest more research on the correlation between ecosystem service provision and NPP, and to point out that the intent of their study was only to provide a first approximation value to be used as a reference point for policy and management decisions.

The National Wilderness Preservation System

Established by the Wilderness Act of 1964 (Public Law 88–577), the National Wilderness Preservation System (fig. 7.2) consists of 765 units and 110,005,113 acres (44,518,459 ha) spread across the conterminous United States, Alaska, Hawaii, and Puerto Rico. New wilderness areas are added from time to time by acts of Congress, so the count and area are subject to change.

Table 7.1 shows the numbers of wilderness units, wilderness land area, and total land area in the conterminous United States by management agency.

Carbon Flux in Wilderness Areas in the Conterminous United States

Multiple ecosystems and carbon pools must enter the accounting when carbon flux in U.S. wilderness areas is estimated. In terrestrial ecosystems, e.g., forested areas, carbon is found in living plants and dead plants, both aboveground and belowground. In addition to the death of whole plants, living plants shed leaves, branches, and other such "litter," which fall to the forest floor and begin to undergo decomposition (Woodall and others 2015). Aquatic ecosystems—lakes, ponds, rivers, streams—are also found in wilderness areas. Carbon is present in those ecosystems in the form of plants, animals, and microbes, for example. Carbon in all these ecosystems must be included.

Data and Methods

The USGS Land Carbon Program data (USGS 2019, Zhu and Reed 2012) on net ecosystem carbon flux, which were the bases of figure 7.1, were used in this analysis. Baseline data

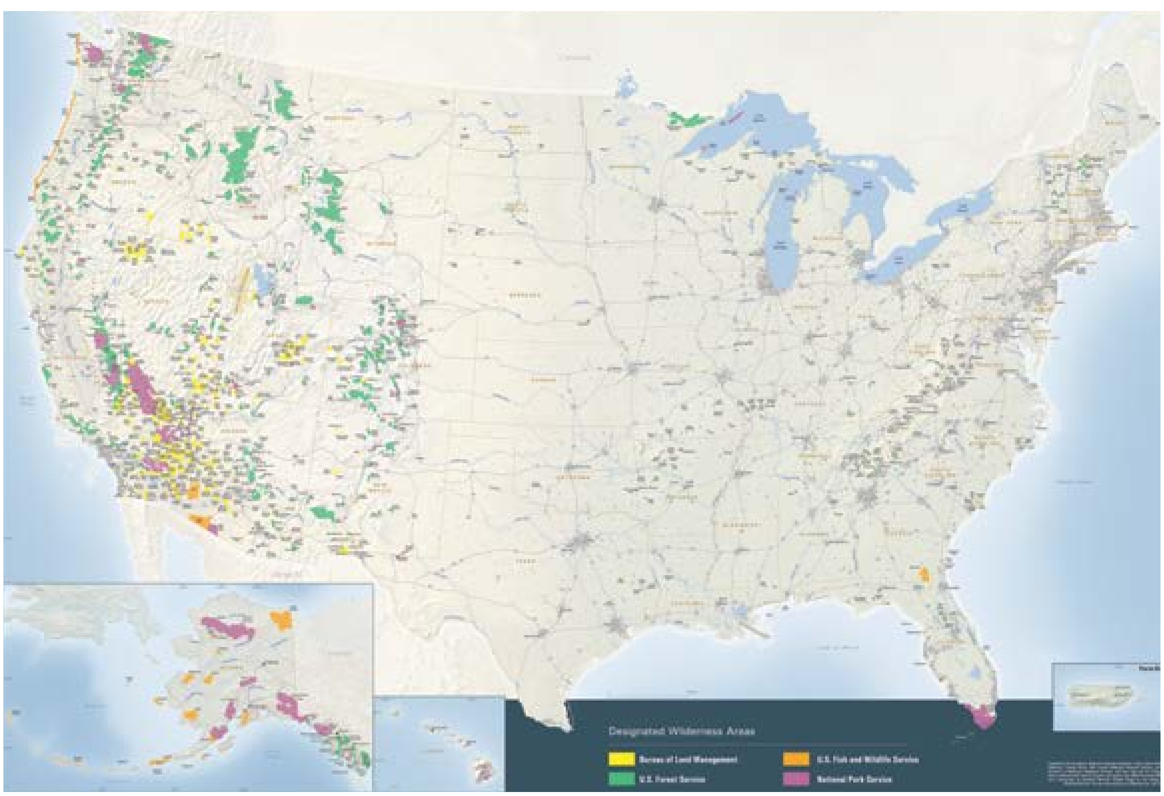

Figure 7.2—The National Wilderness Preservation System.

Table 7.1—Wilderness units, wilderness land area, and total land area by management agency

Agency	National Wilderness Preservation System: Conterminous United States	Alaska	Hawaii	Puerto Rico	Total	Total land area in conterminous United States
	--------------- *number of units[a]/millions of hectares* ----------------					*millions of hectares*
Bureau of Land Management	224/3.5	NA	NA	NA	**224/3.5**	70.0
Forest Service	425/12.5	19/2.3	NA	1/0.01	**445/14.8**	69.1
Fish and Wildlife Service	50/0.8	21/7.6	NA	NA	**71/8.4**	5.1
National Park Service	51/4.4	8/13.3	2/0.06	NA	**61/17.8**	11.1
Total	**750/21.2**	**48/23.2**	**2/0.06**	**1/0.01**	**801/44.5**	**155.3**

Source: Vincent and others (2017), Wilderness Connect (2019).

[a] Thirty-six wilderness units are managed by more than one agency. Each agency includes those units in their count along with their proportionate shares of the land area, so 801 wilderness units are shown in the combined agency statistics as opposed to the 765 actual units.

came from remote sensing, existing resource and soil inventories, climate histories, and measurements by a national network of streamgages. The spatial extent of those data was the conterminous United States and the temporal extent was 2002–2005. The data were projected to Albers Equal Area Conics[5] in the NAD83 datum specification[6] at a resolution of 250 meters. Units of measure were grams of carbon per square meter per year ($gC/m^2/yr$).

The framework incorporates land use and land cover, land management, fire disturbance, and ecosystem-specific information such as mortality and growth rates, and climate and atmospheric conditions and changes. Variables such as fire frequency and severity, rainfall, and temperature are used as inputs into a group of models within the umbrella of the USGS General Ensemble Biogeochemical Modeling System (GEMS).[7] The models were used to estimate net ecosystem carbon balances, i.e., carbon fluxes, for the conterminous United States. Calculations included aboveground and belowground live biomass, soil organic carbon, and dead biomass such as woody debris. Model outputs for the baseline period were calibrated with alternative forest biomass maps and Moderate Resolution Imaging Spectroradiometer (MODIS) Net Primary Production data products (from the National Aeronautics and Space Administration [NASA]). Details on the data and methods can be found in Zhu (2010, 2011), and Zhu and Reed (2012, 2014).

Because carbon flux varies from year to year, we sought a more indicative representation of a baseline level by averaging the carbon flux data from 2002–2005. The resulting map of carbon balances was overlaid with boundaries of: (1) designated wilderness areas (Wilderness Connect 2019) and (2) all Federal lands (National Atlas of the United States 2014).

The Social Value of Sequestered Carbon

The social cost of CO_2 emissions (SC-CO_2)[8] is an estimate, in U.S. dollars, of the net present value of future damages caused by a

[5] Albers Equal Area Conic projection uses two standard parallels to reduce some of the distortion of a projection with one standard parallel. Although neither shape nor linear scale is truly correct, the distortion of these properties is minimized in the region between the standard parallels. This projection is best suited for land masses extending in an east-to-west orientation rather than those lying north to south (GISGeography 2019).

[6] NAD83 is a geocentric datum specification, or reference point. These horizontal datums provide a frame of reference for latitude and longitude locations on Earth. Geocentric means that it is referenced to the center of Earth's mass as opposed to being referenced to a location on Earth, which was the case for the previously used datum specification—NAD27 (ArcGIS 2019).

[7] Underlying data came from a wide variety of sources including the Forest Service FIA, USGS National Land Cover Use Database, U.S. Department of Agriculture Natural Resources Conservation Service Soil Survey, and LANDFIRE (a partnership between the Forest Service, several agencies in the U.S. Department of the Interior, and the Nature Conservancy, among many others). Input data and the GEMS used to tie them together are fully described in Zhu and Reed (2012). The underlying data also contain the effects and consequences of previous management and disturbance events in that those effects and consequences have already played out on the landscape and the carbon stock.

[8] The SC-CO_2 has been commonly referred to as the social cost of carbon (SCC). This can lead to confusion because carbon is generally transferred to the atmosphere in the form of CO_2, and the SCC was defined in terms of a metric ton increase in CO_2 emission. Based on molecular weights, carbon makes up 12/44 of a unit of carbon dioxide. Hence, 1 t of CO_2 contains 0.273 t of carbon. To ensure clarity, the Interagency Working Group on the Social Cost of Greenhouse Gases began to refer to SC-CO_2 rather than SCC in their 2016 update (Interagency Working Group 2016).

1-metric-ton (t) increase in CO_2 emissions in a given year. That includes, but is not limited to, changes in agricultural productivity, human health, property damage from increased flood risk, and values of some ecosystem goods and services due to changes in climate. Damages resulting from CO_2 emissions in a given year are experienced in the future, so the SC-CO_2 is the net present value of a stream of future damages (U.S. EPA 2016).

When an additional 1 t of CO_2e is sequestered instead of being emitted, society incurs neither the damages nor the economic costs related to that metric ton of CO_2e being released. That avoided social cost represents the social value (or benefit) of 1 t of CO_2e being sequestered.

Details of the social cost of CO_2 emissions, and the three integrated assessment models (IAMs) on which it is based, can be found in several places (e.g., Greenstone and others 2013; Interagency Working Group 2016; National Academies of Sciences, Engineering, and Medicine 2017; U.S. EPA 2016). The Interagency Working Group on Social Cost of Greenhouse Gases (Interagency Working Group) calculated four values of the SC-CO_2. Three of the values correspond to the averaged SC-CO_2 values from the three IAMs using discount rates of 5, 3, and 2.5 percent. The fourth value, the "high impact" value, stems from evidence in the literature (Millner 2013, Weitzman 2009) of the potential for lower probability, but higher impact, outcomes of climate change that would be particularly harmful to society. This fourth value of SC-CO_2 comes from further out in the tails of the distributions of SC-CO_2 estimates, specifically corresponding to the 95th percentile of the frequency distribution of averaged SC-CO_2 estimates based on a 3-percent discount rate (Interagency Working Group 2016). The four values of SC-CO_2 for 1 t of CO_2 emitted in 2015, valued in 2017 dollars, are shown in table 7.2. The "central value," as discussed by the Interagency Working Group, is the averaged SC-CO_2 based on the 3-percent discount rate.[9] Lower discount rates place greater weight on the well-being of future generations than do higher discount rates. That greater weighting results in net present values being higher at lower discount rates.

In light of these considerations, the value of SC-CO_2 used in this analysis was $42/t of CO_2. This represents the net present social cost of CO_2e emitted (or the net present social benefit of CO_2e sequestered) in 2015, calculated using a 3-percent discount rate and expressed in 2017 dollars.

Results

Figures 7.3–7.10 present pairs of maps for eight Forest Service regions of the conterminous United States. The first map in the pairs shows average annual net ecosystem carbon flux on wilderness areas, with other Federal lands shaded in gray. The second map in the pairs shows average annual net ecosystem carbon flux on all Federal lands, with wilderness area boundaries outlined in purple. This was done to highlight the carbon fluxes in the wilderness areas. Many of the wilderness areas are so small they are masked by their drawn boundaries on the maps of all Federal lands. The yellow and green colors indicate carbon sinks (positive carbon fluxes or net

[9] This is consistent with the Office of Management and Budget's (OMB) recommendation that 3 percent be used to reflect the social rate of time preference (OMB 2003). A 7-percent discount rate is specified as the default when allocation of capital is affected by a regulation. When regulation primarily and directly affects private consumption without affecting allocation of capital, OMB recognizes that a lower rate may be appropriate. For general regulatory analysis, the guidance is to estimate net benefits using both a 3- and 7-percent discount rate (OMB 2003, The White House 2017). The analyses presented in this chapter and its appendix are not in regard to any regulation or allocation of capital. Hence, the 3-percent discount rate is consistent with OMB guidance and the Executive Order.

Table 7.2—Social cost of carbon dioxide (CO_2) emitted in 2015 (in 2017 dollars) per 1 t of CO_2

Year of emission	Average with 5-percent discount rate	Average with 3-percent discount rate	Average with 2.5-percent discount rate	High impact (95th percentile at 3-percent discount rate)
2015	$13	$42	$65	$122

Source: Interagency Working Group on Social Cost of Greenhouse Gases (2016).

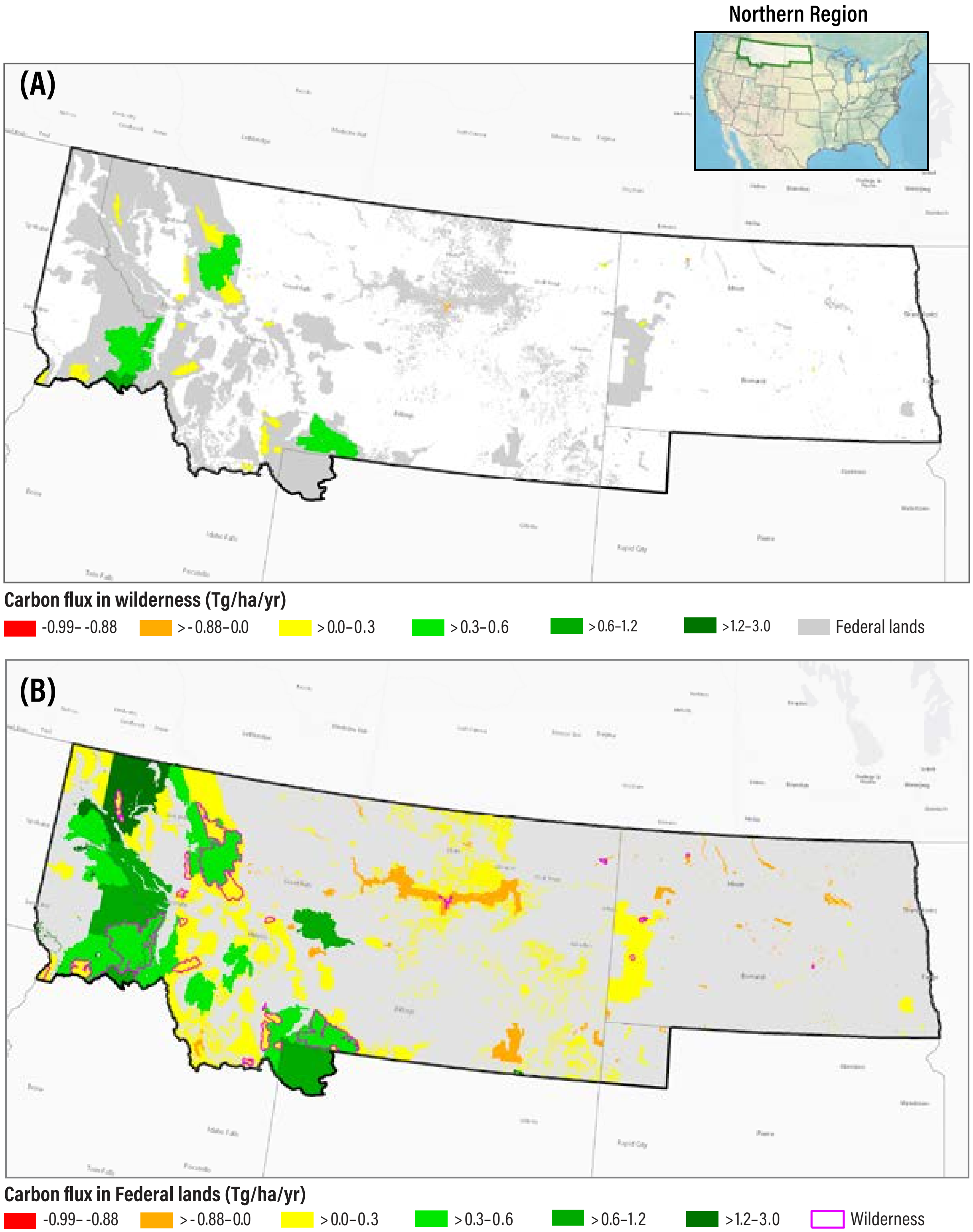

Figure 7.3—Net ecosystem carbon flux in (A) wilderness areas and (B) all Federal lands, Northern Region (2002–2005 average).

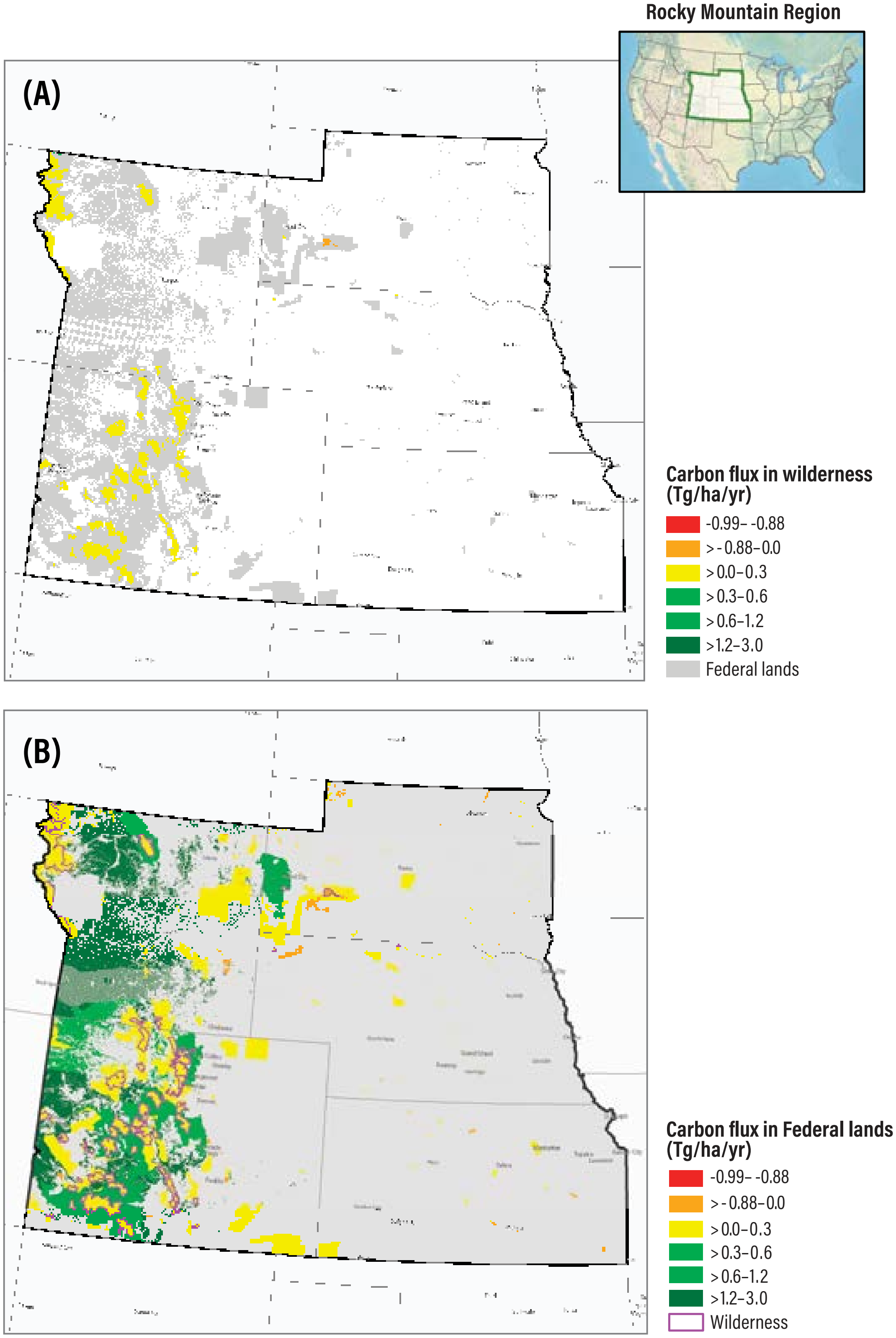

Figure 7.4—Net ecosystem carbon flux in (A) wilderness areas and (B) all Federal lands, Rocky Mountain Region (2002-2005 average).

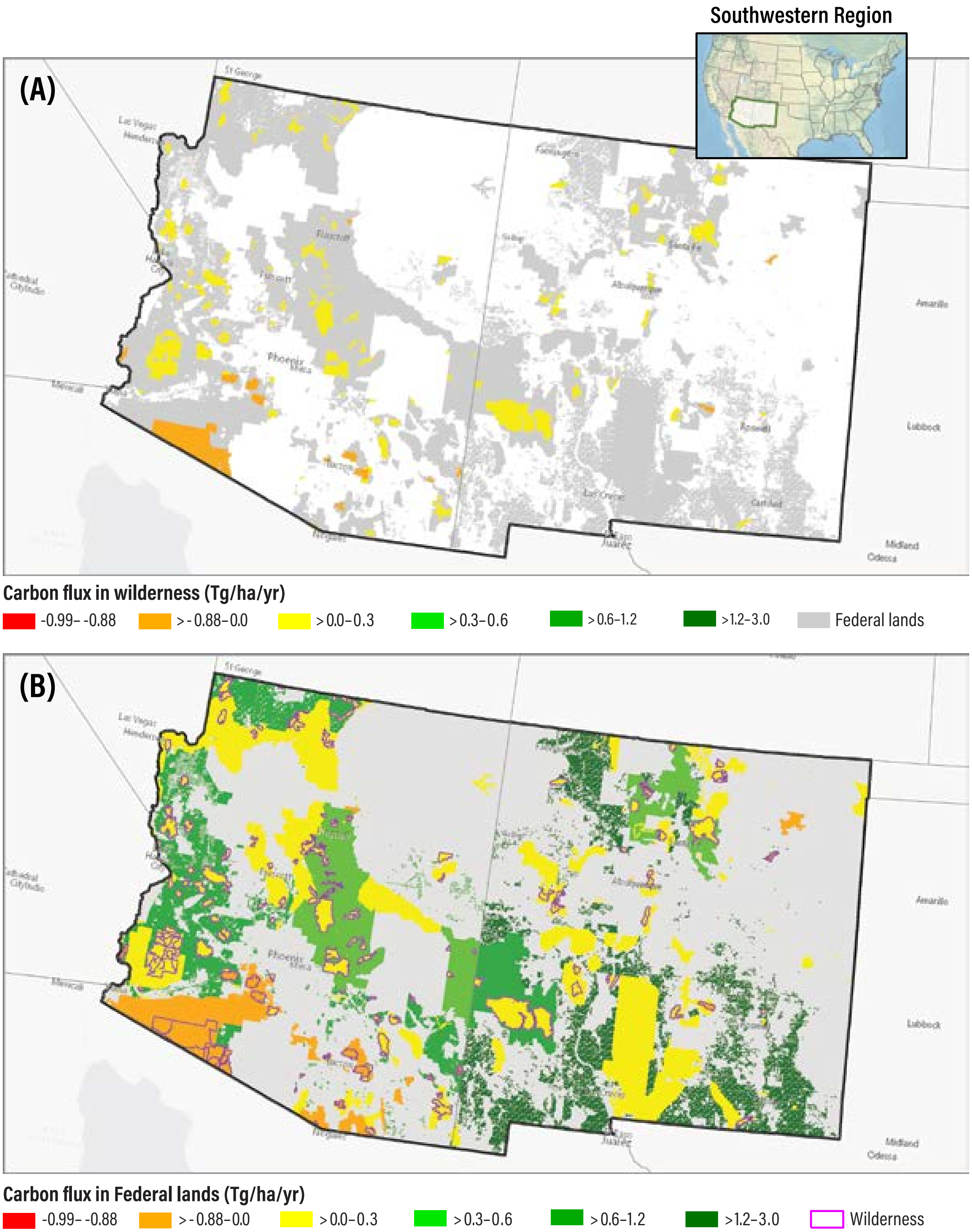

Figure 7.5—Net ecosystem carbon Flux in (A) wilderness areas and (B) all Federal lands, Southwestern Region (2002–2005 average).

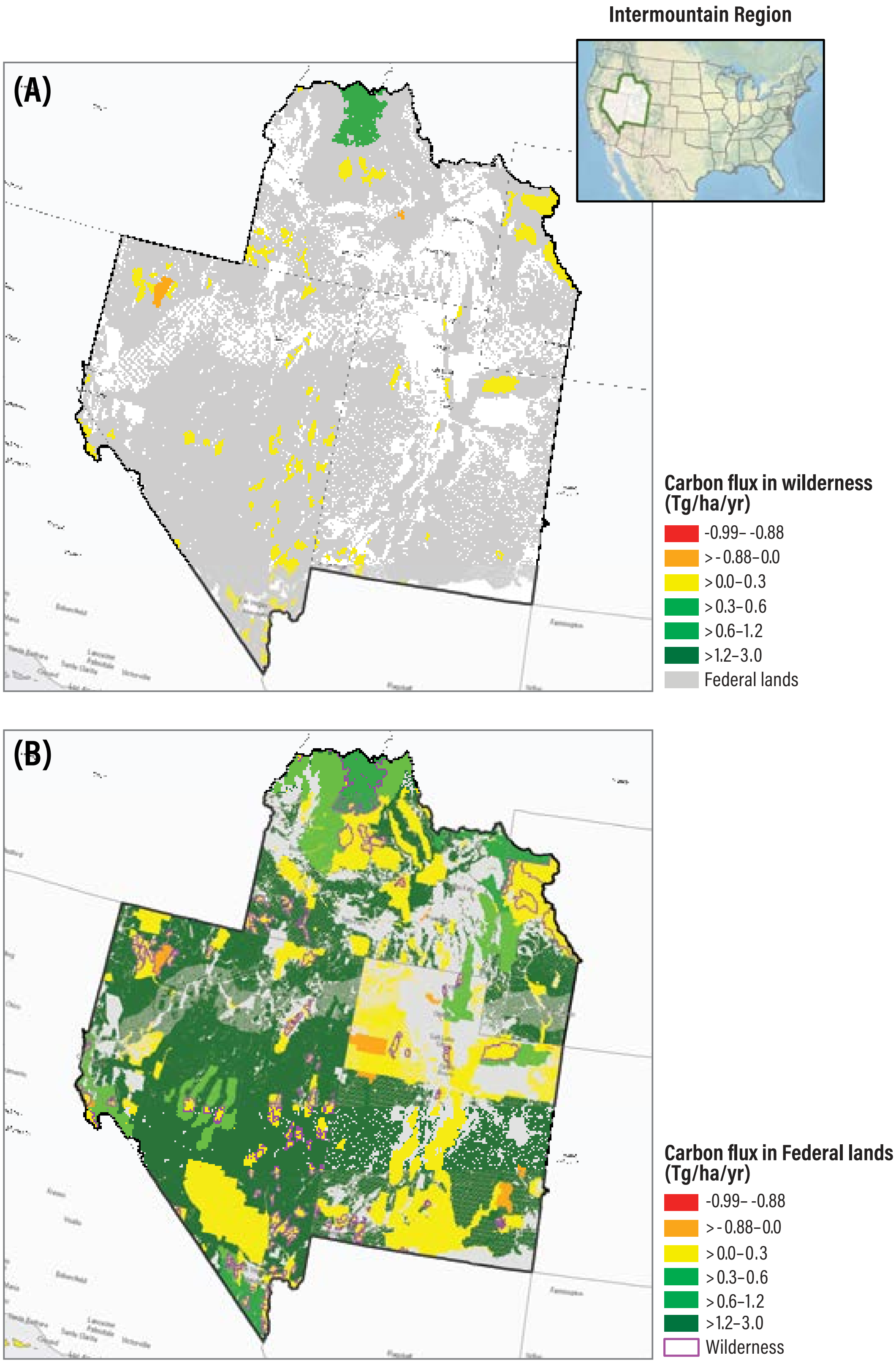

Figure 7.6—Net ecosystem carbon flux in (A) wilderness areas and (B) all Federal lands, Intermountain Region (2002–2005 average).

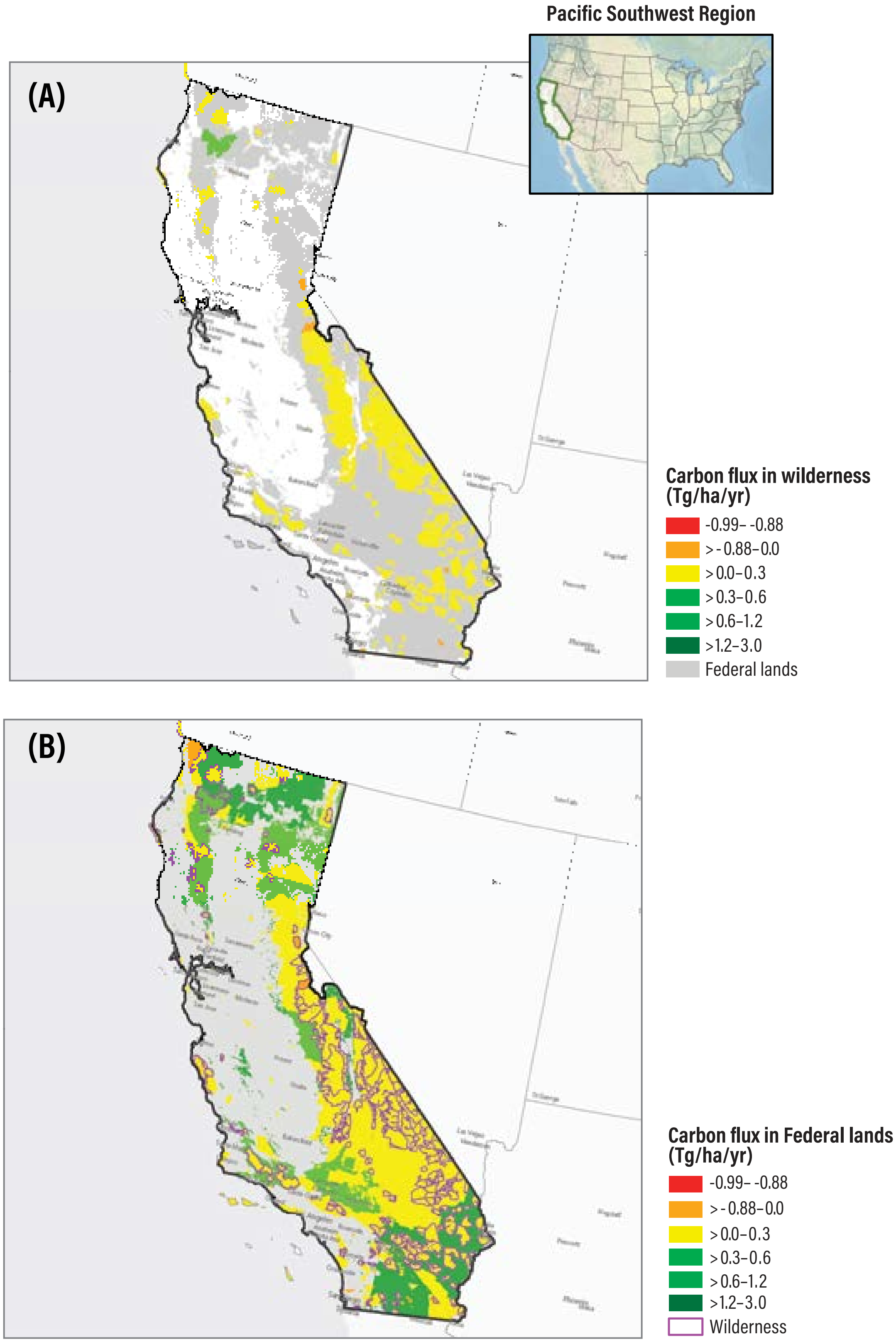

Figure 7.7—Net ecosystem carbon flux in (A) wilderness areas and (B) all Federal lands, Pacific Southwest Region (2002–2005 average).

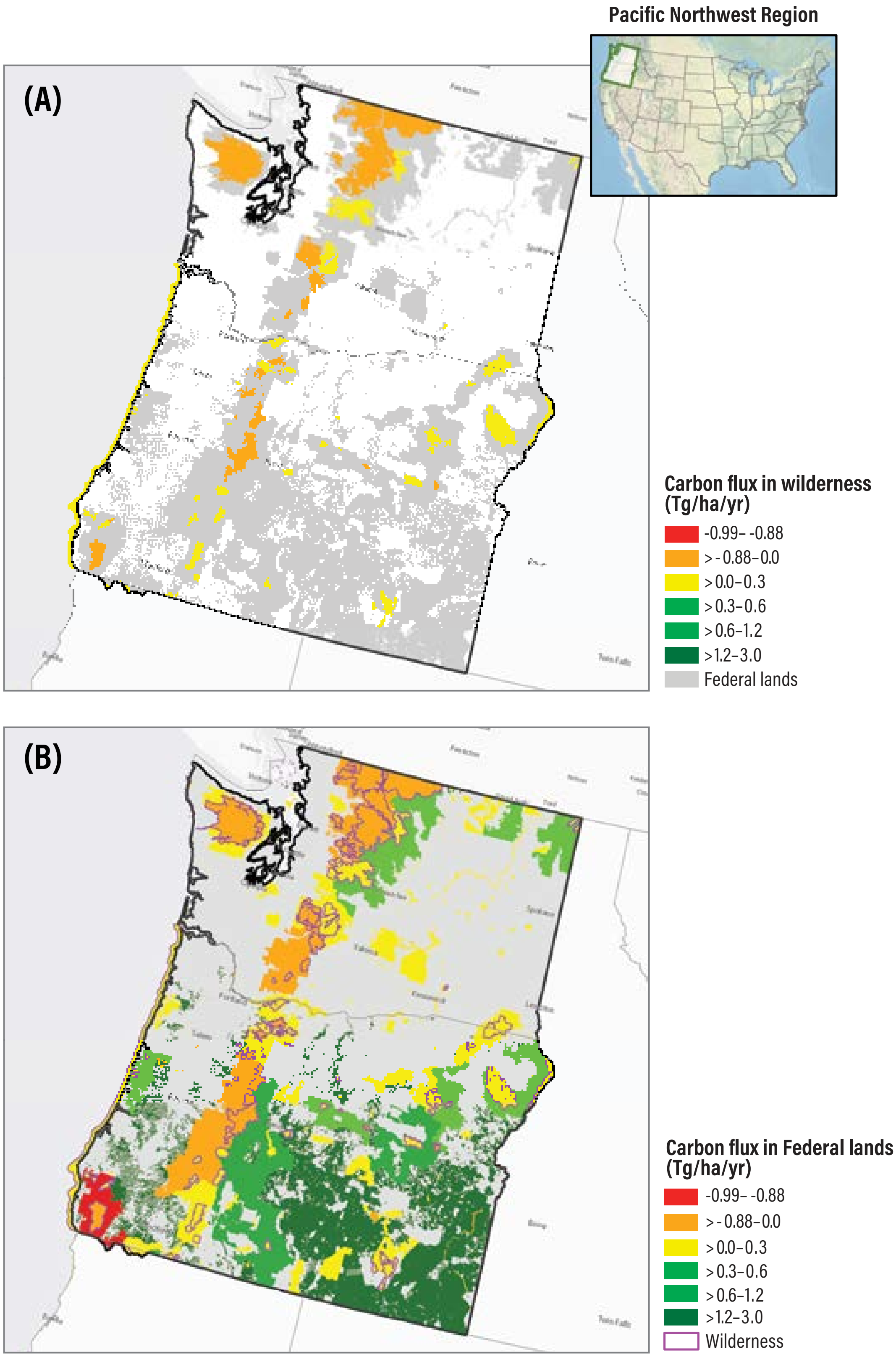

Figure 7.8—Net ecosystem carbon flux in (A) wilderness areas and (B) all Federal lands, Pacific Northwest Region (2002–2005 average).

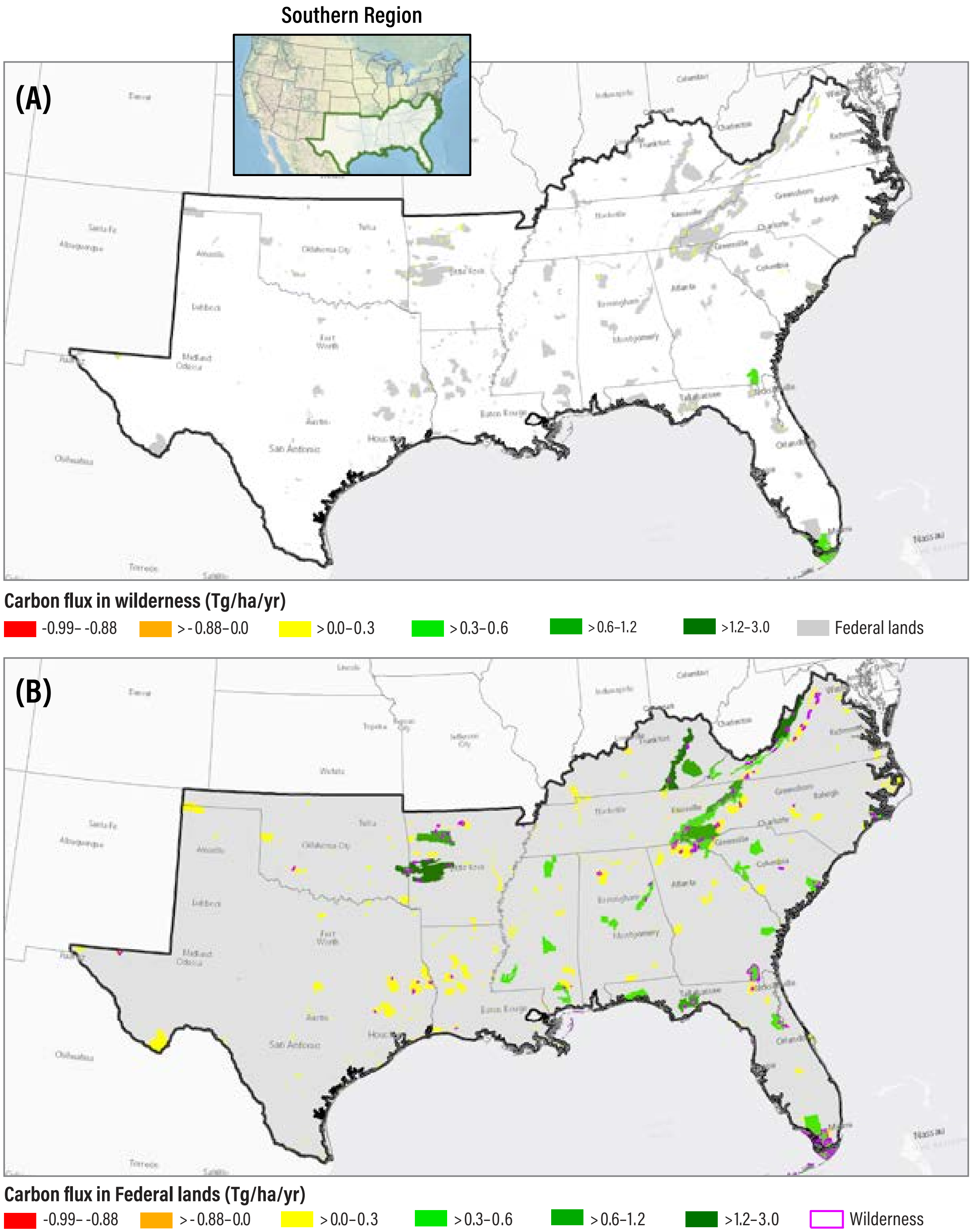

Figure 7.9—Net ecosystem carbon flux in (A) wilderness areas and (B) all Federal lands, Southern Region (2002–2005 average).

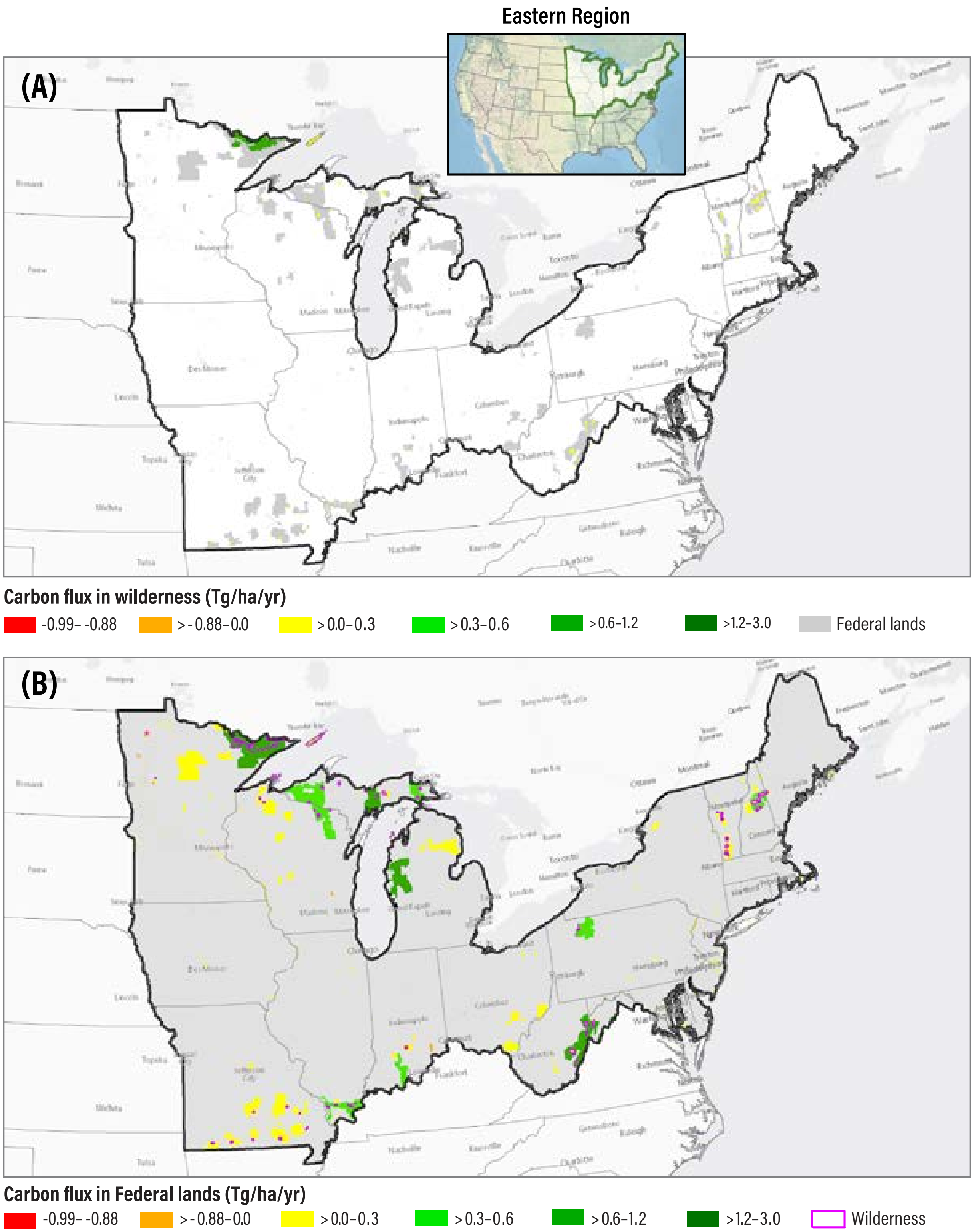

Figure 7.10—Net ecosystem carbon flux in (A) wilderness areas and (B) all Federal lands, Eastern Region (2002–2005 average).

sequestration of CO_2e) while orange and red colors indicate carbon sources (negative carbon fluxes or net emission of CO_2e).

The numbers underlying the wilderness area maps are presented by State, management agency, and individual wilderness area in the appendix (available at https://www.srs.fs.usda.gov/pubs/gtr/gtr_srs254/gtr_srs254_supplement.pdf). The appendix table shows the minimum and maximum carbon fluxes observed in the group of polygons comprising each wilderness area along with the mean value of observed carbon fluxes in that group of polygons.[10] This was done to provide a rough sense of the distribution of carbon flux within a wilderness area. The mean values of carbon flux are further expressed in units of annual total carbon flux and annual total CO_2e flux, and finally in terms of the social value of CO_2e sequestration. (We remind readers that for ease of presentation, we reversed the signs on carbon flux, so a positive number indicates net carbon sequestration and a negative number indicates net carbon emission.)

Table 7.3 summarizes the average amount of carbon and CO_2e sequestered in a year (based on 2002–2005 averages) and the value (SC-CO_2) of that sequestered carbon by management agency. The SC-CO_2 used was $42 per metric ton of CO_2.

Discussion

The National Wilderness Preservation System sequestered an annual average of 51.6 TgCO_2e (or 51.6 million t of CO_2e) valued at $2.17 billion based on 2002–2005 averages. To put these numbers in a context, table 7.4 presents the carbon, CO_2e, and social value of CO_2e on all lands, both wilderness and nonwilderness, administered by the land management agencies in the conterminous United States. And, as noted in the literature review section above, average net carbon flux in all terrestrial ecosystems of the conterminous United States for the period 2001–2005 ranged from 238 TgCO_2e/yr in the U.S. Great Plains to 319 TgCO_2e/yr in the Western United States to 1,023 TgCO_2/yr in the Eastern United States (Zhu 2011; Zhu and Reed 2012, 2014). All numbers reported in tables 7.3 and 7.4 are subject to uncertainty due to sampling, modeling, and estimation of underlying data which are inherent in all datasets of this type. For example, Heath and others (2011b) reported confidence intervals, at the 95-percent level, ranging from +/- 1 percent of the mean carbon stock when considering all Forest Service lands up to +/- 4 percent of the mean carbon stock when considering estimates at Forest Service regional levels. Further uncertainty was reported when estimating changes in carbon stock over the 2000–2008 period. Confidence intervals for the mean net carbon stock change

[10] Digital maps are based on data observed within small geographic areas known as polygons which vary in size depending on the scale of the map. Multiple polygons are combined to make up the geographic area of interest, in this case public land areas such as wilderness areas. Each polygon contributes a data point to the combined set of polygons comprising the area of interest.

Table 7.3—Carbon flux, carbon dioxide equivalent (CO_2e) flux, and social value of CO_2e sequestered <u>in wilderness areas</u> in the conterminous United States by management agency in 1 year (based on average annual net ecosystem carbon flux in years 2002–2005)

Agency	Total carbon flux (TgC/yr)[a]	Total CO_2e flux (TgCO_2e/yr)	Social value of sequestered CO_2e[b] (at $42/t$CO_2$)
			billion dollars
Bureau of Land Management	1.511267	5.541816	0.23
Forest Service	9.842229	36.091452	1.52
Fish and Wildlife Service	0.961904	3.527303	0.15
National Park Service	1.749548	6.415594	0.27
Total	**14.064948**	**51.576165**	**2.17**

[a] Tg = teragram = 1 trillion grams = 1 million Mg (megagrams or metric tons [t]). The positive numbers indicate increased carbon uptake by the terrestrial ecosystem (a carbon sink or net sequestration). Fluxes are shown to six decimal places to facilitate their being read as metric tons. Recall that CO_2e flux was obtained by multiplying carbon flux by a factor of 3.667.

[b] The social cost of carbon dioxide (SC-CO_2) is defined as the social cost (value) of 1 t (Mg) of CO_2 emitted (sequestered). The SC-CO_2 used here is $42/t$CO_2$ emitted in 2015 and valued in 2017 dollars. Converting that into the cost of 1 Tg of CO_2 emitted would yield an SC-CO_2 of $42,000,000/Tg$CO_2$.

Table 7.4—Carbon flux, carbon dioxide equivalent (CO_2e) flux, and social value of CO_2e sequestered in the conterminous United States on all lands administered by four land management agencies for 1 year (based on average net ecosystem carbon flux in years 2002–2005)

Agency	Total land area in conterminous United States	Total carbon flux (TgC/yr)[a]	Total CO_2e flux ($TgCO_2e$/yr)	Social value of sequestered CO_2e[b] (at $42/$tCO_2$)
	millions of hectares			*billion dollars*
Bureau of Land Management	70.0	22.971433	84.236245	3.54
Forest Service	69.1	91.362577	335.026571	14.07
Fish and Wildlife Service	5.1	3.576006	13.113214	0.55
National Park Service	11.1	6.567568	24.083273	1.01
Total	**155.3**	**124.477585**	**456.459303**	**19.17**

Total land areas by agency are from Vincent and others (2017).

[a] Tg = teragram = 1 trillion grams = 1 million Mg (megagrams or metric tons [t]). The positive numbers indicate increased carbon uptake by the terrestrial ecosystem (a carbon sink or net sequestration). Fluxes are shown to six decimal places to facilitate their being read as metric tons. Recall that CO_2e flux was obtained by multiplying carbon flux by a factor of 3.667.

[b] The social cost of carbon dioxide (SC-CO_2) is defined as the social cost (value) of 1 t (Mg) of CO_2 emitted (sequestered). The SC-CO_2 used here is $42/$tCO_2$ emitted in 2015 and valued in 2017 dollars. Converting that into the cost of 1 Tg of CO_2 emitted would yield an SC-CO_2 of $42,000,000/$TgCO_2$.

on all Forest Service lands were reported as +/- 40 percent. Much of the uncertainty came from projecting the sample-based FIA data to population levels. The uncertainty was compounded when data were combined to estimate changes in stock over time (Coulston and others 2015, Heath and others 2011b). We expect similar levels of uncertainty in this analysis though we were unable to calculate specific estimates.

On a grander scale, the total CO_2e flux in the U.S. forestry sector, i.e., all forested lands both public and private, in 2008 was estimated to be 704 $TgCO_2e$ not including the 88 $TgCO_2e$ from harvested wood products in use and in landfills (Malmsheimer and others 2011, U.S. EPA 2010).

How do Growth and Disturbance Events Affect Carbon Sequestration?

The discussion in this section focuses on forests. Many wilderness areas are largely forested ecosystems. The effects described, however, are more general than just forests. They apply to other terrestrial ecosystems, including those found in wilderness areas. Growth and disturbance events, as well as management, are included in the baseline USGS Land Carbon Program data used in this analysis. Their effects are accounted for in the results presented for 2002–2005. They are, in fact, among the drivers of the carbon sequestration reflected in those data. Knowledge about how carbon sequestration can be affected by growth and disturbance events can provide insight into how future conditions might affect wilderness areas and other public lands, either similarly or differentially.

Age class distribution of the forest in a region and forest aging strongly influence carbon accumulation. Coulston and others (2015) describe forest aging as addressing the temporal progression of forests (growth and normal mortality levels) as modified by disturbances (mortality and removals). Both newly established forests and old forests have limited capacity to sequester carbon as compared to juvenile to middle-aged forests (Zhang and others 2012). In an analysis of total forest carbon in the Southeastern United States, carbon accumulation rate peaked in age classes 10–15 years and 15–20 years. The carbon accumulation rate dropped by >50 percent by age class 35–40 and by >75 percent by age class 65–70 (Coulston and others 2015). Those older trees were still accumulating and sequestering carbon but at a slower rate.

Beyond age class, growth is a function of conditions on the land such as moisture, soil, etc. Other things equal, growth and therefore sequestration are also functions of tree species and forest type (Jenkins and others 2003, Smith and Heath 2008). Different species grow at different rates; some species have a higher ability than others to fix atmospheric carbon into their biomass (Liu and others 2016, Maiti and others 2015). Ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), aspen (*Populus* spp.), red oak (*Quercus* spp.), green ash (*Fraxinus pennsylvanica*), and linden (*Tilia* spp.) are among species with moderate to fast growth rates while red maple (*Acer rubrum*), Norway maple (*A. platanoides*), and Austrian pine (*P. nigra*) are among those with moderate growth rates. Piñon (*Pinus* spp.), balsam fir (*Abies balsamea*), and blue spruce (*Picea pungens*) fall among the slower growing tree species (Nowak and others 2002, Wood and Poulson 2017). More and faster growth would have a positive effect on carbon sequestration. Species diversity can also affect, either similarly or differentially, carbon sequestration on wilderness areas and other public lands. Species-rich stands (3–20 tree species) were found to have higher carbon stocks and fluxes than stands with low species diversity or monocultures (Liu and others 2018).

Forest disturbances generally have a negative effect on carbon sequestration, at least in the short term, due to increased mortality, reduced net productivity, gradual decomposition of dead and downed material, and resulting changes in stand structure. Over a longer term, carbon sequestration might be expected to increase as forests grow back and stands revert to more productive age classes. Carbon uptake in the early years of recovery after a disturbance is smaller than carbon release from respiration. It generally takes 10–30 years for growing forests to become net carbon sinks after disturbances. The net effect varies depending on species, management, and environmental conditions (Kasischke and others 2013, Ryan and Vose 2012, Zhang and others 2012).

Fire increases carbon emission quickly in the short term as byproducts of combustion enter the atmosphere, trees and other vegetation are killed, and less forest growth occurs. Other fire effects include possible acceleration of nutrient cycling, shifts in successional direction, induced seed germination, and potentially increased landscape heterogeneity. Erosion can occur when soil disturbance accompanies a fire, e.g., from firefighting or timber salvage (Dale and others 2001). Over the long term, assuming no trend in fire return intervals, emissions resulting from fires are balanced against carbon sequestration by the growing forest. Intense, stand-replacing fires in heavily stocked (or crowded) stands can be so severe that substantial soil carbon stores are lost, and soil structure and nutrient capital are destroyed, delaying regeneration and/or leading to slower regrowth (Dale and others 2001, Malmsheimer and others 2011). At the Great Dismal Swamp, emissions and loss of carbon stock from catastrophic wildfires outweighed the potential of the landscape to biologically sequester carbon. The wildfires led to standing water and vegetation that may never recover (Pindilli and others 2018, Sleeter and others 2017).

Mortality due to insects and disease can rival that of fire and is a significant factor in carbon emissions over time in U.S. forests (Malmsheimer and others 2011, Ryan and Vose 2012). These disturbances tend not to consume dead biomass and reduce soil carbon pools (as can fire), but they do generate considerable quantities of dead biomass. Their effect on forest carbon varies depending on whether the agent attacks all tree species in a stand or only a few. As long as unaffected trees are present in significant numbers, the growth potential of the site "transfers" to the surviving trees, at least some of which are likely to take over growing space vacated by trees that are killed. However, if a stand is a monoculture or the agent attacks all tree species, loss of carbon storage could be substantial, especially if salvage or recovery of dead wood is not an option (salvage harvesting is generally prohibited in wilderness areas). Further, insect infestations can result in changes to stand structure that promote ladder fuels, thereby increasing the risk of severe crown fires which increases the potential for large emissions of carbon from the live-tree pool. Finally, the prodigious amounts of dead biomass produced by the infestations elevate the potential for high-intensity fires and substantial carbon emissions when fires do occur (Malmsheimer and others 2011, Ryan and Vose 2012). As in the case of fire, carbon accumulation would be expected to increase over time as the forest is regenerated and the age class structure changes in the direction of more juvenile to middle-aged trees.

Drought occurs in nearly all forest ecosystems. The primary immediate response of forests to drought is to reduce NPP. When reductions in NPP are extreme or sustained over multiple growing seasons, increased susceptibility to insects or disease can occur (Negron 1998). Drought can also slow down decomposition processes, leading to a buildup of organic matter on the forest floor that may increase fire frequency or intensity or reduce nutrient cycling (Dale and others 2001).

Weather-related disturbances such as windthrows, hurricanes, tornadoes, and ice storms can all be locally significant and affect carbon emissions (Malmsheimer and others 2011, Ryan and Vose 2012). Such events can cause heavy tree mortality, produce canopy disruption, reduce tree density and size structure, and change local environmental conditions. Large quantities of deadwood can be produced, bringing with it carbon emissions from decomposition and increased risk of fire. For example, a 1999 windstorm in the Boundary Waters Canoe Area Wilderness of Minnesota flattened over 148,000 ha of forest (Moser and Nelson 2009). Longer term carbon losses could result from any delay in storm damaged stands re-establishing themselves.

Given management restrictions and limitations in wilderness areas, responses to forest disturbance events are limited. Often little can be done to prevent or mitigate carbon losses due to disturbances. To the extent that disturbances become more likely to occur with increased temperature and altered precipitation patterns that might prolong periods of drought or intensify other stressors, one might expect wilderness areas to be relatively more affected than areas where proactive and mitigating management can prevent damage and accelerate recovery.

Zhang and others (2012) differentiated between disturbance and non-disturbance-related factors that might change forest carbon stocks due to their effects on forest regrowth patterns. Disturbance factors include harvesting, fire, insect infestation, and disease, while nondisturbance factors include CO_2 concentration, nitrogen deposition, and climate variability.[11] Zhang and others used simulation models based on the long-term period 1901–2010 to attribute changes in forest carbon sinks from 1950 to 2010 to disturbance and nondisturbance factors. They estimated that carbon sinks in conterminous U.S. forests from 1950–2010 averaged 206 TgC/yr with 87 percent in living biomass. Compared with simulations including all factors combined, the average carbon sink was reduced by 95 TgC/yr when disturbance factors were omitted from the simulations, and by 50 TgC/yr when nondisturbance factors were omitted (Zhang and others 2012). Other things equal, it appears, removing the long-term effects of forest regrowth after disturbance events led to a greater reduction in carbon sequestration than did removing the growth effects of nondisturbance, i.e., climate-related factors. Conversely, including disturbance factors in the simulations led to relatively more carbon sequestration than did including climate-related factors. An important limitation noted by Zhang and others was the uncertainty stemming from not being able to adequately simulate interactions between disturbance and nondisturbance factors in their modeling.

Changes in temperature, precipitation patterns, extreme weather events, and other climatic conditions projected to occur over the 21st century (U.S. Global Change Research Program 2017) threaten to amplify risks to forest (and other landscape) carbon stocks by triggering

[11] The nondisturbance factors can affect growth rates of vegetation and thereby affect carbon sequestration. Increased CO_2 concentration can lead to increased photosynthetic activity while nitrogen deposition can act as a fertilizer. Variability in temperature and precipitation can affect growth as well. Potential interactions among these factors leave the net results uncertain.

multiple stressors, resulting in increased frequency and severity of disturbances such as wildfires, insect outbreaks, hurricanes, and drought, lowering productivity and long-term storage capacity of some forests and threatening the ability of some forests to remain as forests (Dale and others 2000, 2001; Edburg and others 2012; McKinley and others 2011; Vose and others 2012). Altered patterns of snow cover and melting/runoff could result in flooding and exacerbate soil moisture deficits in some forests (Vose and others 2012). At the same time, increases in temperature and higher concentrations of CO_2, along with longer growing seasons, could lead to increased NPP in some areas. The net effects on carbon stocks are uncertain and area specific.

Interactions between disturbance and nondisturbance factors in forests and other landscapes are complex and important, but no patterns have been identified to improve understanding and simulate them in models, particularly at the regional scale (Zhang and others 2012). Many disturbances are cascading (Dale and others 2001, Edburg and others 2012, Vose and others 2012). Drought can weaken tree vigor, leading to greater susceptibility to attack by insects or disease, or to fire (Negron 1998). Insect infestations or disease promote future fires by increasing fuel loads, and fires promote future infestations by compromising tree defenses. Increased fire intensity or extent could enhance the potential for erosion and landslides. When ecosystems experience more than one disturbance, or when the system has not recovered from the first disturbance before a second perturbation occurs, a new long-term condition could result (Dale and others 2001).

Kasischke and others (2013: 308) summarize the "big picture" of disturbance events and how they affect ecosystems:

> Disturbances have both direct and indirect impacts on ecosystems. Direct effects include changes to the physical and biological characteristics of the ecosystem, while indirect effects result in changes to the abiotic environment that, in turn, affect the biogeochemical processes that regulate carbon cycling. Direct effects include damage from disturbances to plants, trees, microbial communities, and dead organic matter (including mortality and direct removal through combustion). Indirect changes to the abiotic environment include: (1) changes to site microclimate (light, temperature, and precipitation distribution) from physical changes to tree and plant canopies; (2) physically altering site geomorphology (e.g., permafrost thaw causes surface subsidence and reorganization of drainage systems); and (3) changes to soil moisture and surface hydrology, site and ground temperature, and light conditions. The combination of direct and indirect impacts from disturbance often initiates feedback processes that may be self-reinforcing…. These combined effects change the biological processes that control photosynthesis, respiration (both aerobic and anaerobic), and methane oxidation—key processes that control exchanges of carbon between terrestrial ecosystems and the atmosphere.

Conclusions and Implications

According to the Wilderness Act of 1964 (Public Law 88–577), wilderness areas are intended to provide particular values and benefits, including: (1) preservation and protection of lands in their natural condition; (2) areas where the earth and its community of life are untrammeled by man; (3) undeveloped Federal land retaining its primeval character and influence without permanent improvement or human habitation; (4) lands generally appearing to have been affected primarily by the forces of nature with the imprint of man's work substantially unnoticeable; (5) lands having outstanding opportunities for solitude or a primitive and unconfined type of recreation; and (6) lands devoted to the public purposes of recreation, scenic, scientific, educational, conservation and historic use.

Embedded in the Wilderness Act of 1964, as amended, are restrictions on the uses and activities that can take place in wilderness areas. There are also restrictions on management activities in wilderness areas that prevent or limit the ability of managers to proactively manage and mitigate damage from disturbances using harvest, thinning, and fuel reduction treatments commonly used in nonwilderness areas. Further, managers are prevented from doing some of the cleanup activities, such as salvage logging or removal of dead material, that sometimes occur following a disturbance on other public lands. These management restrictions generally prevent managers and policymakers from actions to maximize, or even increase, the level of carbon sequestration in wilderness areas including timber harvest to provide wood products (both consumer products and building materials) and manage age structure of forest stands, forest thinning to reduce fuels to reduce frequency and intensity of wildfires that do occur, and greater use of woody biomass for energy production (Malmsheimer and others 2011, McKinley and others 2011).

Management restrictions in wilderness areas do not necessarily work to the detriment of the land, however. As Dale and others (2001: 729) point out: “Often the least ecologically disruptive response after a disturbance is no action at all, but managers or society usually call for some type of cleanup or restoration, even when such action may retard recovery.” Might wilderness areas provide a test of that supposition, particularly in the case of carbon sequestration?

Management restrictions represent tradeoffs between benefits from wilderness and wilderness character and potential benefits that might accrue from more active or aggressive management. These tradeoffs are balanced within society by managing different areas for different objectives and benefits. Some public lands are managed for multiple uses, including timber, wildlife habitats, grazing, minerals, and energy development. Others are managed to protect natural and cultural resources while simultaneously providing opportunities for public use and enjoyment or to conserve, protect, and restore fish and wildlife resources. Wilderness areas are managed to preserve their natural undeveloped state, minimally affected by human intervention, thus providing a particular package of values and benefits. Carbon sequestration (as a key service supporting climate regulation) is rarely, if ever, an explicit management objective even though it provides an important benefit to people both locally and globally. The degree of carbon sequestration may not be a specific land management objective, but it is useful to understand how carbon sequestration fits into a portfolio of benefits provided by wilderness, and how wilderness and wilderness character might uniquely affect and be affected by carbon sequestration. Further, recognizing the full spectrum of values and benefits helps both managers and the public evaluate tradeoffs in selecting between management alternatives.

Future research might include more detailed investigation of possible regional variation in carbon sequestration. Do wilderness areas have carbon sequestration rates similar to nonwilderness areas in the desert southwest or in the northern Rocky Mountains? Do management restrictions imposed on wilderness areas affect carbon sequestration differently in different areas of the country?

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8

An Economic Perspective on the Relationship Between Wilderness and Water Resources

James R. Meldrum • Christopher Huber

Great Sand Dunes Wilderness (32,643 total acres) in Colorado was designated in 1976 and is administered by the National Park Service. (Courtesy photo by wilderness.net)

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KEY MESSAGES

- A disproportionately high percentage of the Nation's renewable supply of surface freshwater flows from wilderness versus other lands.
- Watersheds with a higher percentage of water originating in wilderness tend to lie along the major mountain ranges of the United States—the Rocky Mountains, Sierra Nevadas, and Cascades in the West; the Appalachian Mountains, which span much of the length of the east coast; and the Boston Mountains in northern Arkansas.
- Twenty-one States have at least one wilderness area with a watershed in the top 90th percentile of drinking water importance to residents of that State, and 34 of the 48 conterminous States have a wilderness area that contains a watershed ranked in the top half of all watersheds for drinking water importance.
- The economic value of contributions to water supplies from wilderness generally increases as regional water availability decreases.
- Challenges to estimating the value added to water resources by wilderness are discussed.

Introduction

Since 1964, the United States has maintained legally designated wilderness areas for the combined "recreational, scenic, scientific, educational, conservation, and historical use" of the public (Public Law 88–577; http://www.wilderness.net/NWPS/legisAct). The Wilderness Act of 1964 famously established this National Wilderness Preservation System (NWPS) to protect areas "where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain…," with the idea of maintaining the ecological integrity of natural areas. As Hendee and others of the U.S. Department of Agriculture, Forest Service put it, "wilderness managers are, in effect, guardians and not gardeners… [wilderness] managers should not mold nature to suit people. Rather, they should manage human use and influence so that natural processes are not altered" (Hendee and others 1978: 7). They and many others argue that this unique approach to managing a subset of public lands offers three main types of benefits to people: experiential, mental and moral restorative, and scientific.

Other commenters go beyond the basic preservationist ethic (e.g., Nash 1973) and these three types of benefits in arguing for additional values of wilderness to the people of America. Although the wilderness economics literature is sparse, it demonstrates that the public has significant willingness to pay for wilderness and the services it provides (Holmes and others 2016, Loomis and Richardson 2001). These services relate both to active uses, such as recreation and tourism, and to nonuse values (also referred to as passive use values), which relate to existence, option for future use, and bequest to future generations. Many commenters also cite the role of wilderness areas in protecting water resources, including for offsite or downstream users. For example, Morton (1999) maintains that a key role of wilderness is watershed protection, with numerous associated benefits including support for native fish, reduced water treatment costs, and the possibility of selling the water for drinking. Similarly, the North American Intergovernmental Committee for Wilderness and Protected Areas Cooperation (NAWPA) summarizes many benefits from wilderness and protected areas associated with water-related services, including providing consistent supply of "some of the world's highest-quality drinking water," as well as water for use for industrial, recreational, and cultural purposes; by fish and wildlife populations; and more (NAWPA 2012). Indeed, some wilderness areas were designated with an explicit purpose of preserving healthy watersheds, such as the Rattlesnake Wilderness in Montana, noted in the Rattlesnake National Recreation Area and Wilderness Act of 1980 (Public Law 96–476) for its use "...by people throughout the Nation who value it as a source of...clean free-flowing waters stored and used for municipal purposes for over a century."

However, notwithstanding the many other public benefits provided by wilderness, it remains an open question whether the water-related ecosystem services supported by wilderness areas provide a utilitarian benefit associated with the allocation and management of those wilderness areas. That is, what is the value added by wilderness to water, i.e., the economic benefit of wilderness areas associated with water-related ecosystem services? Understanding such economic benefits is important for evaluating the efficiency of decisions regarding the designation and management of wilderness areas as a unique category of public lands. Importantly, this question requires consideration of the counterfactual: if the lands were not maintained as wilderness, what would be lost in terms of water-related benefits? In this article, we seek to answer these questions by developing an understanding of the relationship between wilderness areas and water resources, with a particular interest in the associated economic benefits to the general public.

We develop this understanding three ways. First, we examine spatial and hydrological relationships that link U.S. wilderness areas to downstream users. This analysis demonstrates that substantial portions of the total U.S. freshwater resources originate in, or flow through, wilderness areas. Further, it demonstrates the prevalence of watersheds that contain wilderness areas among those rated as being of high importance for downstream drinking water purposes. Next, we provide a brief primer on the economics of water resources, focusing our attention on the special considerations of the resource and how these relate to understanding the value of freshwater flows originating in wilderness. We discuss one potential approach to generating a coarse estimate of the total economic value of the water flowing from wilderness, focusing our attention on the technical and practical limitations of this approach and, importantly, why it would not well capture the value added by wilderness to water resources. Finally, we discuss preferred approaches to valuation, including preliminary case study examples that consider the specific potential effects of alternative management schemes on the localized benefits of water resources. Throughout, we argue that although existing evidence demonstrates many connections between wilderness areas and the water used by people, rigorous characterization of the economic benefits provided by wilderness through water resources, if desired, will require many new case studies using these types of alternative approaches.

Wilderness and Freshwater Runoff

The first step in understanding the relationship between wilderness areas and water resources is to characterize the amount of water associated with these areas and where that water flows.

Runoff from Wilderness Versus from Other Lands

To characterize the contribution of wilderness areas to total freshwater runoff, we build on the analysis of Brown and others (2016). They report that approximately 25 percent of the water that originates on Federal lands in the conterminous United States comes from areas designated as wilderness. Their total estimate is based on the 30-year average of the mean annual water yield, as modeled by the Variable Infiltration Capacity (VIC) model, implemented at a daily time step over 1981–2010 for each 1/8- by 1/8-degree grid cell across the conterminous United States. Further processing of Brown and others' (2016) results allows us to construct estimates of the percentage of the total annual runoff within a given region that originates within a designated wilderness area. We depict these estimates at two scales of hydrologic unit code (HUC) (Seaber and others 1987): the two-digit "water resource region" scale (HUC2) and the eight-digit "cataloging unit" or "watershed" scale (HUC8), respectively, in figures 8.1 and 8.2. Further, figure 8.1 depicts the geographical extent of designated wilderness areas around the country.

The percentage of overall runoff that is associated with wilderness varies strongly across different regions of the country. As figure 8.1 shows, there exists a clear pattern of higher percentages across much of the Western United States than in the Eastern United States. Specifically, the value is ≤1 percent for 10 of the 18 water resource regions of the conterminous United States, all of which are in the eastern half of the country. The Souris-Red-Rainy and Missouri regions, in the Central United States, receive 5 and 7 percent of their runoff from wilderness areas, respectively. In contrast, percentages in the Western United States range from a low of 8 percent for the Lower Colorado region to 17 percent in the Pacific Northwest and 25 percent in the Upper Colorado. However, the coarser HUC2 representation of figure 8.1 glosses over an important pattern demonstrated by figure 8.2. Namely, figure 8.2 demonstrates that some HUC8 watersheds derive nearly all their runoff from wilderness areas, with numerous watersheds in the Western United States deriving >50 percent of their runoff from wilderness areas. Even in the Eastern United States, there exist numerous watersheds for which a nonnegligible proportion of the runoff originates in wilderness.

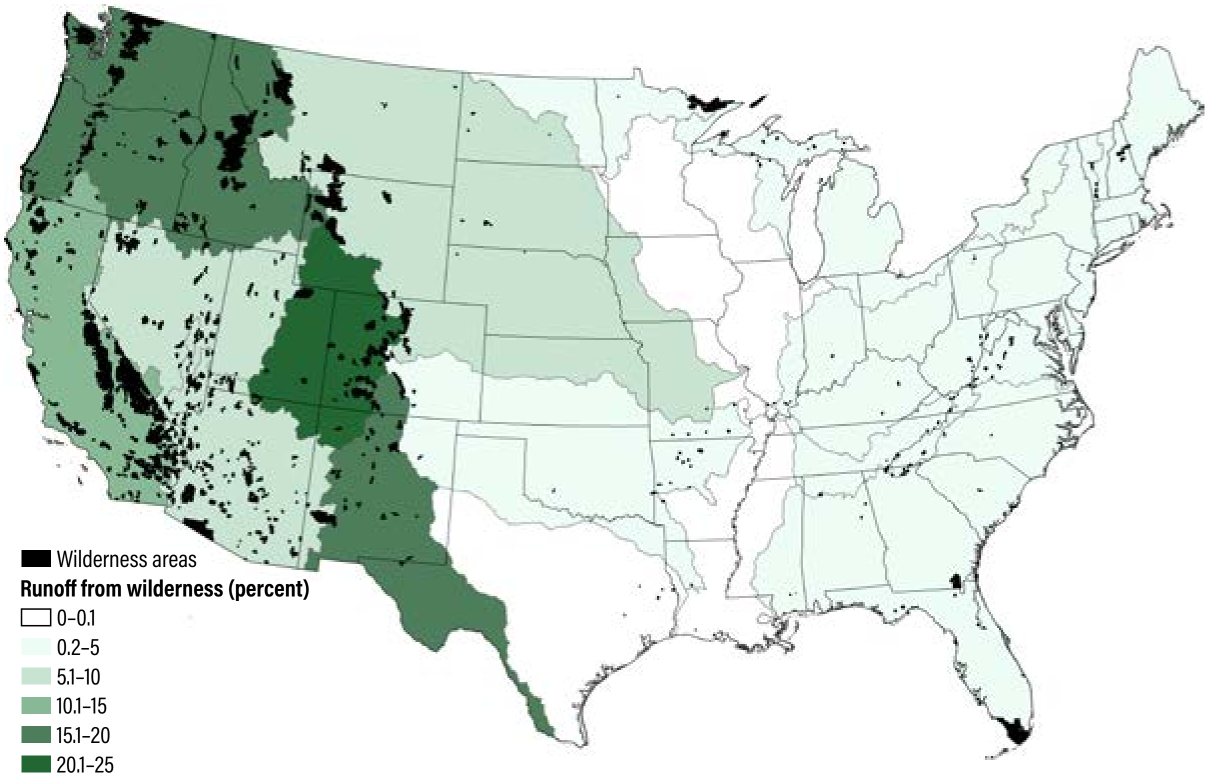

Figure 8.1—Percentage of freshwater runoff from wilderness areas versus freshwater runoff from all areas within a water resource region (HUC2 area), and boundaries of designated wilderness areas.

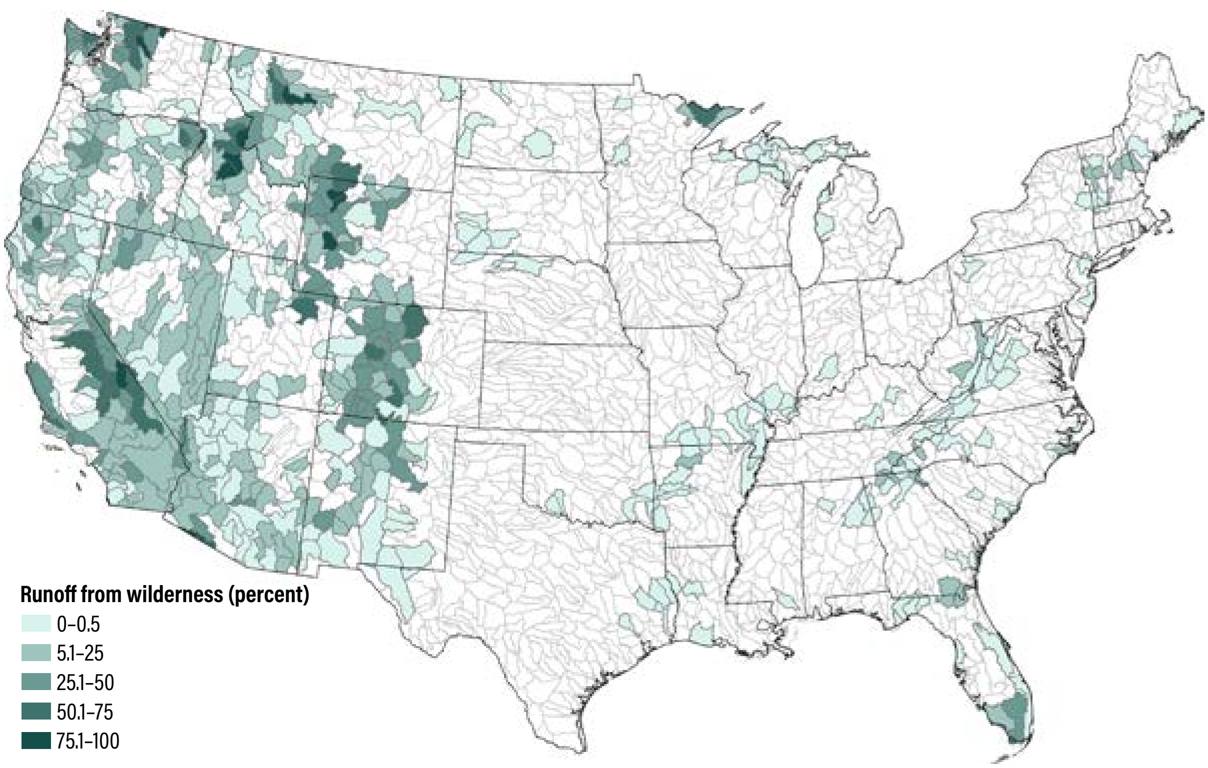

Figure 8.2—Percentage of freshwater runoff from wilderness areas versus freshwater runoff from all areas within a water resource region (HUC8 area).

Figure 8.2 shows that the watersheds with higher percentage of water originating in wilderness tend to lie along the major mountain ranges of the United States: not only the Rocky Mountains, Sierra Nevadas, and Cascades in the West, but also the Appalachian Mountains, which span much of the length of the east coast, and the Boston Mountains in northern Arkansas. Notably, this matches the spatial distribution of wilderness areas across the continental United States, shown on figure 8.1, as well: the bulk of the footprint of designated wilderness lies in the Western United States, and many wilderness areas also tend to lie along the same mountain ranges as those mentioned above. In fact, the percentage of a watershed's total water runoff that comes from wilderness is highly correlated with the percentage of land within a watershed that is designated as wilderness ($R^2 = 0.85$).

This analysis demonstrates that, indeed, a disproportionately high percentage of the Nation's renewable supply of surface freshwater flows from wilderness versus other lands. Whereas 3 percent of the land in the conterminous United States is designated as wilderness, 5 percent of the total runoff for the conterminous United States comes from these wilderness areas. However, the insights above also suggest multiple challenges in characterizing to what extent wilderness areas contribute to the economic value of water resources. First, the spatial heterogeneity suggests the importance of local context for understanding the relationships, with the possibility that these relationships themselves change from one region to another. Second, much of the U.S. surface freshwater supply, particularly in the western half of the conterminous United States, originates as either rainfall or snowmelt along mountain ranges. Because this is also where many wilderness areas are located, it remains an open question whether the association of wilderness with water resources is a mere coincidence of their placement or something particular about being managed as wilderness. Third, with much of the wilderness footprint lying in remote and sometimes hard-to-access regions, it is not immediately clear what would be the appropriate counterfactual use of the land in many of these cases, and estimation of the economic value of a certain management decision requires comparison against a realistic counterfactual, as will be discussed in more detail below.

Wilderness Areas and Drinking Water

Next, we leverage the Forest Service's Forest to Faucets (F2F) database to take our analysis one step further, linking water supplies to one important source of demand: drinking water. The F2F database pairs runoff data, as shown above, with flow routing, surface drinking water intake locations, and population metrics to estimate the relative importance of watersheds across the country for drinking water (see Weidner and Todd [2011] for details). This is calculated at the HUC12 scale, which subdivides the 2,149 HUC8 watersheds nationwide into approximately 160,000 "subwatersheds," 83,000 of which are in the conterminous United States. Using this F2F database, we identify wilderness areas that contain at least one half of the total area of a subwatershed considered as highly important for downstream drinking water, that is, wilderness areas that provide an important contribution to drinking water. Table 8.1 lists the number of these wilderness areas, per State and region, that contain at least one subwatershed identified as in the top 90th, 75th, and 50th percentiles in terms of importance for drinking water. Overall, the table demonstrates the widespread importance of wilderness areas for drinking water purposes. Twenty-one States have at least 1 wilderness area with a watershed in the top 90th percentile of drinking water importance, and 34 of the 48 conterminous States have a wilderness area that contains a watershed ranked in the top half of all watersheds for drinking water importance.

Similar to above, this analysis identifies important relationships between water supplies and wilderness areas in the Western United States, especially in the States of California,

Table 8.1—Number of wilderness areas, by region and State, that contain at least one subwatershed in the top 90th, 75th, or 50th percentile in terms of the Forest to Faucets (F2F) surface drinking water importance index

	Number of wilderness areas		
Region/ State	**90th percentile**	**75th percentile**	**50th percentile**
Midwest	**1**	**7**	**21**
Illinois	0	5	8
Indiana	1	1	1
Michigan	0	0	2
Minnesota	0	0	2
Missouri	0	1	6
Wisconsin	0	0	2
Northeast	**5**	**15**	**17**
Maine	0	1	1
New Hampshire	0	4	5
New Jersey	1	1	1
Pennsylvania	2	2	2
Vermont	2	7	8
Plains	**1**	**1**	**7**
Oklahoma	0	0	2
Texas	1	1	5
South	**35**	**60**	**77**
Alabama	3	3	3
Arkansas	1	4	12
Florida	0	0	1
Georgia	7	10	10
Kentucky	2	2	2
Louisiana	0	0	1
North Carolina	2	7	7
Tennessee	10	11	11
Virginia	6	16	22
West Virginia	4	7	8
West	**45**	**115**	**233**
Arizona	0	7	23
California	10	30	65
Colorado	7	22	34
Idaho	0	1	4
Montana	1	2	11
New Mexico	0	1	5
Nevada	1	2	5
Oregon	16	26	32
Utah	1	3	19
Washington	8	16	23
Wyoming	1	5	12
TOTAL	**87**	**198**	**355**

Wilderness areas that cross State boundaries are counted individually for both States.

Colorado, Oregon, and Washington. This again reflects, in part, the high prevalence of wilderness areas in the West. However, unlike the above, population and location of drinking water intakes are important factors in the analysis as well. Accordingly, if you look at figure 8.3 (recreated from data reported in Weidner and Todd [2011:15]), which depicts the national map of the general F2F surface drinking water importance index without considering wilderness, the Eastern United States tends to have much higher values, based on a "high population density relative to other parts of the country and a greater reliance on surface water than on groundwater" (Weidner and Todd 2011: 15). Thus, Table 8.1 also shows that despite the low prevalence of wilderness areas in the Eastern United States and their low contributions to overall runoff as shown in figure 8.2, there exist many wilderness areas in the East (i.e., in the Northeast and South regions) that rank among the highest in terms of the importance of their watersheds to the drinking water supply.

Similarly, the map in figure 8.4 depicts the overall F2F drinking water importance index ranking for subwatersheds that intersect a designated wilderness area. Again, we see that most of the wilderness areas, particularly those containing watersheds in the higher percentiles for the F2F surface drinking water importance index, run along mountain ranges. We also see the clearer balance between the eastern and western halves of the country in this metric than in metrics that do not account for population density, with quite a few wilderness areas in both sides containing watersheds ranked in the top tenth of importance in terms of drinking water. Thus, this analysis not only demonstrates that many wilderness areas are linked to downstream populations through the important flow of drinking water supply, but it also reflects the relevance of considering how a resource is used for understanding its relationship to society.

Overall, this section demonstrates the general relationship between wilderness areas and water supplies. The high prevalence of

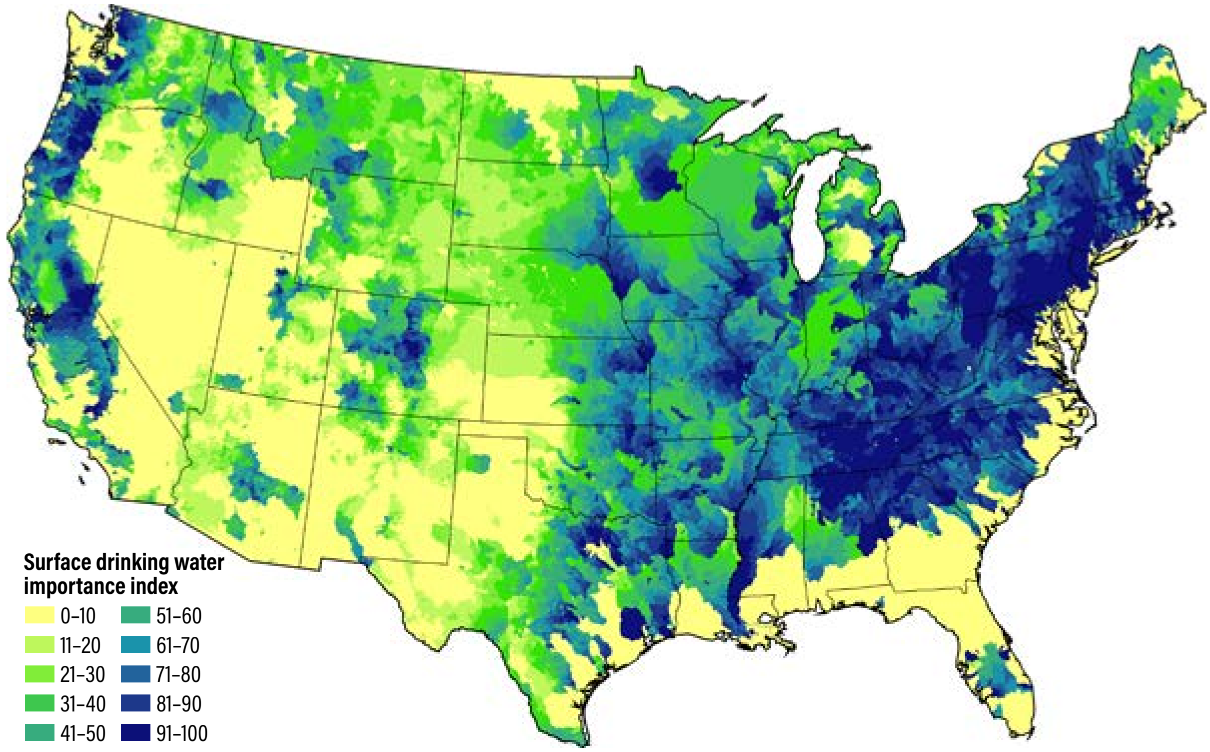

Figure 8.3—Map depicting Forests to Faucets (F2F) surface drinking water importance index (recreated from data reported in fig. 7 of Weidner and Todd [2011]).

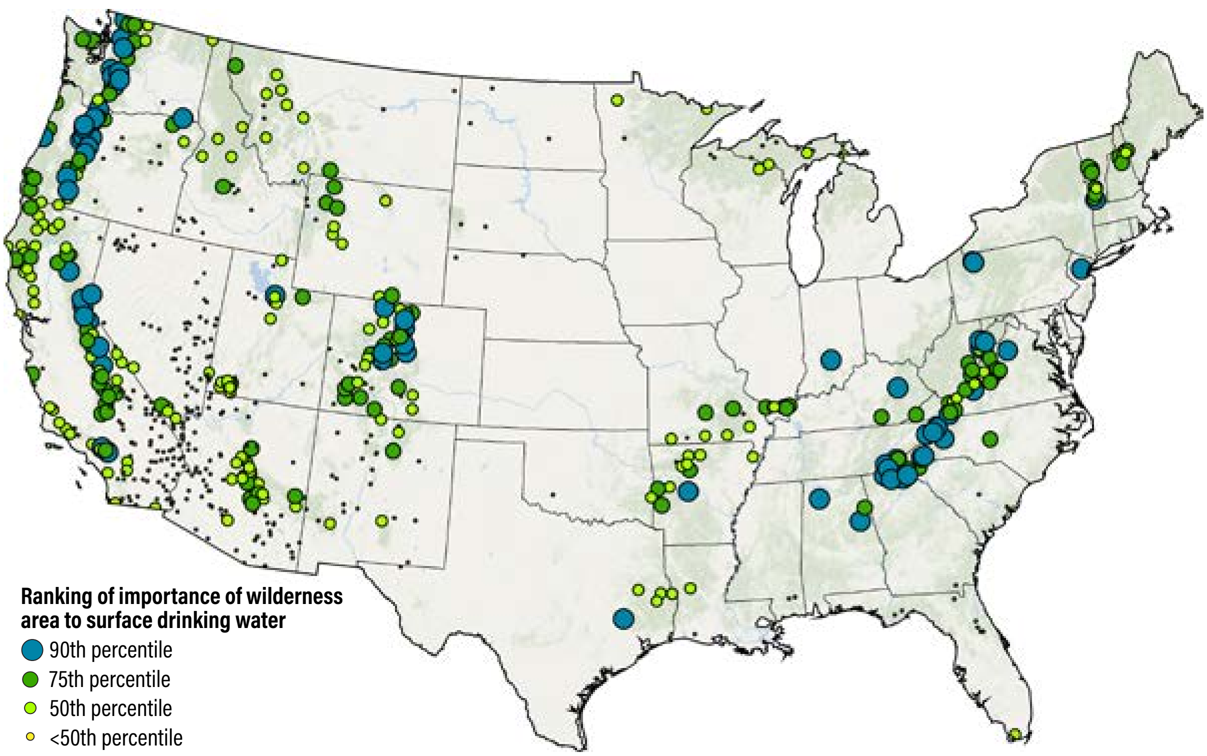

Figure 8.4—Ranking of subwatersheds that intersect designated wilderness areas in terms of drinking water importance relative to all subwatersheds (based on analysis of the Forests to Faucets [F2F] surface drinking water importance index; Weidner and Todd [2011]).

wilderness areas as the source of runoff that is later used by people suggests that impacts to the water resources—whether to the timing, quantity, or quality of that water—will have impacts on these downstream users. Understanding the magnitude and implications of these effects, however, requires an understanding of the economics of water resources. In the next section, we provide a broad overview of this field of study.

The Economics of Water Resources

Water resources have long intrigued economists. Indeed, Adam Smith famously used water as an example of the *prima facie* paradox of the relative values of water, which is essential to life, versus diamonds, which are not: "Nothing is more useful than water: but it will purchase scarce anything; scarce anything can be had in exchange for it. A diamond, on the contrary, has scarce any value in use; but a very great quantity of other goods may frequently be had in exchange for it" (Smith 1776).

Decisions about water allocation projects, restoration activities, and land management may affect the timing, quantity, and quality of water necessary for society. Economic efficiency criteria provide a useful frame for considering the effects of changes to water timing, quantity, and quality for two reasons: (1) maximizing net economic benefits is an important objective in a world of scarcity and competing uses, and (2) it provides a useful way to evaluate the opportunity costs (forgone benefits) of competing projects or objectives (Young and Loomis 2014: 25). Economists define "benefits" or "value" in terms of the tradeoff individuals are willing to make among alternatives (Segerson 2017). Economic theory says that the policy-relevant case is at the margin, i.e., at the last additional unit of water affected by some action (Hanemann 2005, U.S. EPA 2013), and that the efficient outcome of resource allocation decisions of water-related projects occurs when marginal benefits are equal across all uses (Gibbons 1986). In the context of public goods, where a market may be missing or highly distorted, such as for many uses of water, measuring marginal tradeoffs in monetary terms is especially useful (Habb and McConnell 2002). In fact, water projects in the American West have been a major impetus for needing to understand the benefits and costs of publicly funded projects (see Banzhaf [2010] for a historical perspective). Relevant legislation includes the Reclamation Act of 1902 (Public Law 57–161), the Flood Control Act of 1936 (Public Law 74–738), and formal guidance on water projects as first outlined in 1950 by the Inter-Agency Committee on Water Resources (Federal Inter-Agency River Basin Committee, Subcommittee on Benefits and Costs 1950). More recently, since 1981 the Federal Government has been instructed to assess the costs and benefits of major spending projects as directed by Executive Order 12291. Other relevant legislation on considering costs and benefits from Federal projects stem from the Clean Water Act (Public Law 92–500); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Public Law 96–510); and the Oil Pollution Act (OPA) (101 H.R.1465, Public Law 101–380).

Special Considerations for the Economics of Water

Understanding the economic (marginal) value of water requires special consideration of not only hydrological and physical attributes but also social attributes, including legal and political institutions (see Young and Loomis [2014] for a complete discussion). First, the hydrological and physical attributes of water are complex. Among other things, water is mobile and requires relatively high costs from excluding other potential users in order to establish property rights (Young and Loomis 2014: 4), and supplies can be highly variable over space (as is the case with wilderness) and time. Social attributes of water include concerns about equity associated with a range of factors including the fundamental human need for a minimum amount of water for survival (e.g., Hanemann 2005) and the importance of water in many cultural belief systems and rituals (e.g., Armatas and others

2014, Moon Stumpff 2013), as well as unique legal and political institutions, such as the two main legal regimes to water: riparian rights, common in the Eastern United States, and the prior appropriation doctrine, common in many Western U.S. States. Indeed, water management practices can have profound implications for understanding freshwater resources, even if these practices do not affect the physical water yield of water sources (e.g., Momblanch and others 2017).

In addition to these physical, social, and legal considerations of water, evaluation of economic value also necessitates understanding the characteristics of demand for water (Young and Loomis 2014). These characteristics include identifying who is using the water, the purpose of use, and whether that use is consumptive or nonconsumptive. One common typology of demand for water separates offstream uses, including those by municipal, industrial, and agricultural sectors, from instream uses, such as for environmental services (including providing habitat for aquatic species and supporting outdoor recreation). Offstream uses are typically private and can be classified either by the amount of water withdrawn from the water source (e.g., Maupin and others 2014) or by the amount consumed, which refers to the amount withdrawn minus the amount returned, i.e., water that is physically removed from the basin of origin (Gibbons 1986). Withdrawals often reflect a private need, whereas consumption reflects a reduction in availability of the resource for other uses, and the proportion of water withdrawn that is consumed can vary widely by use (e.g., Solley and others 1998), complicating comprehensive analysis. In contrast, instream uses such as navigation and recreational boating or angling do not remove water from the basin. This means that the water is available downstream for other uses and thus, such uses are typically considered nonconsumptive (Young and Loomis 2014). Relatedly, water use can be characterized as rival, meaning that one person's use diminishes others' ability to use it, as in the case with irrigation, or nonrival, meaning that one person's use does not diminish others' ability to use it downstream, as in the examples of boating or angling.

In addition to being nonrival and nonconsumptive, instream water uses are also typically nonexcludable, meaning it is difficult and expensive to limit those not legally entitled to access, and thus the instream flows that support these uses are often (though not always) considered to be public goods. Water use can be additionally classified as an intermediate or final good depending on use (Gibbons 1986). For example, water would be considered an intermediate good when used for irrigated agriculture as an input to produce other goods (e.g., crops). Alternatively, water can be considered a final good when directly used by consumers, such as for household needs, boating, or swimming. Gibbons (1986: 4) explains how the concept of value differs between final and intermediate uses of water: as a final good, it is valued directly by the individual consumer, and when it is an intermediate good, its value is derived from the ultimate value of the final good or service.

Economic Value of Water Resources

Theory defines economic value in terms of choices among tradeoffs (Segerson 2017); it is useful, though not necessary, to measure value in monetary terms for ease of comparison (Habb and McConnell 2002). Willingness to pay (WTP) is a standard metric for monetizing the economic value to people of both market and nonmarket goods and services, including those that arise from water (Brown and others 2007). This measurement links to the concept of preferences among alternatives, in which WTP measures the amount of money an individual would be willing to give up to obtain a good or service (e.g., an additional unit of water) or to avoid a loss in a good or service (e.g., reduced water quality or fishing access).

Methods for measuring the economic value of water vary depending on the context of the use of the water (refer to Gibbons [1986] and Young and Loomis [2014] for an expanded discussion on these methods). For municipal water uses, it is possible to estimate demand curves and price elasticities (that is, sensitivity of consumption to changes in price or quantity supplied), which can be used to estimate marginal values (see Dalhuisen and others [2001] and Espey and others [1997] for summaries of price elasticities for residential use). For agricultural water uses, basic methods for estimating the marginal value include crop-water production function analyses and farm crop budget analyses (see Scheierling and others [2006] for a review of price elasticities of water demand for irrigation). Like agriculture, industrial uses of water can also be evaluated as inputs to production. As Young and Loomis (2014) note, most of the existing research on water inputs for manufacturing have focused on its use for cooling, process water, and incorporation into other products but can also include hydropower generation and inland navigation. For offstream industrial uses, empirical evidence has shown that water plays a minor role in production when compared to other industrial inputs such as labor and capital. A notable exception is the electricity sector, with an estimated 45 percent of total water withdrawals nationwide attributed to thermoelectric generation in 2010 (Maupin and others 2014), but a large proportion of that water was subsequently returned to the basin and thus not consumed (Solley and others 1998). Mirroring the diversity of uses and their contexts, estimates of the economic value of water range widely both within and across these different sectors. For example, the U.S. Environmental Protection Agency compiled estimates per acre-foot (i.e., 325,851 gallons) for different uses, based on a variety of methods, and found: up to $4,500 for public supply and domestic self-supply; from $12 to $4,500 for irrigated agriculture; from $14 to $1,600 for manufacturing; from $12 to $87 for thermoelectric power; from $1 to $157 for hydropower; and from $40 to $2,700 for mining and energy resource extraction (U.S. EPA 2013).

As described above, most instream water uses are nonconsumptive and nonexcludable, i.e., they relate to public goods. Because public goods are not traded in efficient markets, they do not have observable prices. Thus, nonmarket valuation techniques must be relied upon to elicit associated values (see Champ and others [2017] for additional information on nonmarket valuation). Broadly, nonmarket valuation techniques include revealed preference (estimating value from observed behaviors and actual expenditures in related markets) and stated preference techniques (asking for people's value based on hypothetical proposed changes to the good or service). Revealed preference techniques infer value from data such as travel costs, residential property values, reported defensive behaviors, and avoided damage costs; these techniques can be applied to public goods that are used by consumers, such as water-based recreation or aesthetic benefits. Stated preference techniques include the contingent valuation method and choice models (conjoint or choice experiments) and are flexible enough to be used to study use values (e.g., angling) as well as nonuse values. Nonuse values include cases where individuals may be willing to pay for conserving a resource for its own sake (existence values) or for future generations (bequest values) regardless of actual use (see Freeman [2003] for the theoretical framework on nonuse values). Nonmarket valuation techniques have been applied to a variety of water-based resources, many of which can be found in summaries of WTP for game fish caught (Johnston and others 2006); surface water quality improvements (Johnston and Thomassin 2010, Johnston and others 2017); water-based outdoor recreation (Recreation Use Values Database 2016, Rosenberger and others 2017); salmon preservation (Weber 2015); river restoration improvements (Bergstrom and Loomis 2017); and conservation of threatened, endangered, and rare species (Richardson and Loomis 2009), many of which are aquatic.

Estimated Total Annual Value of Water from Wilderness

In an unpublished discussion paper, Brown (2004) undertakes the somewhat herculean task of compiling estimates of the full marginal value of instream flow, summed across marginal values of different uses of water specific to each water resource region across the country, pulling from a wide variety of available data similar to that surveyed above. He emphasizes that "these [marginal value estimates] are large scale averages based on numerous assumptions and sketchy valuation data" (Brown 2004: 44), but also notes that these marginal values "can be considered a lower bound on average value" (Brown 2004: 96). In table 8.2, we report these marginal value estimates by water resource region, with the attendant uncertainty compounded by simply inflating by the Consumer Price Index from 2003 to 2017 dollars. We report these values alongside estimates of the amount of runoff originating in wilderness within each water resource region. This demonstrates the large geographic heterogeneity in both the mean annual runoff from wilderness and the estimated marginal value of that runoff, as well as the positive correlation between the two values. In other words, this analysis underscores the basic fact that a higher percentage of the surface freshwater supply tends to come from wilderness in the regions of the country where water is most valuable—namely in the Southwestern United States. The one outlier, the Pacific Northwest region, has a low-to-moderate estimated marginal value of water and yet is associated with both a large volume of wilderness-originated runoff and a large percentage of total water supply originating in wilderness.

Table 8.2—Estimates of freshwater runoff originating in wilderness compared to estimates of the full marginal value of water, by water resource region

Water resource region	Mean annual freshwater runoff from wilderness[a]	Total mean annual water supply from wilderness[a]	Marginal value per acre-foot per year[b]
	million acre-feet	*percent*	*2017 dollars*
1. New England	0.69	1	$9
2. Mid-Atlantic	0.48	0	$12
3. South-Atlantic-Gulf	2.46	1	$11
4. Great Lakes	0.33	0	$23
5. Ohio	0.42	0	$12
6. Tennessee	0.47	1	$20
7. Upper Mississippi	0.04	0	$13
8. Lower Mississippi	0.03	0	$7
9. Souris-Red-Rainy	0.46	5	$9
10. Missouri	6.36	7	$56
11. Arkansas-White-Red	0.61	1	$19
12. Texas-Gulf	0.04	0	$28
13. Rio Grande	0.86	16	$61
14. Upper Colorado	4.04	25	$76
15. Lower Colorado	0.36	8	$112
16. Great Basin	1.23	9	$72
17. Pacific Northwest	45.46	17	$27
18. California	12.61	14	$60

[a] Source: Authors' calculations of data reported in Brown and others (2016).
[b] Source: Table 26, Brown (2004), inflated to 2017 dollars; see caveats and discussion therein.

One could easily multiply these two columns of values to compute a rough approximation of the lower bound of the total economic value of the runoff originating in wilderness, and indeed this approach has been taken in numerous papers. However, we refrain from doing so not only because of the many layers of substantial uncertainty embedded in these data, but also, and more importantly, because the resulting estimates do not provide information that is particulary meaningful for decision making. Analagously to the case of wilderness lands, Brown (2004: 93) describes this in the context of national forests:

> Reporting on the total value of resources originating on national forests can leave an incorrect impression, because not all of the value of resources flowing from a national forest...is attributable to national forest management. The total value of all the resources is to some extent the result of purely natural events. For example, trees grow and water flows without help from land managers. The contribution of national forest management is to enhance or protect these outputs, and to make some of them available for purchase, thereby adding value (e.g., forest management makes timber available for harvest by controlling wildfire and administering sales, and watershed management may protect the quality of water flow). Thus, in reporting on the total value of resource flows from the national forests, the agency is not claiming that all of that value is attributable to the agency's management. Rather, it is asserting that such value originates on the national forests.

Further, as Brown (2004) argues, the value of water as an input directly into consumer's utility or as an input to production is only relevant in a practical sense when considering marginal (or incremental) changes to water quality or quantity. Estimating the "total value" of water originating in a wilderness area may not be useful from a practical sense because it ignores decreasing marginal returns of water as an input and substitutability (Young and Loomis 2014). In other words, beyond the technical uncertainties, while estimates such as those that could be calculated using the data in table 8.2 would reflect the value of water resources that originate on wilderness lands, they are limited in terms of reflecting the value associated with the allocation or management of that land as wilderness. That is, these estimates explicitly do not provide an understanding of the value added to water resources by wilderness. As such, the only policy-realistic case is when considering incremental benefits relative to incremental costs from water-related decisions.

The Added Value of Wilderness to Freshwater Resources

Following the above discussion, an ideal estimation approach would include both a demonstrable effect of wilderness protection on the water resource (e.g., on the quantity, quality, and/or timing of the water flows) and a local, theoretically grounded estimate of the economic value of that resource. Carefully designed, case-specific studies using stated preference techniques such as contingent valuation or choice experiments, as thoroughly discussed by Champ and others (2017), offer one approach to generating such information. Further, techniques such as benefit transfer can provide the latter without conducting original research in a local area, but without the former, it is not clear that an estimated value of the water resource is attributable to wilderness protection; in a counterfactual case of an alternative land use for the same area, would the same level of water resources be provided? In this final section, we discuss possibilities of such an approach for developing more nuanced estimates than those presented above. We consider challenges to some commonly taken approaches and offer suggestions for possible future directions.

Representing a common approach, Johnson and Spildie (2014) overview a series of case studies suggesting economic benefits associated with the water coming from wilderness and other protected lands. These case studies consider examples of when costly filtration plants were avoided by municipal suppliers, with "the quality of the natural source" noted as primary justifications for being allowed to avoid these plants. Cited examples of avoided filtration facilities include a $500-million plant for the San Francisco Water Department, an estimated $3-million annual cost of filtration for Portland, OR's Bull Run surface water source, and a $6- to $8-billion plant for New York City. The last example, in particular, was first highlighted as an example of the value of ecosystem services by Daily and Ellison (2002) and has been cited often since then. Each of these case studies relies on the concept of replacement cost, which requires three conditions: (1) that the ecosystems services provided by the protected lands are equivalent to those that would have been provided by the filtration plants; (2) that the filtration plants would be the next least-cost alternative for providing those services; and (3) that an equivalent amount of the services would be demanded from the higher cost alternative, if available (see Brown [2017] for thorough discussion of replacement cost and other substitution methods). As Brown (2017: 357–358) discusses, the first two conditions are plausibly satisfied due to the necessity of satisfying Clean Water Act requirements and the fact that filtration plants are the baseline option in most U.S. municipalities, respectively. However, the third condition is most problematic, and indeed, economists tend to agree that "underpriced water resources [have] created an artificial demand for water in urban and industrial as well as agriculture uses…" (Young and Loomis 2014: 26). This suggests that many of these examples should be considered a measure of the upper bound of the benefits because they typically do not consider the impacts that the avoided, but legally mandated, costs would have on how much water people would use if they were required to fully bear those costs. At the same time, the services that would be provided by the avoided filtration plant typically do not include the full portfolio of ecosystem services that would be provided by the protected land, such as the recreation and existence values associated with aquatic habitat in and downstream of protected lands. This, conversely, implies that these avoided cost estimates represent a lower bound of the total value of the relevant ecosystem services. In other words, while the costs of avoided water treatment facilities are suggestive that watershed protection provides high-valued services to the public, these approaches typically can only provide rough approximation of the economic benefits of those services, and it can be difficult to determine whether that approximation is an upper or a lower bound.

In addition, such examples could be strengthened by deeper consideration of the counterfactual for the land management and, relatedly, the scale of natural system change that would be associated with alternative land management. As Latimer (2000) emphasizes, most areas that are managed as wilderness would otherwise be under protection as national forest, park, monument, or wildlife refuge, leaving the level of development that would occur absent the designation as wilderness an open question. That said, certain activities that are precluded by wilderness designation, such as mining and drilling, could potentially have marked impacts on water resources, and information about plans for these activities could support the development of strong counterfactuals. More generally, rigorous estimation of the benefits of wilderness areas on water resources needs to rely on focused case studies built by interdisciplinary teams of researchers, who can connect the specific impacts of wilderness protection status on natural systems to the associated ecosystem service benefits. This is particularly important, as Brauman and others (2007) point out in their detailed review of the nature and value of ecosystem services associated with freshwater resources. Specifically, although they note that "ecosystems with intact groundcover and root systems are generally very effective at improving water quality" (Brauman and others

2007: 77) and that "for water-related services, processes such as soil formation or tree growth are slow in relation to human time frames, making service provision difficult to repair [if degraded]" (Brauman and others 2007: 81), they also emphasize that "in general, effects of land-cover change on hydrologic processes are not measurable until at least 20 percent of a catchment has been converted, although in some places as little as 15 percent or as much as 50 percent conversion may be needed to observe these effects" (Brauman and others 2007: 80). Relatedly, Johnson and Spildie (2014) note that although natural lands are generally known to support groundwater recharge, little quantitative information is available on the contributions of wilderness areas to groundwater resources, hampering rigorous study of the associated value.

For example, wilderness areas are often characterized by their lack of roads, and roads in forests are commonly associated with increased erosion and sediment in rivers (e.g., Croke and Hairsine 2011, Mockrin and others 2014). Similarly, deforesting riparian areas can narrow streams and reduce instream processing of nonpoint and point source pollutants (e.g., Sweeney and others 2004); Binder and others (2017) provide a detailed review of the effects of forest management within riparian zones on drivers of aquatic ecosystem health. Warziniack and others (2017) take such results one step further and model the effect of developing undeveloped forest land on water treatment costs by linking estimates of the increase in turbidity associated with converting a portion of forested land in a watershed with the increase in water treatment costs associated with that turbidity. However, they conclude, "Despite growing desire for a direct measurement of the benefits of watershed/source water protection, the complex nature of ecosystem dynamics, watershed processes, and water treatment technologies precludes easy answers" (Warziniack and others 2017: 18). Similarly, as Dosskey and others (2010: 272) review, "despite a large body of research into water quality functions of riparian zones and the existence of large programs that promote restoration of permanent riparian vegetation in developed landscapes, there have been few direct studies of the responses of stream water chemistry to the loss of riparian vegetation and to its restoration."

In addition to water treatment costs, stream chemistry is important for fish habitat. Fish habitat is associated with nonmarket benefits from recreational fishing and the existence value of threatened and endangered species. The nature of these benefits suggests the importance of estimating their value through nonmarket valuation techniques, such as contingent valuation, which have been employed with simplified assumptions and models of ecosystem processes and, importantly, can be used to directly estimate the total economic value of alternative management options. For example, Loomis and others (2000) and Holmes and others (2004) both use this approach to estimate the benefits of fully restoring two rivers at around $5 per household per mile, for the Platte River and the Little Tennessee River, respectively. In another vein, a detailed analysis demonstrates the importance of the Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*) to a variety of stakeholders in the region around the Shoshone National Forest and further links the continued viability of this species to the wilderness-protected condition of high-elevation streams [see case study]. Again, however, evidence demonstrates the strong importance of context, including physical setting, forest attributes, and fish populations, in determining the effect of forest management or restoration on fish habitat (e.g., Keeton and others 2007, Nislow 2005). Additionally, riparian ecosystems and instream chemistry represent just one component of the broader natural systems intended to be preserved by wilderness allocation and management.

Conclusion

While the Wilderness Act emphasizes the preservation of natural systems and processes in designated wilderness areas, it also explicitly states that these areas are to be managed for the benefits they provide to people. Better understanding of these benefits can inform decisions about the allocation and management of wilderness and of other lands that have the potential to influence these benefits. In this article, we examined the role of wilderness areas in contributing to the benefits provided by water resources to the general public. We found that, indeed, significant volumes of water originate in wilderness, and relatedly, that wilderness areas include many watersheds of high importance for the public's drinking water supplies. This demonstrates an important link between the public and the way its lands are managed, even when those lands are far from the suburbs and cities where most people live. However, we also found strong spatial heterogeneity in the relationship between water resources and wilderness areas and that it seems possible that at least some of these relationships might be due to coincidences of location rather than the management of the lands as wilderness. Similarly, we note the challenge and importance of determining counterfactuals for the land management if one wishes to estimate the value added to the water resources as they flow through wilderness areas, which often are located in remote, hard-to-access regions by design.

We then presented a series of analyses that attempt to estimate the value added by wilderness to water resources, noting the relevance of many special circumstances of water resources that complicate the field of water economics. We considered "back-of-the-envelope" style estimates of the total economic value of water from wilderness, but we note that they do not reflect the more meaningful total marginal value of that water and that it is inappropriate to attribute the entire value of the resource to the management of the land. We noted that if the costs of water filtration plants avoided due to upstream protected lands are not passed directly to consumers and the associated effects to demand considered, then such costs only provide an upper bound of the consumers' WTP for the water's quality and quantity. Finally, we discussed specific mechanisms through which wilderness management can contribute to the value of water resources and examples of how this value can be understood. Overall, this investigation demonstrates that although relevant interdisciplinary and economic techniques exist, more work needs to be done to confidently estimate the public benefits of wilderness areas through their impacts on water resources.

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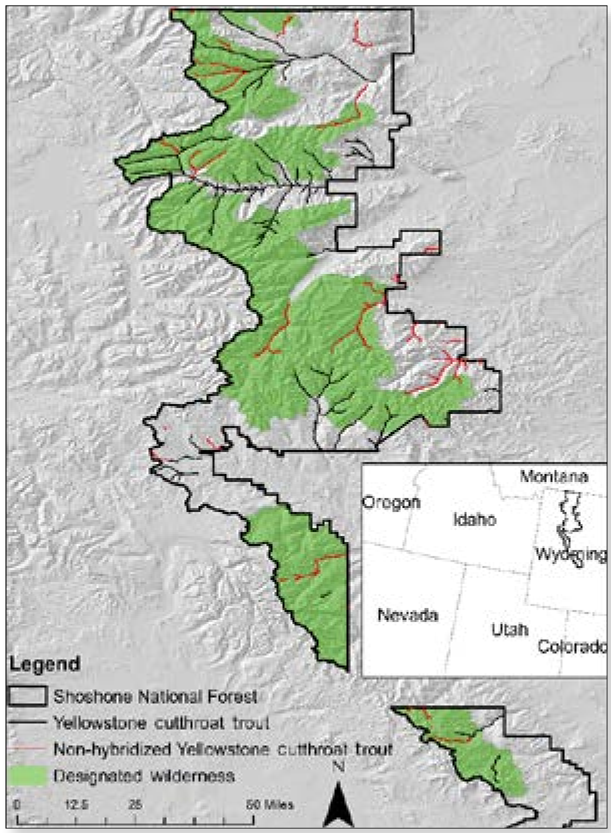
Case Study:

The Yellowstone Cutthroat Trout, People, and Wilderness on the Shoshone National Forest

Chris Armatas

The Shoshone National Forest (SNF) comprises nearly 2.4 million acres of public land within the eastern portion of the Greater Yellowstone Ecosystem. Five different wilderness areas make up 1.4 million acres, or 58 percent, of the SNF. Water stored in the glaciers, lakes, and rivers on the SNF support a diverse social-ecological system as it flows east from the continental divide down steep mountainous terrain onto the sagebrush steppe and into rural cities and towns of Wind/Bighorn River Basin. Recent research, which applied both monetary and nonmonetary valuation methods, detailed four general stakeholder perspectives on the importance of, and tradeoffs among, a broad range of water-based ecosystem services in the region (Armatas and others 2017, 2018). Among the most relevant ecosystem services to a broad range of stakeholders are the conservation of biodiversity and keystone species, and river-based angling. The Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*) (YCT) is integral to the continued provision of these ecosystem services and, consequently, the social and economic fabric of the region.



Yellowstone cutthroat trout and wilderness within Shoshone National Forest.

Armatas and others (2017) highlighted that people in communities surrounding the SNF consider the YCT as important for a variety of reasons, including its support of the region's identity as a world-class fishing destination, the benefit to future generations of experiencing the YCT in its native habitat, and its integral role in supporting the ecosystem as a whole. From an economic perspective, the importance of the YCT is also reflected by the millions of dollars spent in the region on angling and nature-based tourism (USFWS and U.S. Census Bureau 2014), the considerable resources contributed to several YCT restoration efforts in the area, and the positive willingness to pay for improving both biodiversity and angling opportunities by households in the region (Armatas and others 2018). This positive willingness to pay is underpinned by both active use and nonuse values, as reflected by the vast majority (81.5 percent) of respondents who expressed agreement that "future generations should get the same consideration as current generations" when managing natural resources (Armatas and others 2016).

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The importance of the YCT to the social-ecological system is well established; however, the continued viability of the species is at risk. Rice and others (2012) highlighted that the YCT in the region are threatened both by rising stream temperatures and increased genetic hybridization from invasive trout species, two effects expected to worsen with climate change. One potential source of refuge from these threats, according to Rice and others (2012), are high-elevation, clear, cold streams. Wilderness plays a critical role in protecting such streams. As shown in the map, a significant portion of the current habitat on the SNF for the YCT is within wilderness, particularly in the case of nonhybridized YCT (which are important for maintaining a resilient and adaptable population).

Understanding the relationship between wilderness, YCT, and human well-being may provide support for future natural resource decision making in the region.

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9

Through the Taos Lens: Underlying Values and Emerging Tribal Strategies for Protecting Wilderness and Wild Lands

Linda Moon Stumpff

Gila Wilderness (559,311 total acres) in New Mexico was designated in 1964 and is administered by the Forest Service. (USDA Forest Service photo by Diane Taliafero)

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KEY MESSAGES

- The case study method is used to explore the context for deep cultural meanings and values that are embedded in place. Within this context, the cultural history of the Taos Pueblo and the cultural values manifest in the protection of Blue Lake Wilderness are described.
- Tribal values related to nature and wildlands overlap with those of federally designated wilderness, but differences exist at the foundational level for understanding the human relation to ecological and cultural landscapes.
- Greater levels of trust and collaboration between Tribes and wilderness management agencies are emerging, and models of Tribal wilderness management are expanding the scope for desirable future wilderness conditions and the means to attain them.

Introduction

Exploring Tribal values associated with Tribal wildland and wilderness protection reveals a history of change and evolving opportunities for collaboration.[1] Tribal values in wilderness are symbolic of the deep concerns for the quality of water and watersheds expressed by American Indian Tribes across the country from Standing Rock to Hopi, and from the Skokomish to the Nisqually Tribes on the northwest coast (Stumpff 2013). Several studies discuss the unique land and water values demonstrated by Tribes (Armatas and others 2017; Cajete 2000; Krahe 1995; Watson and others 2003, 2012, 2014), and it is important to understand that many of the 567 federally recognized American Indian and Alaska Native Tribes hold diverse cultural preferences, perspectives, and applied uses regarding wildlands and waters on American Indian trust lands. Further, Tribal cultural values are not limited to Tribal trust lands, but are carried into relationships with Federal, State, and local lands. This chapter explores those values through Tribal relationships with wildlands and wilderness so that specific examples illuminate Tribal values related to the lands.

The historic and current struggles of Taos Pueblo in northern New Mexico to protect its sacred wilderness values in the Blue Lake Wilderness are a primary subject of this study.[2] This approach provides the opportunity to understand the emergence of Tribal values in the policy process and finally in Tribal wilderness and wildland management. The case study method is used to explore the context for deep cultural meanings and values that are embedded in place (Basso 2011, Yin 2013). It is foremost a study of a wild place and of the values attached to it expressed through a historic struggle that began in the 1600s. The enormous strength of Taos Pueblo wilderness values is evident in the actions, strategies, and wilderness policy positions when the more than 400-year battle to protect Blue Lake Wilderness is examined. Truly, this example shows that the Taos Pueblo's Blue Lake Wilderness Area, often referred to as the Blue Lake Wilderness, was the subject that long ago captured the people's hearts. The tenacity with which they held to these values over the centuries-long effort illustrates how deeply their religious and cultural values were held.

This chapter begins by providing an overview of the cultural landscape of Taos Pueblo. This is followed by a description of the struggles endured by the Taos Pueblo in their efforts to protect the sacred Blue Lake Wilderness.[3] Within this framework, the cultural values manifest in the protection of the Blue Lake Wilderness are then described.[4] Brief sketches of other approaches to wilderness preservation by the Sandia Pueblo and the Confederated Salish and Kootenai Tribes are presented. The final section of the paper offers a comparison of how Tribal values are expressed through various governance authorities including cooperative management, comanagement, Tribal management, and special relationships.

[1] In this chapter, the generic term "wilderness" generally refers to federally designated wilderness areas, although the meaning depends upon context. "Wildlands" is used more broadly, refers to lands with wilderness characteristics, and includes federally designated wilderness. Some Tribes have protected wildlands as "Tribally designated wilderness" and these areas will be referred to using place names. For example, Blue Lake and the surrounding area were returned to the Taos Pueblo in 1970 from the USFS Wheeler Peak Wilderness, as legislated in Bill P.L. 91-550. As this legislation mandated that the Pueblo continue to manage the area as wilderness, with specific exemptions, this area is referred to as "Blue Lake Wilderness." Tribes have found ways to integrate their specifically Tribal values into wilderness planning and management where underlying values are compatible with Federal wilderness designation. The term Tribal value in wilderness describes the distinctly Tribal nature of these values, while recognizing the integration into broader wilderness characteristics and values.

[2] The names Taos, the Pueblo, and Taos Pueblo all refer to Taos Indian Pueblo in this chapter as distinct from the city or county of Taos.

[3] Tribally defined wilderness values apply not only to Tribal lands; they may also extend onto public lands where specific Tribal legal protections exist or collaborative agreements are created. Sacred sites in the wilderness not only provide for religious functions and wild habitat, they are also valued downstream for their contributions to traditional agriculture, grazing, drinking water, viewsheds, and other services with high value in sustaining the culture. These values interconnect in a web of relationships that reaches from the past to future generations through Indigenous knowledge and sustainable actions.

[4] The study of direct economic value from Indigenous wilderness is beyond the scope of this research, but there is a need for further research to support collaboration. Not all Tribes wish to enter this discussion. But for some, clean water for drinking and traditional organic agriculture, not to mention pressures for city water and business, are factors.

This work seeks to contribute to greater cooperation and understanding as new wilderness and protected wildland areas are established to increase opportunities for comanagement protections over larger land and watershed areas.

Tribal Wilderness: Place, Time, and Values

The primary case study in this chapter tells the story of the Taos Pueblo's struggle to protect the Blue Lake Wilderness. For the people of Taos Pueblo, Tribal values in wilderness encompass both the sacred qualities of resources such as Blue Lake while also recognizing the essential contributions that wild ecosystems provide for the sustenance of life. Tribal values attached to place, Tribal commitment to values over the long term, and the emergence of their values in relationships and agreements provide a basic framework for revealing the nature and the content of those values.

The Northern Rio Grande and Taos Pueblo Cultural Landscape

The Taos rift valley rises in northern New Mexico encircled by lakes, streams, and rivers that pour from mountain wildernesses to support wildlife, agriculture, cultural activities, and tourism. The Rio Grande originates as a small waterway in Colorado that is enlarged by the web of tributaries flowing from the Sangre de Cristo Mountains in New Mexico. It runs all the way to Brownsville, TX, to pour what is left (if anything) of its much-used waters into the Gulf of Mexico.

Taos Pueblo is located within the northern watershed of the Rio Grande (fig. 9.1). It sits at the base of Taos Mountain with access to clean and abundant water that flows from the wilderness lands in the high country above. Blue Lake, hidden in a basin 20 miles from the Pueblo behind Taos Mountain, is the Pueblo's great treasure and its source of water. It sits in a glacial cirque at 11,000 feet and is the main source of the Rio Pueblo, a tributary of the Rio Grande that is vital for drinking and traditional agricultural water. The entire watershed is considered a sacred site by the Pueblo (Ebright and others 2014). The area is dotted with shrines and sites for religious activities such as sacred closed ceremonies and pilgrimages that take place within the watershed.

The Pueblo landscape opens to mountain and sagebrush vistas, mostly managed by Federal agencies. Wheeler Peak, the 13,161-foot mountain and the highest point in New Mexico, towers in the background. Forested watersheds surrounding it create a unique, productive, and beautiful setting for the Pueblo.

In addition to Blue Lake Wilderness, three Federal wilderness areas—the Pecos (221,806 acres), the Wheeler Peak (19,154 acres), and the recently designated (2014) Columbine-Hondo (44,372 acres)—protect headwaters within the Sangre de Cristo Mountains. The Rio Pueblo along with other key tributaries like the Rio Lucero and Rio Hondo running through Taos Pueblo flow into the Rio Grande Gorge to the west, now designated as the 235,000-acre Rio Grande del Norte National Monument. Within the monument, Ute Mountain and San Antonio Mountain have strong wilderness characteristics and may eventually be designated.

Of the Taos Pueblo land holdings (99,000 acres), more than one-half (54,000 acres) are Tribally designated wilderness.[5] The second largest land use is allocated to rangeland (16,957 acres), followed by housing and crops (10,938 acres), recreation (6,500 acres), and areas for religious and ceremonial use (6,150 acres). The Pueblo has 242 acres of lakes and 175 miles of streams (Tiller 2005: 65), and the 2010 Census showed a population of 4,384 residents.

The Element of Time: A Brief History of Taos Pueblo and the Blue Lake Wilderness

Near the ancient Pueblo, the Rio Pueblo sourced drinking water for Taos Pueblo from time immemorial. The Pueblo itself, originally comprising 300,000 acres, contains the ancient North House and South House that were constructed in 1000 and 1450 AD,

[5] Tribes like Taos and Salish Kootenai designate wilderness areas on Tribal lands under their own sovereign authority, apart from the Federal Wilderness Act.

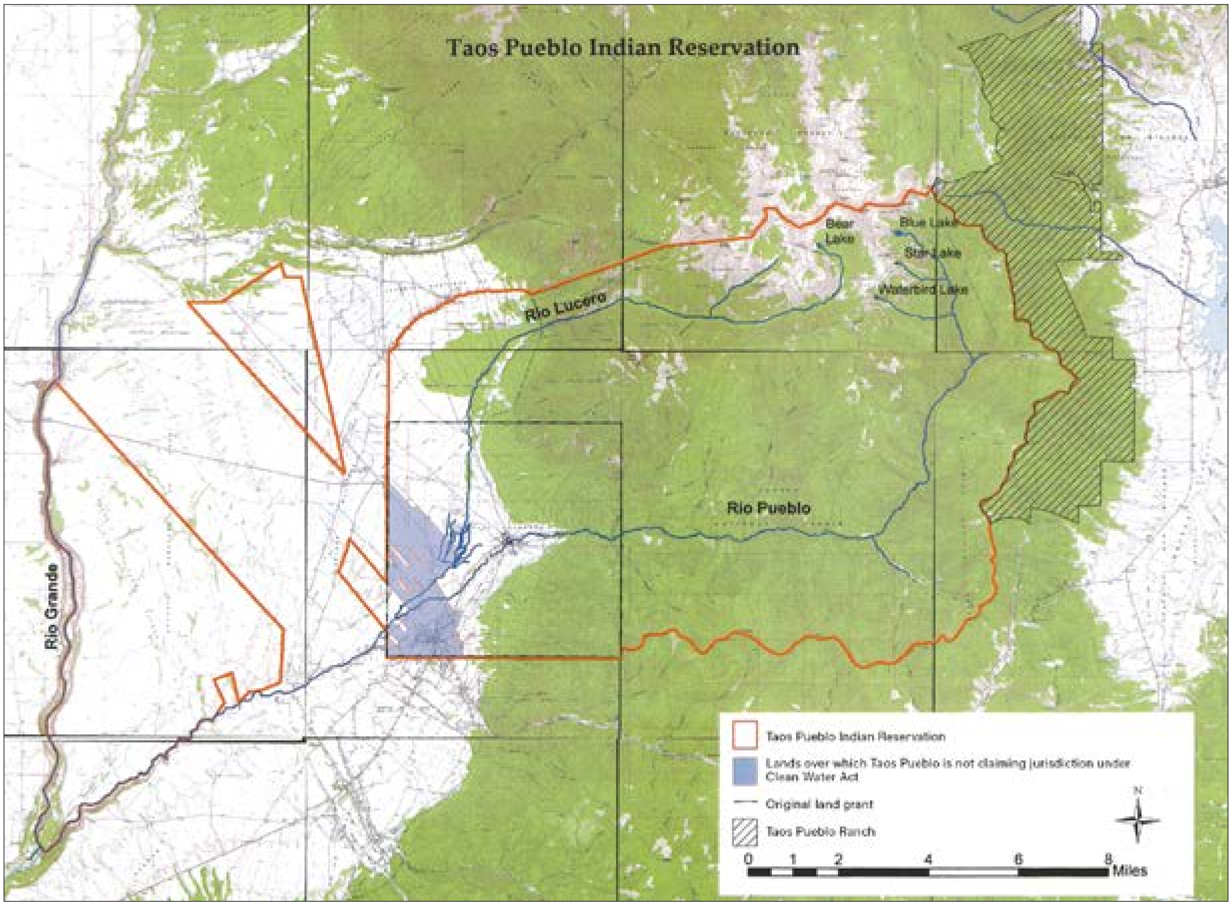

Figure 9.1—Taos Pueblo Indian Reservation.

considerably before Spanish contact occurred in 1540 (Tiller 2005). Taos is the best preserved of the northern Pueblos from the pre-Hispanic period that has been continuously occupied to the present day with archeological evidence dating to 900. It received World Heritage Site status in 1992 and is also a National Historic Landmark. The Pueblo maintains a long history of sustainable agriculture and inter-Tribal trade. Apache and Ute camps were interspersed across the lands of the Northern Rio Grande watersheds, Picuris Pueblo sits to the east of Taos in the mountains, and a string of Indian pueblos follows the Rio Grande to the south. The cultural landscape of Taos includes the natural features surrounding it, and the Pueblo defended these with determination. In 1689, the Spanish assumed they could claim sovereignty when King Charles I of Spain pronounced New Mexico a Spanish province. He “granted” tracts of land to Indian Pueblos in the Southwest, including 17, 000 acres to Taos. After the Mexican Revolution in 1821, Mexico took over administration of the former Spanish-claimed lands in northern New Mexico. Just as the Spanish had done, they recognized the original grant of 17,000 acres plus much of the land that Taos exclusively used and occupied, including Blue Lake (Gordon-McCutchan 1991). During this time, the Pueblo kept the forested Blue Lake watershed in pristine condition, protecting the deepest cultural and religious values.

As Spanish settlement expanded and encroached on the ancient cultures of the Northern Rio Grande, religious oppression, taxation, and forms of forced labor led to revolt. Fierce defenders of their lands and waters, Taos spearheaded the Pueblo Indian Revolt of 1680 against the Spanish, a revolt against Mexican rule in 1836, and again against the United States in 1847. In the years to come, the town of San Fernando de Taos was built up on Taos Indian land by Spanish and U.S. citizens.

Although there were substantial losses from the original 300,000 acres of pre-Hispanic Pueblo use, throughout the ensuing battles for sovereignty, Taos maintained control of the Blue Lake area through Spanish and Mexican authorities. After the U.S. war with Mexico ended in 1848 with the Treaty of Guadalupe Hidalgo, the United States recognized only the original 17,350 acres of the Spanish land grant that was patented to the Pueblo League in 1864. Blue Lake was considered to be unclaimed territory by the United States. This would soon threaten the Pueblo's ability to manage Blue Lake as pristine wilderness. Despite the changing authorities and claims, the Pueblo people maintained strong cultural traditions and kept up an active ceremonial calendar.

The struggle deepened when Blue Lake plus 48,000 acres surrounding it was incorporated into Carson National Forest in 1906. Before this, the Pueblo held the 17,350 acres contained in the Pueblo League patent and other smaller tracts it had purchased, while it maintained exclusive use of the Blue Lake area. The transfer of lands from the Spanish to the Mexican governments, and then to the United States in 1848 under the Treaty of Guadalupe Hidalgo, failed to clarify Spanish land tenure systems such as leaving fairly extensive lands near the land grants, especially wildlands, to local and Indigenous use. The United States took the position that these were unclaimed public lands.

The U.S. Government decided to make the Taos wilderness and watershed a forest reserve due to the "excellent stewardship of the Taos Pueblo" (Ebright and others 2014: 294). After the Blue Lake watershed became part of the Forest Reserves under management of the U.S. Department of Agriculture, Forest Service in 1906, Taos responded immediately with a letter asking for an exclusive use permit for the pristine Blue Lake watershed, which was granted. The Forest Service's concept of stewardship in the early 1900s fit under the progressive concepts of multiple use and highest public good that contrasted sharply with the Pueblo's notion of pristine wilderness connected to deep cultural and religious values (Pinchot 1998).

Gifford Pinchot, the Chief of the Forest Service, and Elliot Barker, the Carson National Forest Supervisor, wanted Indian land to be treated as public land open to multiple uses. Though the Taos understood that the permit gave them exclusive use, this was all but ignored in action. Barker pushed grazing in the Blue Lake area and ended the Pueblo's unfettered access. Miners, loggers, tourists, and Forest Service personnel intruded on Pueblo ideas of pristine wilderness stewardship and privacy for ceremonies. Taos was supposed to have the right of concurrence with any Forest Service-issued recreation permits. Forest Service personnel basically ignored the concurrence part of the agreement. Camping near Blue Lake occurred all summer with the cabin for a Forest Ranger in residence, in full violation of the agreed-upon need for privacy during ceremonies. The annual ceremonial pilgrimage to Blue Lake was unprotected.

In 1921, Commissioner of Indian Affairs Charles Burke began his attack on Indian religions. He intruded on Tribal councils, calling Taos elders "half-human" (Ebright and others 2014: 295). When they refused to renounce their religion or bar youth from ceremonies, he had them jailed in Santa Fe. The Pueblo Lands Act of 1924 (43 Stat. 636, chapter 331 [USC 331 note]) initiated further actions to remove Pueblo lands. The Pueblo offered to relinquish claims in the town of Taos in return for the Blue Lake watershed and were greatly dissatisfied with State, Federal, and local government actions that followed. Intergovernmental agreements between the Federal Government, Taos, and the State of New Mexico ultimately led only to honoring the Pueblo's willingness to give up rights to the town of Taos and ignored the agreed-upon exchange for Blue Lake. Despite this disappointment, the Pueblo kept negotiating. At last President Coolidge took a positive action and withdrew 300,000 acres from mining in the Carson National Forest.

The Forest Service agreed to a 50-year special use permit for Taos Pueblo in 1933 which granted protection for religious and cultural uses for 32,000 acres around Blue Lake, but this fared no better than earlier agreements. The move to Forest Service management initiated a long-term conflict between recreation and Indigenous religious values (Ebright and others 2014). Inherent sovereignty from hundreds of years of exclusive ceremonial use was violated. It was not feasible to ensure the privacy for ceremonies under Federal management, and the conflict was amplified by the fact that the time and date of ceremonies were also secret.

Years of one-sided agreements with the Forest Service ensued, sometimes seemingly cooperative, other times hostile (Ebright and others 2014). The worst violations of the agreements occurred when tourist permits were issued without Pueblo foreknowledge during times that disrupted religious rites. These setbacks would lead the Pueblo to pursue reclaiming the land and putting it into trust rather than making agreements. The past had forged an iron determination that continued without abatement even through the 1950s when the Federal Government was pursuing a policy of termination of Indian Tribes and their lands.

In 1946, the U.S. Congress created the Indian Claims Commission (ICC). After years of wrangling and delays, the question of Taos control of the Blue Lake watershed finally came before it in 1964. The authority of the ICC was limited to the award of monetary claims, but Taos pressed on for the lands within the Blue Lake watershed. After stunning testimony from Tribal religious leaders and religious officials, followed by anthropologists and historians supporting their cause and by positive comments from across the political spectrum from U.S. Senators Ted Kennedy to Barry Goldwater, the ICC gave an interlocutory judgment that the Pueblo's claim for Blue Lake was valid. In this case, the Pueblo conceded to submit detailed maps. Meanwhile, Taos Pueblo continued to work to build local support, developed relationships among other kinds of religious and conservation groups, and employed attorneys to keep the pressure up for legislative efforts in Washington, DC. They refused monetary compensation, although a small portion of one determination was paid at one point. Opponents to the return of Blue Lake claimed that it would set a precedent for the loss of public lands, and the Pueblo would not be able to conserve the lands or the watershed. Ironically, it was the Pueblo conservation, framed by Taos religious values, that had kept the lands and water in pristine condition for hundreds of years.

The political battle went on for a few more years before congressional legislation resolved it. Taos became the first Indian Nation to receive lands back rather than money through an ICC determination. Although the ICC did not have authority to return the lands, they could make the recommendation. Finally, although the Taos Pueblo requested the return of 50,000 acres, they agreed to take 48,000 acres into trust if the Federal Government agreed that the remaining 2,000 acres would fall into wilderness designation. The 2,000 acres became a critical component of the 5,000 acres needed for the Wheeler Peak Wilderness. President Richard Nixon joined the Blue Lake issue with his proposed Indian Self-Determination and Education Assistance Act (Public Law 93–698) which recognized Tribal sovereignty and the right of Tribes to determine their own future, which was signed into law in 1975. Tribes around the country were watching to see if the new policy was going to benefit them. Like the Taos, they were looking for a statement of good faith for religious and cultural self-determination (Gordon-McCutchan 1991). Taos became the turnkey. The Pueblo's actions created a foundation for future returns to other Indian Nations when the U.S. Congress enacted the Taos Pueblo Wilderness Act (Public Law 91–550) on December 15, 1970. Additional areas were added later to the Pueblo's trust lands, including Bear Lake and 700 acres needed to protect sacred site access, as well as the 764-acre Bottleneck tracts needed for the pilgrimage and access to ceremonies.

The Pueblo's effort to regain the Blue Lake watershed stretched over nearly 65 years. Over this long period, its worst enemies fell away while the Taos built new partnerships. Although they continued to negotiate, the Pueblo never gave up pushing the three-point foundation of its strategy: (1) they had a legal right for time immemorial through consistent use and the highest level of preservation management, (2) they held a claim for religious use, and (3) they maintained the critical functions of the watershed for the continuance of Pueblo life and the well-being of their neighbors.

Values: Cultural Narratives and Wilderness

Blue Lake, Ma-wha-lo in the Tiwa language, sits within the bowl of a primeval forest. Its multiple meanings and functions include forming the spiritual center of Taos Pueblo, providing water for drinking and ceremonial use, and supplying the multiple valued resources that sustain the culture. As a spiritual center, it is regarded as the place of emergence and the center for ceremony and spiritual life. It is regarded as the source of all life for Taos Pueblo and the final resting place for their souls after death: "Blue Lake for our life is living. Blue Lake is where the spirit of Indian God is still living today. We go over there to pray, and we go over there to worship. The stars and the moon and the sun and the sky and the clouds and the air and whatever nature has provided for us, we do believe in this" (Quinino Romero in Keegan 1991: 14).

The watershed holds many shrines that receive active use. Essential values are embedded in the bond between people and the lands through the shrines. They give a place for homage through ceremony and prayers for the gifts of Blue Lake. In return, the Pueblo concept of stewardship requires taking action against any alteration of the land that might threaten the bond. Preservation and restoration are sacred duties for the Taos Pueblo people, and in return they receive the life-giving benefits of the waters, forests, soils, and wildlife. Other essential values include the secrecy of religious knowledge and practices to ensure that Blue Lake continues as the center of spiritual being.

The battle for the return of Blue Lake to the Pueblo illustrates the conflict of Taos values with the progressive use policies of government agencies, particularly the emphasis on general public recreation use of the lake. In addition, the turn-of-the-century forestry idea that preserving a pristine old-growth forest was wasteful and should be harvested (Kimmins 2003) was in direct conflict with Pueblo values and traditional knowledge. At the heart of the Pueblo's claim was the sanctity of their religious use of the area and the need for complete privacy to conduct ceremonies. Leaders tied ceremonial and religious use with provision of clear water for drinking and agriculture as the lake fed the streams below that entered the Pueblo and Spanish settlements. The continued efforts of Taos leaders such as Seferino Martinez, Paul J. Bernal, John Rayna, and the cacique Juan de Jesus Romero, all of whom asserted Pueblo cultural and religious values, formed the foundation for the successful return of Blue Lake to Taos Pueblo: "Our Blue Lake wilderness keeps our water holy, and by the water we are baptized. If our land is not returned to us, if it is turned over to the government for its use, then that will be the end of Indian life. Our people will scatter as the people of other nations have scattered. It is our religion that holds us together" (Juan de Jesus Romero in Keegan 1991: 61).

The essential nature of cultural and religious values associated with Blue Lake captured in the cacique's statement was clearly illustrated in the historical and policy records from the Blue Lake Wilderness. This thread of interwoven Indigenous values shoots through cultural narratives, stories, and expressions of the Taos people. Taos Pueblo is rich in cultural narratives that reflect values for sacred lands and waters. Wintertime was regarded as the time for telling stories that carried important values through the generations.

Some of the stories collected by anthropologist Elsie Clew Parsons, who worked in the region from the 1920s to 1940, included stories of Blue Corn Maiden and Yellow Corn Maiden. For different reasons, the maidens journeyed to the Blue Lake, to the "Big House" where the mothers and fathers were, where they might enter the lake and reappear on the surface as cobs of blue or yellow corn (Clew Parsons 1996). In other narrative journeys, Blue Lake figures as a magical source of corn and fruit even in wintertime. It reveals the sustainable as well as the magical, spiritual nature of this water source. Some stories feature animal beings that illustrate awareness of the nature of water resources. A large bird, possibly a goose, finds the river dry. He flies for several days and finally finds water that is iced over. He pecks at the frozen water and witnesses the breaking of the ice that releases water into the river (Clew Parsons 1996), exemplifying the importance of the seasonal cycle for water and concerns about drought. In this and other narratives, happiness is associated with flowing water. Relationships that occur in each season of the land and water cycles are built into the cultural narratives; Blue Lake emerges at the center as the place of origin.

Many stories are concerned with relationships to animals in wilderness areas and the rituals of hunting. Apache and Plains Tribes sometimes contributed to the narratives (Clew Parsons 1996). The stories usually begin with the names of the animal personages and the places where they live, which helps identify where uses occurred and where the relationships underlying ceremonial events took place. In other stories, animals communicate and hunters learn protocols and prayers to give them good fortune in their hunting (Clew Parsons 1996). Sometimes prey gets even with the hunter. Happiness is often associated with flowing waters. The element of the trickster is present in many Pueblo stories. The Coyote trickster breaks taboos but brings the buffalo to Taos from east on the Plains.

These cultural narratives record, transform, and share knowledge and values through intergenerational story telling. The stories illustrate the importance of honoring the land and waters through prayer and ceremony, and keeping the components of the ecosystem inviolate including relationships with animals and Blue Lake itself. Failure to do so results in dire consequences. The narratives illustrate the importance of the law of interdependence to the Taos in governing relations between humans, natural forces, animals, forests, and higher powers (Clew Parsons 1996).

Ceremonies and feast days express Tribal values. San Geronimo Feast Day is held in September. Vespers, dances, pole climbing, and other activities celebrate the Pueblo's values on this day. Clowns move through the crowd exhibiting behaviors that illustrate values by doing the opposite, from helping themselves to the vendor's wares to grabbing children and running about. People are seen letting their children wade in the Rio Pueblo, a normally prohibited activity. The clowns stand by the Rio Pueblo enforcing a dip in the cold water for some of those passing by. Taos young people tend to gather around waiting for a chance to experience this kind of ritual baptism in the river: "Water is a blessing that is part of creation and part of life itself.… indeed for all living things" (Suazo 2011).

Tribal Values in Wilderness Include Protection of Essential Ecosystem Services

The revered beauty and ecological functions of the forested watershed connected it to ancient rights to hunt and fish. The Pueblo held to a religious requirement to "preserve the trees in their primordial state" (Ebright and others 2014: 312). Most every multiple use activity allowed by the Forest Service after 1906 impacted the Pueblo values and rights. The clearcut timber operations of the time brought erosion and pollution. While foresters thought the forest was full of "overripe timber" (Kimmins 2003), the Taos saw the existence of this forest for time immemorial as an integral part of a functioning ecosystem.

Though the Forest Service later implemented wilderness policy under the Wilderness Act of 1964 (Public Law 88–577), it was still not enough to meet the pristine standard of the Taos. Pueblo values conflicted with western ideas about wilderness in that the exercise of the Taos religion required the protection of the entire watershed system, not just a bounded space. Casual recreational use that might be considered acceptable under wilderness policy was not compatible with Pueblo cultural and religious use. These noneconomic values were connected with the ecosystem benefits of clean water for drinking and agriculture, and the ability to hunt, fish, and to gather food, wood, and medicines—activities that made sustainable Pueblo life possible. The Pueblo executed closures on their lands whenever negative alterations to the watershed that might seem minor to outsiders occurred. Full closure occurred when actions like littering and overstocking fish could not be tolerated due to the sacred nature of the area. Honoring sacred land and waters through prayer and ceremony and keeping parts of the land inviolate as sacred areas both overlapped and exceeded wilderness management as implemented by the Federal agencies. Because the wilderness itself held direct connection to subsistence and cultural lifeways maintained through traditional knowledge, it required a unique management authority.

The return of Blue Lake Wilderness secured the flow of clean, clear water for the Rio Pueblo and other streams that supported sustainable agriculture and cultural ways. Wilderness water values connect directly with subsistence, culture, healing, and food sovereignty. In many ways, the idea of ecosystem services comes closest to the Indigenous Taos concept of the sacred and connected functions of valuing both noneconomic and sustainable ecosystem values. Native cultural understandings do not make the same kinds of distinctions between cultural and natural values as government agencies. Sometimes economic and noneconomic values can be conflated from this perspective, especially with regard to water, but, in fact, the whole interdependent ecosystem holds both kinds of values.

The principle of interdependence with the watershed affects the capacity for resilience. After the fight for Blue Lake, the use of the water for traditional agriculture became another component of restoring cultural values. Current Pueblo efforts to return to traditional agriculture are key to preserving the rights to the wilderness waters and culture just as cultural preservation and wilderness water are key to the return of native agriculture. Corn planting at Taos Pueblo represents a cycle of access to water, traditional seeds, and equipment. It implies knowledge of seasonal planting and harvest, technical knowledge of growing corn, and support by mechanical means for plowing due to the rocky nature of the lands (Zink 2017).

From the Tribal viewpoint, the sacred values placed upon pristine forests and watersheds do not necessarily conflict or need to be held separate from their ecosystem values. The sacred sites in the wilderness not only provide for religious functions and wild habitat, but they are also valued downstream for their contributions to traditional agriculture, grazing, drinking water, and other uses with high cultural values. These values interconnect in a web of relationships that reaches from the past to future generations through Indigenous knowledge and sustainable actions.

Waters fed by wilderness hold increased economic value today, particularly in the arid West. The Taos Pueblo Water Settlement (Abeyta Water Rights Adjudication 2012) added a layer of economic value to wilderness water in the water markets of the West and places Tribes in a position to enter these water markets. Direct economic value attached to the wilderness water may be of concern to traditional Taos Pueblo members and raises the question of whether or if water rights would really be returned to the Pueblo after being leased (Mirabel 2016). For some, this may be integrated into the whole value system for these waters that originate from wilderness. Others may hold different views and question the policy of selling the water from the ongoing

Tribal water settlements like those at Taos that are coming out of the Federal courts. Outdoor and cultural tourism creates another area for wilderness valuation and water values. Taos Pueblo is ideally situated for managing cultural tourism programs because they actively participate in tourism development.

Current Expressions of Wilderness Values: Taos Pueblo Advocacy for Federal Wilderness Expansion

The most recent expansion of wilderness within the aboriginal sphere of Taos was the designation of the Columbine-Hondo Wilderness on the Carson National Forest in 2014. It encompassed 45,000 acres of wilderness protecting wildlife habitat, water, hunting, and fishing and added 650 acres to the Wheeler Peak Wilderness. Support came from a broad coalition including Taos Pueblo and other northern Pueblos. The Taos War Chief Sam Gomez was among the supporters making statements about the importance of wilderness designation to protect the lands and waters, and the Tribal Council passed a resolution in support (Gomez 2011). The new wilderness designation protected additional water resources including the Rio Hondo and the Red River and placed areas adjacent to Blue Lake in wilderness designation.

Carson National Forest and Santa Fe National Forest began the process of identifying and finalizing a proposal for wilderness study areas as part of their overall land management planning process in 2016. A significant expansion of the Pecos Wilderness high country is under consideration. Taos Pueblo supports the expansion, as does the neighboring Pueblo of Picuris. Governor Pyne of Picuris Pueblo stated key Pueblo values: "This land is precious to the people of Picuris Pueblo. By adding the area to the Pecos Wilderness, it will protect the Pueblo resources, preserve our watershed, our clean water, and our unique landscape and will enhance our economy" (Black 2016).

A broad coalition including Taos and other Pueblos with environmental groups and businesses supported the proposal to establish the initial wilderness study areas that expand existing wilderness areas. The studies may lead to future inclusion in the wilderness system, although some local residents in the Penasco area oppose it. Discussions of special management areas as wilderness buffers and identification of historic uses by Penasco residents are ongoing. The Sipapu Ski Resort opposes the wilderness study areas; the resort is connected to the Snowbowl in northern Arizona's San Francisco Peaks through its major investor where deep conflict with Arizona Tribes continues after increased ski development and the use of recycled sewage water for snow-making (Stumpff 2013). Additional areas are under consideration as wilderness study areas in the Taos area and include further expansions on the Questa Ranger District of the Carson National Forest near the Blue Lake Wilderness, additions to Wheeler Peak Wilderness, and consideration of the Valle Vidal Unit in the Tres Piedras Ranger District in Carson National Forest. In the meantime, the Questa Ranger District of the Carson National Forest assists Taos Pueblo by patrolling the boundary areas during the Pueblo ceremonies at Blue Lake to assure their valued privacy. The dedication of these understaffed wilderness area rangers in high season is surely appreciated by the Pueblo. Backcountry skiing is on the increase on the Questa Ranger District, adding to increasing responsibilities of the limited wilderness staff.

Alternative Tribal Approaches to Protecting Wilderness Values

Tribes with wilderness policy concerns have expanded upon the Taos story in new contexts. Below, two alternative approaches to Tribal wilderness management are described, based upon efforts made by the Sandia Pueblo and the Confederated Salish and Kootenai Tribes to protect wilderness values. A brief consideration is also given to Tribal lands in Alaska.

Sandia Pueblo and the T'uf Shur Bien Preservation Trust

In 2003 court proceedings, Sandia Pueblo set legal precedent by forcing re-interpretation of Spanish grant documents honored through the Treaty of Guadalupe Hidalgo (Ebright and others 2014), creating the T'uf Shur Bien Preservation Trust inside Sandia Mountain Wilderness. Private inholdings existed within the boundaries, and existing recreational use posed expensive management challenges due to the location near the sprawling urban area of Albuquerque. If these contested lands became Pueblo trust lands, management expenses and levels of political conflict would be high. Sandia Pueblo determined that the best land management strategy was comanagement under Federal wilderness designation of the trust area within the Sandia Mountain Wilderness, with the Forest Service retaining primary title and primary funding responsibilities.

The comanagement agreement was made, and the contested lands were placed into Federal wilderness designation for the protection in perpetuity of wilderness character. The agreement prohibits gambling, mineral production, timber production, and new uses to which the Pueblo objects. The Pueblo retains free and unrestricted use for cultural and traditional uses. In this arrangement, the Pueblo gave up trust title, but got most of their values protected in the comanagement agreement. Sandia Pueblo Governor Stewart Paisano said, "It is the spiritual value of the mountain that was most important: central to our belief, practices and prayers. It is the only source of resources needed for religious ceremonies, shrines and pilgrimages" (Ebright and others 2014: 146). Sandia comanages the entire area with the Forest Service with the exception of the 8,800 acres in private property status.

If the Pueblo had fully implemented the court's decision in favor of Sandia's title, it would have meant further struggles and perhaps further court battles with more political fights stemming from the issue of the private property inholdings and heavy recreational use from the adjacent urban areas. Conflicts lead to greater burdens like enforcing regulations and critical media comment for already stretched Tribal administration resources. Sandia Pueblo was able to protect cultural values similar to those of Taos with a different kind of agreement that is becoming more common today. Comanagement made resolution swifter, but some things were exchanged in the bargain. Sandia was unable to avoid fish and wildlife regulation as interpreted by the State of New Mexico, and they had to accept the impacts of public use.

Mission Mountains Tribal Wilderness

The Mission Mountains Tribal Wilderness established by the Confederated Salish and Kootenai Tribes in 1982 offers another expression of Tribal values in wilderness. In this case, the wilderness area was established on trust lands by Tribal Council resolution (Krahe 1995). The manner of designation was Tribal: full management authority was retained by the Tribe via their Treaty, not the Wilderness Act. The lands bear the patterns of historic Tribal management, so human intervention remains a critical component in their existence. Prescribed burning, gathering, and hunting—supported and carried out through human activity—were infused with value in these Tribal homelands. The management of Tribal wilderness land includes sacred obligations which "may take the form of ritual observance on the land at sacred sites, of continual conduct of the hunt of game species, and the return to the land of the remains of plant of animal harvest after human use" (McDonald and others 2000). This wilderness is open to public use, except for areas reserved by the Tribe and subject to closures to meet Tribal objectives. Tribal wilderness is off-limits to any commercial use, but Tribal guides and outfitters may guide hunts and recreational activities in the wilderness buffer zones. This management authority allowing for recreation and public use means Tribal managers must wrestle with visitor desires to ensure Tribal values are protected and communicated.

The Tribal wilderness model allows the Tribe to develop regulation appropriate to Tribal values, to control data, and to protect sensitive information and sacred areas. The close connection between Tribal values and Tribal wilderness designation is expressed in the Tribal resolution that established this wilderness: "Wilderness has a paramount role in shaping the character of the people and the culture and people of the Salish and Kootenai Tribes; it is the essence of traditional religion and has served the Indian people of these Tribes…..for thousands of years" (McDonald and others 2000: 294).

A Comparison of Tribal and Federal Wilderness Management Authorities

The term wilderness precedes the Wilderness Act of 1964 by decades. Although Tribes do not seem to have a traditional word that is a synonym for wilderness, it is true that neither did the Europeans. As Europeans came to colonize the Americas, significant changes in land use occurred from the European forms of agriculture, industrialization, and land ownership systems. Writers like Thoreau and later John Muir developed the concept of wilderness as a way of describing landscapes less affected by these more intensive forms of human settlement and use and the growing threats to the environment. Later, the Wilderness Act codified certain characteristics and practices attached to the term wilderness. These broad characteristics are clarified in the act in ways that enabled Congress to find some flexibility in establishing new wilderness areas that reflect the strength of the Wilderness Act to apply to a variety of environments.

Tribes have found useful ways to work with the wilderness concept in practice while identifying specifically Tribal understandings. John Marshall III gives the example of the contemporary Lakota word for wolf as sung-manitu-tanka, which is translated as dog-wilderness-great in contemporary translations; he notes that in earlier times there was no concept in place that identified areas where people did not live as "wild" or "wilder" than the places that they did live, so the translation would have been different in those times (Marshall 1995). Given earlier translations, from the perspective of the traditional Lakota language, neither wild nor wilderness have meaning.

In contemporary times, many Tribes have learned to use the wilderness concepts for Tribal benefit, focusing on underlying values and similarities rather than differences. From the Alaska Native perspective, Bernadette Demientieff advocates for full Federal wilderness designation as the only possible course for protecting Gwich-in way of life and values, while Polly Napiruk Andrews notes that although traditional Cup'ik word for wilderness is lacking, so are the words for computers and airplanes (Kaye and others 2021). In the examples in the matrix (table 9.1), Tribes have found ways to integrate Tribal values in wilderness into practice. Although passages in the Wilderness Act, especially those placing "man apart," may not comport with Tribal values, some Tribes have developed strategies in practice that are beneficial to their values and are designed to reach for underlying values and add in nonconflicting values. From the Klamath in Northern California and Oregon to the Picuris Pueblos in New Mexico, Tribes have advocated for extensions of federally designated wilderness. At the same time, it is to be remembered that there are 574 federally recognized American Indian Nations and not all of them will agree on any one policy.

These examples are but a few of those that show that Tribes have understood significant benefits from using the wilderness word and concept as a means of furthering Tribal values in wilderness. Finding Tribal values in wilderness has become a way of working with Federal wilderness in practice. Sometimes, Tribal values are not exactly the same as Federal wilderness values in theory, but they may represent the same underlying values, and it is possible to integrate the two value systems in practice. In the case of the T'uf Shur Bien Preservation Trust Area established by Congress within the boundaries of the Sandia

Mountain Wilderness on the Cibola National Forest, Tribal values in wilderness expressed in traditional activities like mining for natural paints with nonmechanical means, gathering medicinal herbs and materials, and conducting traditional hunting methods and practices are approved. While the practice of these valued activities are permitted within the wilderness framework in the Sandia Mountain Wilderness within the Cibola National Forest, they would not be considered typical in some wilderness areas. For other Tribes, Federal wilderness designation may be the only reasonably available means to protect sacred sites.

Table 9.1 expresses different ranges of values connected with each wilderness area authority's particular concept of conforming uses. Thus the Tribal values expressed in the Taos Blue Lake Wilderness are different than the values expressed through the Wilderness Act and have some differences from other Tribes like the Confederated Salish and Kootenai Tribes. Taos stands out as holding the highest values for pristine wilderness, with a Tribal management authority that limits use to cultural and religious activities. The Tribal management authority is backed by a legal decision: it is only limited by some Federal processes for restricted restoration practices like thinning and prescribed burning. The Sandia case is based on an agreement between the Forest Service and Sandia Pueblo that offers special uses and protections of a Tribal wilderness area within a federally designated wilderness area. In this case, shared management with the Forest Service provides

Table 9.1—Alternative expressions of Tribal wilderness management authority and values

Wilderness area management authority	Cultural values	Value expression	Ecosystem values
Taos Pueblo trust lands (Blue Lake Wilderness)	Pristine: sacred Religious: privacy	Full closure Religious: shrines, pilgrimages, ritual hunting, sacred lake and forests Restoration	Watershed, sustainable cultural practices, trade, water flows Cultural landscape
Confederated Tribes of the Salish and Kootenai (CTSK) (Mission Mountains Tribal Wilderness)	Preservation: religious and cultural limits Recreation	Regulation and closures: CTSK values remain primary for wilderness recreation Restoration practices Religious and traditional activities, hunting, gathering, fishing	Watershed, sustainable cultural practices, recreation revenues, water uses
Sandia Pueblo (T'uf Shur Bien Preservation Trust Area within Sandia Mountain Wilderness)	Preservation: religious and cultural	Negotiated agreement limits approval for new recreation activities based on legal settlement	Sustainable culture through ecosystem services; sources for cultural materials for arts and ceremonies
Forest Service (retains title to T'uf Shur Bien Preservation Trust Area within Sandia Mountain Wilderness)	Preservation: wilderness characteristics	Recognized rights to Pueblo religious uses, gathering ceremonial materials, pilgrimages	Watershed functions
Costewardship (Sandia Mountain Wilderness)	Balance value conflicts	Regulation, planning to balance wilderness recreation and hunting	Landscape protection/outfitter and permittee businesses
Federal wilderness designation (various Federal lands)	Preservation values for defined wilderness characteristics: binary distinction of humans and wilderness Legally determined values for science and recreation	Wilderness recreation regulation Various legal and discretionary regulation for cultural/religious values	Watershed functions, viewshed, nonmotorized protection/outfitter and permittee businesses Science

for Sandia review of any new uses. Although Sandia might have pressed for full trust title after a favorable court decision, the practicality of managing the large area with existing heavy recreation use by adjacent urban populations, the problem of private land inholdings, and the high costs of management and enforcement created a context for the negotiated agreement for comanagement. The Mission Mountains Tribal Wilderness of the Confederated Salish and Kootenai Tribes is entirely on Tribal trust lands and the Tribe is in full charge of management activities, providing for the greatest flexibility in dealing with responses to threats like climate change. The Tribal wilderness is adjacent to Federal wilderness and allows for recreational uses. The context of adjacency to federally designated wilderness in this case makes recreational use almost a necessity, since enforcing full closure from recreational use would be impractical and extremely difficult. In fact, except for the establishment of cultural areas and the flexibility of Tribal management, recreational regulation is similar to the Federal model, though it can produce some tension with Tribal values. Finally, the full Federal management authority for wilderness itself is grounded in the concept of humans as visitors. It allows for wide recreational use, scientific study, and the pristine values as defined by the Wilderness Act. All of the wilderness management authorities subscribe to the Federal prohibition on roadbuilding in inventoried roadless areas, although some other Federal and Tribal wilderness areas do have some limited administrative use for subsistence road access under certain legal and discretionary conditions.

Alaska Natives and Wilderness

Alaska Native Tribes have a legal history and environmental context that make them uniquely distinct from Tribes in the contiguous United States. Congress passed the Alaska Native Claims Settlement Act in 1971 (Public Law 92–203) as a move to settle Alaskan land claims, but it left many issues unresolved. Alaska Native corporations were set up to make natural resource and economic decisions (they exist parallel to the Alaska Native governments who retain the right to make other kinds of decisions), but some Alaska Native groups set up local corporations that took different positions from the larger corporations. Later, the U.S. Congress passed the Alaska National Interest Lands Conservation Act of 1980 (Public Law 96–487) to restore Alaska Natives rights to subsistence and settle many other questions. Subsistence rights, Alaska Native corporations, and climate change impacts resulting in moving whole villages and changing hunting and use areas all lead to further complexity. Millions of acres in Alaska are under the management of the Forest Service; the U.S. Department of the Interior (DOI), National Park Service; and the Bureau of Land Management, all of whom have different missions and, in some areas, different relationships to applied wilderness policy. Court cases ensued that have helped to outline some of the Tribal-Federal relationships, but applied wilderness policy in specific situations is still evolving in Alaska.

Summary and Conclusions

Indigenous values related to nature and wildlands overlap with those of federally designated wilderness, but differences exist at the foundational level for understanding the human relation to ecological and cultural landscapes. The history of the Taos Pueblo's struggle to establish wilderness management authorities that reflect Tribal values is a story that reveals the depth of those values and Tribal determination to ensure the pristine level of protection for wilderness as defined by the Taos. Though Taos has decided to reject recreational values, except for the viewshed, they now hold significant water rights worth millions of dollars should they decide to lease those rights (Brown 2007).

In other Tribes as well, noneconomic values may overlap with subsistence and ecosystem service values in relationships that respect interdependence. At the spiritual and cultural level, common themes emerge within Tribal values as ethical imperatives for action. Broad principles of the interdependence of all things material and nonmaterial and Tribally defined values for responsible stewardship and interaction with wildlands and waters form the undercarriage for Tribal wilderness governance. In contrast, Federal agencies began to protect lands under the thesis that they were "pristine" and without human intervention and thus "untrammeled." Today, under the extreme challenges from climate change in the Southwest, including wildfire and reduced water resources, Taos and Sandia may work more closely with managers of Federal wilderness areas and the waters that flow from them (Brown and Froemke 2009).

Today, Tribes are actively developing ways to protect their cultural values through a variety of special Tribal land designations. In the case of wilderness resources, such as water that provides ecosystem services, water flows may be attached to multiple kinds of valuation ranging from noneconomic spiritual values to economic values in water markets. Beyond the scope of this paper, further research on the noneconomic and economic values of wilderness for Tribes is needed. Finally, Alaska Natives offer a unique set of additional circumstances for further research.

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10

Wilderness Economics in the Anthropocene: Expanding the Horizon

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Middle Prong Wilderness (7,482 total acres) in North Carolina was designated in 1984 and is administered by the Forest Service. (Courtesy photo by wilderness.net/Jack Henderson)

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KEY MESSAGES

- Rapid growth in the rate and scale of environmental stress being placed upon ecological and socioeconomic systems due to anthropogenic factors is creating new land management challenges for policymakers. Changes in climatic variables (such as temperature and precipitation) as well as natural disturbances (such as wildfires, droughts, storms, and invasive species) have begun to alter ecosystem service provision, demand, and value within wilderness and other wildlands. Management actions are being undertaken within designated wilderness ecosystems to help address the complex array of impacts induced by a changing climate. Scientific and traditional ecological knowledge, including that of Indigenous peoples, can help policymakers understand how management options might be deployed in designated wilderness and comparable wildlands. Economic analysis can help policymakers better understand societal values and tradeoffs inherent in the allocation of resources to support wilderness adaptation to climate change.

- While the National Wilderness Preservation System provides an important foundation for protecting high-value natural environments, many nonlegislatively protected landscapes provide an assortment of wilderness characteristics and ecosystem service values including recreational opportunities, biodiversity protection, sources of high-quality water, and carbon sequestration. Economic analysis can inform policymakers regarding the costs and benefits of alternative strategies for managing wilderness and comparable wildlands as an integrated system in which synergies and tradeoffs between land management approaches can be explored.

Introduction

Since the beginning of the Industrial Revolution, rapid expansion of human populations and the use of fossil fuels has fundamentally changed the global environment. The unprecedented rate and scale of anthropogenic forces imposed upon climatic, physical, and biological systems have pushed the Earth into a novel geological epoch referred to as the Anthropocene (Crutzen 2002). Ecological impacts emerging during the Anthropocene are occurring across the entire gradient of land uses (Steffen and others 2007) and are anticipated to threaten forest extent and biological diversity within wilderness (Holsinger and others 2018). Further, by mid-21st century, changes in land use and land cover within 10 km of wilderness are anticipated to reduce core natural vegetation (contiguous interior habitat) by roughly 50–75 percent, thereby creating further risks to biological diversity (Aycrigg and others 2021). The degree to which wilderness and other wildlands should be managed in response to anthropogenically induced stress is controversial and depends on ecological knowledge as well as social objectives and values. These stressors are further threatening the well-being of Indigenous peoples, with important implications for land management (Chief and others 2014). Such impacts already have been addressed through wilderness-related changes; for example, Congress transferred designated wilderness lands in Olympic National Park to the Quileute Nation in part to address flood threats (Nie and Barns 2005).

Costs and Benefits of Wilderness Ecosystem Adaptation to Climate Change

Some guidance in wilderness management objectives is provided by the wording of the Wilderness Act. However, critical dimensions regarding what constitutes an acceptable degree of human intervention in wilderness management remains ambiguous. The act specifies that wilderness ecosystems should retain their "primeval" character, be preserved in their "natural condition," and remain "untrammeled" by humans. As reasoned by Cole (2000), each of these terms suggests a somewhat different approach to wilderness management. Specifically, he argues that "primeval" refers to historical ecological conditions prior to Euro-American colonization, "natural" suggests ecosystem trajectories that preceded the advent of modern technological society, and "untrammeled" refers to the absence of intentional human control. Looking back more than a half-century to the time that the Wilderness Act was signed, these three terms may have been understood to mean basically the same thing—that an untrammeled landscape would be natural and appear to retain a high degree of historical fidelity.

Within the new global environment of the 21st century, the range of possible management strategies for climate change adaptation in wilderness has been suggested to fall into four categories: restraint (leave some places alone), resilience (strengthen ecosystem ability to absorb stress by, say, controlling nonnative invasive species), resistance (resist change through intensive actions such as creating fuel breaks), and realignment (facilitating change through actions such as assisted species migration) (Stephenson and Millar 2012). Although scientific knowledge can facilitate understanding the need for, and the implementation of, each of these strategies, application of scientific knowledge requires consideration of the economic and social values that are affected by wilderness intervention efforts (Landres and others 2020).

Lieberman and others (2018) showed that management interventions in wilderness are currently being undertaken across all four management agencies, across all geographic areas, and within small and large wilderness. As reported in that study, responses to an online survey indicated that more than 20 types of management interventions have recently been implemented to address management concerns regarding vegetation (such as planting or application of herbicides), wildfire (such as constructing control lines or postfire restoration), fish and wildlife (such as adding or removing wildlife), and water (such as installing a water structure). Notably, survey data showed that more than one-quarter of interventions received no public input as required by National Environmental Protection Act guidelines, leading authors to conclude that "wilderness managers should understand stakeholder values to help clarify costs and benefits of ecological interventions in wilderness" (Lieberman and others 2018: p. 900).

The repository of knowledge gained from experiential observations of ecological dynamics over millennia by Indigenous people is increasingly being recognized as an asset that can help build socioecological resilience to the challenges being wrought by global climate change (Gómez-Baggethun and others 2013). Systems of traditional ecological knowledge (TEK) have developed by learning from natural disturbances and ecological surprises, providing social mechanisms and adaptive management strategies that facilitate resilience as natural systems change (Berkes and others 2000). Although long-standing hegemony of the U.S. Government over Tribal Nations created social and ecological traps that have been maladaptive for Indigenous people and the resilience of ecosystems, efforts being undertaken within the USDA Forest Service have acknowledged the importance of TEK as evidenced by cooperative and comanagement arrangements with Tribes on public lands (Long and Lake 2018). The use of low-intensity Indigenous burning practices by Indigenous peoples to restore diverse ecosystems and promote valued resources has gained increased attention within Federal land management agencies (Anderson and Barbour 2003, Kimmerer and Lake 2001, Lake and others 2017, Long and others 2020). These practices and others can restore ecological and cultural values through costewardship on public lands in ways that are consistent with recent policy directives such as The Tribal Homelands Initiative announced in November 2021. This collaborative effort, codified in a joint secretarial order from the Departments of the Interior and Agriculture, will facilitate Tribal collaboration in the costewardship of Federal lands and waters.

Ecosystem Service Valuation in a Wilderness and Wildlands Network

The Wilderness Act emphasized the importance of protecting wild landscapes for "the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness." Although recreational uses were explicitly recognized in the act, accumulating impacts of changes in climate and land uses surrounding wilderness on species at risk and ecological processes has led to an expanded rationale for protecting wilderness that includes a suite of ecosystem services such as the conservation of biological diversity, the provision of high-quality water, and the sequestration of carbon. While the National Wilderness Preservation System (NWPS) has grown from 9.1 million acres to about 111.7 million acres, the politics of wilderness designation have become more controversial, and the scope of wilderness legislation has gradually devolved from national to state to local in focus (Keiter 2018). Consequently, wildlands other than wilderness are being evaluated for their conservation benefits (Talty and others 2020).

Wildlands with Wilderness Character

Under the Wilderness Act, the Forest Service was directed to inventory roadless areas that might be suitable for inclusion in the National Wilderness Protection System. After a long and contentious process during the 1970s in which the Forest Service undertook two nationwide reviews of its roadless lands (RARE I and RARE II), Congress passed, in 1984, 20 statewide national forest wilderness bills and released undesignated roadless lands to be managed under the Forest Service multiple-use mandate. This action led to a series of legal actions by wilderness advocates that created a "near perpetual deadlock of management of roadless national forest lands" (Keiter 2018: 78). To address this problem, the agency finalized its roadless rule in 2001 and Inventoried Roadless Areas (IRAs) now encompass about 58.2 million acres and places restrictions on road construction, road reconstruction, and timber harvesting. IRAs cover about one-third of the national forest land base and exceed the 36.7 million acres of legislated Forest Service wilderness. In several States, primarily Western States, IRAs exceed the amount of land designated as wilderness (fig.10.1), and >90 percent of IRAs are located within 10 km of wilderness and other high-value protected areas (Talty and others 2020). The spatial extent of IRAs and their proximity to designated wilderness suggests that they interact synergistically with many wilderness preservation objectives.

Public debates regarding the 2001 roadless rule continue as concerns are raised regarding economic values and whether provisions in the rule should be increased, decreased, or remain the same (Riddle and Vann 2020). Some favor maintaining or broadening the prohibitions in the rule and argue that the rule has protected many nonmarket economic values provided by IRAs, including water quality benefits, carbon sequestration benefits, and outdoor recreation benefits (Berrens and others 2006), and that proximity to IRAs result in higher local property values (Izón and others 2010). Others argue that the prohibitions in IRAs are too stringent and that they harm timber and mining industries and the economies of surrounding communities (Murkowski 2019). Economic tradeoffs in these alternative perspectives require careful analyses to help inform decisionmakers regarding the costs and benefits of alternative policies.

In addition to IRAs, management efforts undertaken by Native American Tribes also support protection and conservation of wildlands across management boundaries. For example, the Mission Mountains Tribal Wilderness Area, comprising 92,000 acres in Montana, is contiguous with the Federal Mission Mountains Wilderness (74,524 acres) that, in turn, lies alongside the Bob Marshall Wilderness Area (1.06 million acres), providing an expansive area rich in wildlife and other wilderness values. In Wyoming,

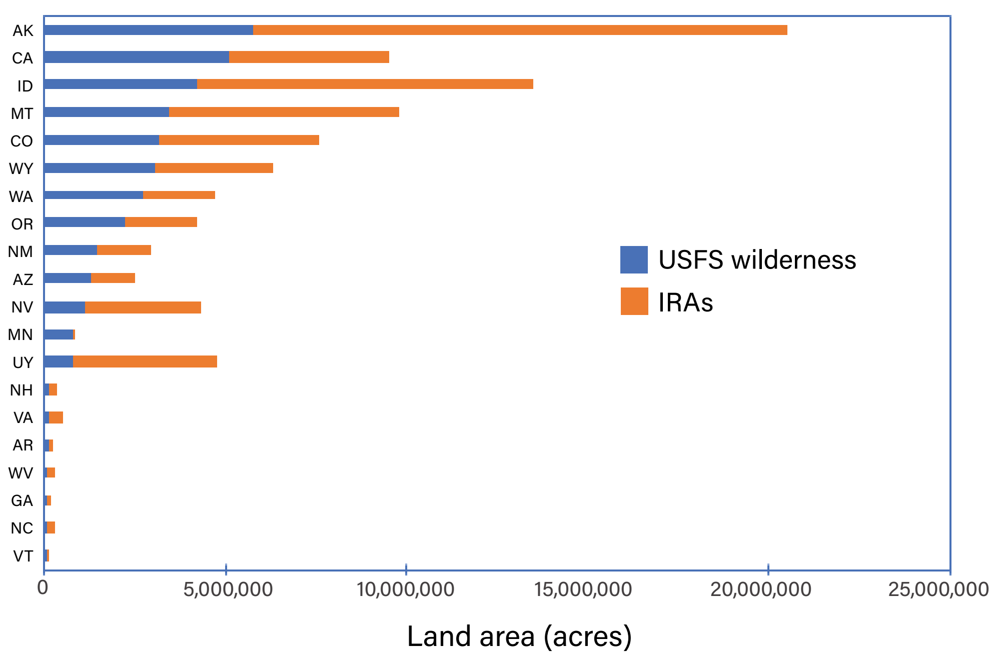

Figure 10.1—Land area in USDA Forest Service (USFS) wilderness and Inventoried Roadless Areas (IRAs), by State. Data sorted by wilderness size. Only States for which wilderness >100,000 acres are shown. Data source for USFS wilderness area: https://wilderness.net. Data source for USFS IRAs: Riddle and Vann (2020).

the Wind River Roadless Area, which has been managed since 1934 by the Wind River Indian Reservation, adds 180,000 acres to the 1-million plus acres of Federal wilderness in the Wind River Mountains. The 4,000-acre inter-Tribal Sinkyone Wilderness, lying within the redwood forest ecosystem along the coast in northern California, is being managed to restore cultural and ecological values in collaboration with the 7,250-acre Sinkyone Wilderness State Park. Finally, the Blackfeet Nation secured the designation of the Badger-Two Medicine Roadless Area in the Lewis and Clark National Forest in Montana as a Traditional Cultural District, thereby closing this ecologically and culturally important area to oil and gas development. These Tribal initiatives offer innovative models for protecting multiple cultural and ecological values provided by wildlands.

Economic Valuation of Ecosystem Services Provided by Wilderness and Wildlands

Publication of the Millennium Ecosystem Assessment (2005) raised global awareness of the importance of maintaining natural capital for sustaining and enhancing human well-being. Analyses regarding the economic valuation of ecosystem services contributes to those goals by helping governments, corporations, traditional communities, and individuals make more informed decisions (Daily and others 2011). A great deal of information describing the economic analysis of ecosystem services can be found in the literature on nonmarket valuation (e.g., Champ and others 2017). Recommendations regarding the stages to be followed when conducting ecosystem service valuation studies are available, such as presented in a guidebook prepared for Federal resource managers (Olander and others 2015) as well as in publications specifically focused on providing guidance to forest planners and policymakers (Binder and others 2017, Sills and others 2017).

Hundreds of economic studies have been conducted regarding the nonmarket value of ecosystem services provided by nature. The scope and richness of these studies provide economists with data needed to conduct state-of-the-art statistical meta-analyses and benefit transfers that can inform policy decision making (Rosenberger and Loomis 2017). These analytical methods allow ecosystem service values estimated in primary study areas to be transferred to policy sites such as wilderness or other wildlands. Meta-analyses have been conducted for a variety of ecosystem services provided by wilderness including the value of outdoor recreation (Rosenberger and Loomis 2000), biological diversity (Nobel and others 2020, Ojea and Loureiro 2011), endangered species (Richardson and Loomis 2009), water quality improvement (Johnston and others 2017, 2019), wetlands (Woodward and Wui 2001), coastal and freshwater ecosystems (Latinopoulos 2010, Wilson and Carpenter 1999), and forest cover (e.g., Barrio and Loureiro 2010). This approach has also shown that public values for resource preservation are greater than for resource restoration (Hjerpe and others 2015). The ability to transfer ecosystem service values obtained using meta-analysis has been enhanced by the availability of spatially referenced data (such as National Hydrography Dataset and the National Land Cover Database). Spatially referenced land use/land cover data permit economists to analyze a variety of spatial issues such as the impact of distances between human populations and natural amenities or the availability of complementary/substitute landscapes on economic values (e.g., Johnston and others 2019). Further development of these methodologies and databases will enable economists to provide policymakers with information regarding synergies and tradeoffs in the costs and benefits inherent in managing ecosystem services in wilderness and spatially connected wildlands.

Conclusion

Management actions are being undertaken within designated wilderness and comparable wildlands to help address the complex array of impacts induced by a changing climate. Scientific and traditional ecological knowledge can help policymakers understand how management options might be deployed in wilderness. Although management in wilderness is a contentious topic, it appears that "the vast majority of potential management actions for climate change adaptation, both active and passive, are possible under the Wilderness Act, provided that the right procedural steps are followed, and the right substantive analyses are produced" (Long and Biber 2014: 689). Active and passive management in wilderness can be enhanced by considering synergistic interactions with spatially connected landscapes exhibiting wilderness character including IRAs and areas on non-Federal lands. Economic analysis can help policymakers better understand societal and ecosystem service values at stake by clarifying cost and benefit tradeoffs inherent in the management and allocation of resources that support adaptation to climate change in wilderness and wildlands.

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Wilderness is a culturally constructed concept that evolves over time with changes in socioeconomic, technological, and political conditions. Societal transformations, including growth of minority and underserved populations along with greater calls for environmental justice, in combination with changes in climatic variables (e.g., temperature and precipitation) and natural disturbances (e.g., wildfires, droughts, and invasive species) are creating new challenges for wilderness management agencies. This report provides up-to-date knowledge on societal benefits and ecosystem service values provided by wilderness and associated wildlands while also suggesting research directions that can help policymakers better understand social values and tradeoffs inherent in the allocation of resources to support wilderness preservation and management.

Keywords: Anthropocene, benefit-cost analysis, cultural values, economic values, ecosystem services, public preferences, wildlands.