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A History of Wilderness Fire Management in the Northern Rockies

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Abstract

Suppression of most wildland fire ignitions has defined fire management in the United States since 1935. These past suppression activities, along with climate change impacts and other factors, have resulted in longer fire seasons and increased frequency of large fires in many forest ecosystems across the western United States, thus resulting in a fire management crisis. But suppression has not been the default approach in a few large wilderness areas of the U.S. Northern Rocky Mountains: the Selway-Bitterroot Wilderness, the Bob Marshall Wilderness Complex, and the Frank Church-River of No Return Wilderness. Instead, wildland fire has been managed over the last four decades to play a more natural role in these ecosystems. The fire management approach in these wilderness areas provides an excellent, and relatively rare, case study of wildland fire managed for resource benefit. This report recounts historically important fires managed in these wilderness areas and analyzes the development of wilderness fire management in the Northern Rockies from the pioneering days in the 1970s to the present. An improved understanding of this history, including the challenges overcome and lessons learned by managers in this region, could help inform fire management policies and decisions across the Nation.

Keywords: Northern Rockies, wilderness fire, Selway-Bitterroot Wilderness, Bob Marshall Wilderness Complex, Frank Church-River of No Return Wilderness, fire management

Cover. Clockwise from top left: the 2013 Gold Pan Fire in the Frank Church-River of No Return Wilderness, as viewed from the historic Magruder Ranger Station (Licensed by Leah Moak, Understand.com); a fire lookout tower that was covered with an aluminized structure wrap in response to the 2007 Corporal Fire in the Bob Marshall Wilderness (USDA Forest Service photo by Erin Noonan-Wright); and a portion of the North Fork of the Blackfoot River in the Bob Marshall Wilderness that burned in 1988, then burned again in 2007 (Courtesy photo by Andrew J. Larson, University of Montana).

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CONTENTS

INTRODUCTION

Fires in the U.S. Northern Rocky Mountains (hereafter, the Northern Rockies) have been crucial to shaping national fire management policy since the early 1900s. Until the 1970s, large fire events in the Northern Rockies often resulted in changes to national fire policy that favored fire suppression. The 1910 fires, which burned more than 3 million ac (1.2 million ha) in the Northern Rockies and threatened many towns, were unprecedented in both size and severity for the Euro-American settlers of the region. After the devastation of 1910, forest fire management became synonymous with fire suppression. The newly formed Forest Service (U.S. Department of Agriculture) placed priority on firefighting and gave very little thought to fire management beyond suppression (Pyne 1982). With the New Deal of the 1930s came a buildup of firefighting resources and crews, which set the stage for another national policy shift. In response to the massive 1934 Selway Fires in Idaho (Koch 1935), the Forest Service established the 10 a.m. policy, which called for full suppression of a wildfire by 10 a.m. the next day (Loveridge 1944; Pyne 1982). Other Federal land management agencies quickly adopted this policy.

These continued efforts to suppress all wildland fires have resulted in the "wildfire management paradox," in which accumulated fuel loads and postponement of risk increase the likelihood of future, suppression-resistant, catastrophic wildfire (Arno and Brown 1991; Calkin et al. 2015). Confronting this challenge will require a drastic shift in how land management agencies approach fire management (Thompson et al. 2018).

Wilderness fire management in the Northern Rockies offers an example of such a management shift. The adoption of wilderness fire management in the Northern Rockies served as one of the primary catalysts for the Forest Service's shift away from universal implementation of the 10 a.m. policy. In the early 1970s, the Selway-Bitterroot Wilderness in the Northern Rockies became the first Forest Service wilderness area to allow naturally ignited fires to burn (DeBruin 1974; Smith 2014; van Wagtendonk 2007). A study in the White Cap and Bad Luck drainages of this wilderness (hereafter, White Cap Study) was conducted with the intent of developing a plan so that fire could begin to resume its natural role on the landscape (USDA-FS 2017). After successful implementation of this plan, a policy of managing, rather than always suppressing, naturally ignited fires was put into practice in several other Forest Service wilderness areas throughout the United States (Fischer 1984), catalyzing a policy evolution to increased fire management for resource benefit (USDA and USDOI 2009; van Wagtendonk 2007). Today, several large wilderness areas in the Northern Rockies, as well as Yellowstone and Glacier National Parks, have adopted wilderness fire management, or management of lightning-ignited wildfires for resource benefit.

This paper compiles and synthesizes the evolution of and key lessons learned from wilderness fire management in the three largest Forest Service wilderness areas in

the Northern Rockies: the Selway-Bitterroot Wilderness, the Bob Marshall Wilderness Complex, and the Frank Church-River of No Return Wilderness. From this history, much can be learned about fire ecology, as well as fire management strategies and effects. This report also discusses the setbacks and accomplishments during more than four decades of wildland fire management for resource benefit. As the first comprehensive history of wilderness fire management in this region, this review provides suggestions for incorporating the lessons learned into future fire management policies and decisions.

METHODS

The Selway-Bitterroot Wilderness, the Bob Marshall Wilderness Complex, and the Frank Church-River of No Return Wilderness each contain an extensive land area (1,347,644 ac, or 545,372 ha; 1,609,108 ac, or 651,183 ha; and 2,358,940 ac, or 954,629 ha, respectively), and all have allowed for some level of wilderness fire management for at least 40 years. They therefore serve as large natural laboratories to study fire management and fire effects on the landscape.

To synthesize all available information on these wilderness areas, we began with an extensive review of peer-reviewed studies, management documents, and Forest Service reports and plans. This literature review provided critical information on both the fire ecology and fire management practices within the Northern Rockies. The literature was obtained in two ways. The first relied on a systematic approach in which the search algorithms ("Bob Marshall" OR "Frank Church" OR "Selway-Bitterroot") AND ("fire"), as well as ("Northern Rockies" OR "Northern Rocky Mountains") AND ("wilderness") AND ("fire") were implemented in the Web of Science and Treesearch databases on March 22, 2018. Given that much of this literature comes from older, sometimes unpublished, government reports, however, we also relied on subject matter experts to identify the pertinent literature.

We also read existing interviews and conducted new interviews with key wilderness fire managers from the Northern Rockies, both retired and current. Existing interviews were obtained from the Fire Management Deep Smarts Project (Thomas et al. 2012) and the Lessons from Wilderness Fire Project (Northern Rockies Fire Science 2020). The 20 new interviews were conducted from June 2018 to June 2019 (exhibit 1). The individuals selected for these interviews held a variety of positions related to wilderness fire, ranging from district and forest fire management officers, district rangers, forest supervisors, and regional and national fire officers, to fire research scientists. The careers of these interview subjects collectively spanned from the beginning of the Northern Rockies wilderness fire program in 1970 to the present day.

The questions asked during our interview process were aimed at (1) clarifying facts about the history of wilderness fire management in the Northern Rockies, (2) gaining the interviewee's perspective on lessons learned, (3) determining professional incentives for allowing more fires to burn, and (4) discussing the subject's professional opinions on how to strengthen the practice of wildland fire management for resource benefit. All interviews were open-ended and fluid, with questions adapted uniquely to the interviewee and his or her responses. A single interviewer conducted all interviews, the audio of which was recorded for later reference. The interviews, both old and new, were particularly useful in identifying the decision-making processes that determined whether to suppress or manage a fire in the wilderness, as well

Interviewee	Date of interview	Location of interview	Professional background
Gene Benedict	June 14, 2018	Phone interview	Retired. Past fire management officer (FMO) for the Payette National Forest.
Sonny LaSalle	June 21, 2018	Phone interview	Retired. Past forest supervisor for the Payette National Forest (1986–1992).
Dave Bunnell	October 10, 2018	Missoula, Montana	Retired. FMO for the Flathead National Forest, then national fire use program manager.
Norm Kamrud	October 18, 2018	Missoula, Montana	Retired. FMO for the Rocky Mountain Ranger District (1981–2010).
Rich Lasko	October 23, 2018	Missoula, Montana	Retired. Acting FMO for the Flathead National Forest (1984), then FMO for the Spotted Bear Ranger District (1985–1991).
Orville Daniels	November 5, 2018	Missoula, Montana	Retired. Forest supervisor for the Bitterroot National Forest during the White Cap Study, then forest supervisor for the Lolo National Forest (1974–1996).
Bob Mutch	November 19, 2018	Missoula, Montana	Retired. Research scientist at the Missoula Fire Lab (1960–1977), then fire use specialist for the National Forest System's Northern Region.
Chuck Mark	November 26, 2018	Phone interview	Current forest supervisor for the Salmon-Challis National Forest.
Byron Bonney	November 27, 2018	Missoula, Montana	Retired. FMO for the Lincoln Ranger District, then fire staff officer for the Clearwater-Nez Perce National Forests.
Seth Carbonari	November 28, 2018	Hamilton, Montana	Current district ranger for the West Fork Ranger District (2018–present); previously FMO for the Spotted Bear Ranger District (2007–2018).
Dave Campbell*	November 28, 2018	Hamilton, Montana	Retired. District ranger for the West Fork Ranger District (1997–2013).
Stu Hoyt*	November 28, 2018	Hamilton, Montana	Retired. FMO for the West Fork Ranger District (1997–2005), then the Moose Creek Ranger District (2005–2009).
Jack Kirkendall	December 3, 2018	Missoula, Montana	Retired. FMO for the Bitterroot National Forest (1992–2005), then fire operations specialist at the national level.
George Weldon	December 5, 2018	Phone interview	Retired. Fire director for the Northern Region.
Mike Munoz	December 7, 2018	Phone interview	Current district ranger for the Rocky Mountain Ranger District (1999–present).
Deb Mucklow	January 16, 2019	Phone interview	Retired. District ranger for the Spotted Bear Ranger District (1999–2017).
Jerry Williams	January 18, 2019	Missoula, Montana	Retired. Fire staff officer for the Lolo National Forest. Later served as regional fire director and then national fuels and fire use specialist.
Carl Seielstad	March 15, 2019	Missoula, Montana	Associate Professor of Forestry at the University of Montana; fire/fuels program manager, National Center for Landscape Fire Analysis.
Tim Love	March 29, 2019	Missoula, Montana	Adjunct Professor of Forest Planning at the University of Montana; previously, forest supervisor for the Lolo National Forest.
Jim Habeck	June 4, 2019	Missoula, Montana	Professor Emeritus of Botany at the University of Montana; previously, wilderness fire research scientist.

Exhibit 1—Interview information with past and current fire managers. The asterisk (*) indicates that the two subjects were interviewed together.

as the challenges in implementing this management strategy and the important lessons learned.

In addition to the literature review and interviews, we examined the spatial and temporal differences in area burned within the three wilderness areas. This comparison allowed us to quantify the effects of shifting fire management strategies, as well as how these shifts interacted with climatic changes. Specifically, we compiled existing fire atlases for the Northern Rockies (Gibson et al. 2014; Parks et al. 2015a,b,c) and updated these atlases to include fires through 2017 using fire perimeter data from the Northern Region (Region 1) and Intermountain Region (Region 4) of the Forest Service's National Forest System. We then calculated area burned and fire rotation period (FRP) for three time periods, each representing a different approach to fire management, for each wilderness area (Morgan et al. 2008). Area burned was calculated as the sum of the area burned by a wildland fire within a given management period. Fire rotation period was calculated by dividing length of time (in years) of a management period by the ratio of area burned to total wilderness area.

Study Area

The Northern Rockies Ecosystem

For this review, the Northern Rockies encompasses northern and central Idaho and western Montana (fig. 1). This area falls within the temperate conifer forest ecosystem of the Inland Pacific Northwest (Lassoie et al. 1985). The climate is maritime-continental, with short, dry summers and long, cold winters with high precipitation, primarily as snow (WRCC 2018). The diverse topography of the region includes broad valley bottoms and high mountain peaks, which results in a variety of microclimates and strong orographic effects.

Mountain ranges running generally north to south divide this region. As the prevailing winds come from the west off the Pacific Ocean, these ranges force the maritime air to rise and release precipitation. Therefore, the western slopes of the region tend to be moister than the eastern slopes (Arno 1980; Gibson 2006).

Lightning-ignited fires were historically the primary source of disturbance in this region, but the fire regime varies dramatically depending on the climate and topography, which drive the fuel and vegetation types (Agee 1993; Arno et al. 2000). Low-severity, high-frequency nonlethal fire regimes are characteristic of low-elevation ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) forests. Mixed-severity fire regimes, which dominate in mid-elevation forests and produce patches of live and dead trees, are emblematic of the Northern Rockies, covering approximately 50 percent of National Forest System lands (Arno et al. 2000; Barrett 2004; Quigley 1996). In

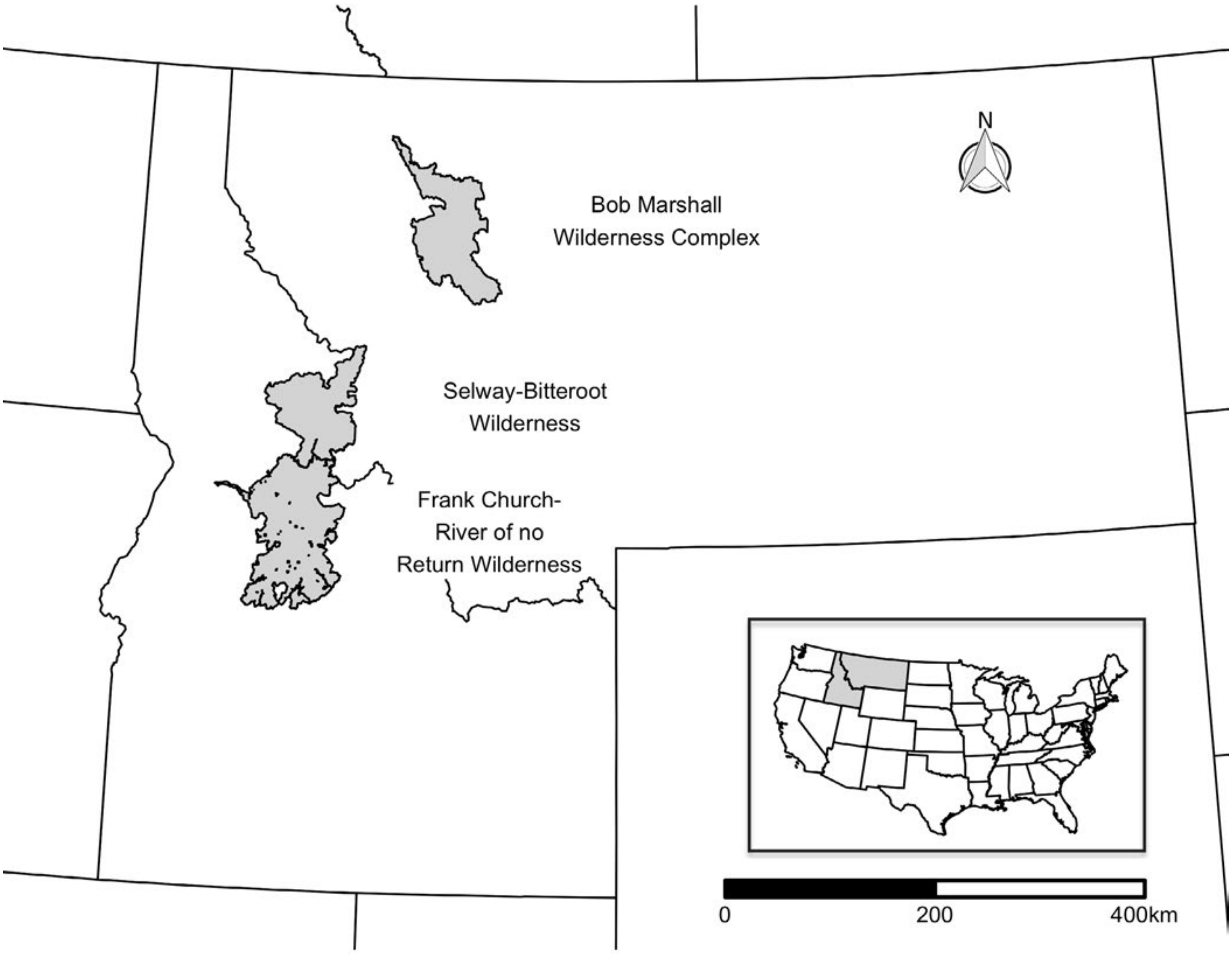


Figure 1—Wilderness areas covered in this review.

high-elevation and subalpine forests, fire regimes are typically stand-replacing, as the dominant species have very low fire resistance. In this forest type, fire-free intervals average a century or more due to climate conditions that typically result in high fuel moisture (Barrett 2004). Therefore, when high-elevation sites do burn, tree mortality is generally 80 to 100 percent.

The diversity of fire regimes across the region means that forests in the Northern Rockies were once defined by a mosaic of even-aged and uneven-aged stands at a variety of scales (Ayres 1900; Baker 2009; Leiberg 1900). Vegetation species and forest structural diversity were high both within and between stands, and this diversity was maintained by the variable fire regimes (Arno et al. 2000; Baker 1993; Keane et al. 1998; Romme 1982; Hessburg et al. 2019). Exclusion of fire from the ecosystem by Euro-American settlers resulted in broad homogenization of Northern Rocky forests, both in stand age and in species composition (Arno et al. 2000; Baker 1993; Keane et al. 2002).

Native Americans in the Northern Rocky Mountains

Prior to the arrival of Euro-Americans, the human population of the Northern Rockies was about 30,000 people (Baker 2002). The Flathead (Salish), Pend d'Oreille (Kalispel), Nez Perce, and Northern Shoshone tribes inhabited the Northern Rockies west of the Continental Divide, whereas the Blackfoot Confederacy lived in the area east of the divide (Baker 2002; Waldman 2009). From written records and oral history interviews, these tribes are known to have regularly set fire to the landscape (Barrett and Arno 1982, 1999; Stewart 2002). They would ignite fires to influence game drives, promote forage and grazing material, maintain campsites and trails, and communicate among tribe members. Such fires were most commonly set in valley bottoms dominated by grassland ecosystems and in low-elevation ponderosa pine or ponderosa pine-Douglas-fir forests (Barrett and Arno 1982, 1999).

Because human-ignited fires were mostly confined to areas with heavy use, Native Americans very likely had a profound but localized impact on the fire ecology of the Northern Rockies. This interpretation is supported by studies that have found historical fire intervals in valley bottoms much shorter than could be explained by lightning ignitions alone (Arno 1976, 1980; Arno et al. 1997; Baker 2002). Furthermore, a study of climate and human population trends in relation to biomass burned revealed that climate variability explained much of the variability in area burned across Western forests until the late 19th century (Marlon et al. 2012). Therefore, the sharp decline in Native American burning following increased Euro-American presence beginning in the 1860s probably had the greatest impact in the low elevation, ponderosa pine–Douglas-fir stands of the Northern Rockies (Barrett and Arno 1999).

The Selway-Bitterroot Wilderness

The Selway-Bitterroot Wilderness (SBW) lies along the border of Montana and Idaho and is the third largest contiguous wilderness in the conterminous United States (Wilderness Connect 2017). It is administered by the Bitterroot, Clearwater, Lolo, and Nez Perce National Forests (fig. 2a). The topography of the SBW is extremely rugged, with over 2,500 m (8,202 ft) in relief (Rollins et al. 2001).

The climate of the SBW varies from Pacific-maritime in the northwest to continental in the southeast (Finklin 1983). Annual precipitation ranges from 1,000 mm (39 in) along the Lochsa and Selway Rivers to 1,800 mm (71 in) in the Bitterroot Mountains. Most of this precipitation falls as snow, and snowpack at the highest elevations typically persists into late June (Finklin 1983).

The SBW can be divided into three broad geographic regions. High mountains and forested valleys typify the northwestern portion of the wilderness, which contains the upper portions of the Lochsa and Selway Rivers. Due to the Pacific-maritime climate, forest stands here consist of western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), and western white pine (*Pinus monticola*). High ridges and steep canyons define the central and southern portions of the SBW, whereas the eastern portion is delineated by the Bitterroot Mountains. These steep granitic mountains are dissected with glacial valleys that run east to west (Rollins et al. 2001, 2002).

The continental climate of the central, southern, and eastern portions of the SBW results in drier vegetation communities that vary with elevation. Ponderosa pine and Douglas-fir stands characterize the lower-elevation forests, which change to Douglas-fir, western larch (*Larix occidentalis*), grand fir, and Engelmann spruce (*Picea engelmannii*) forests within mid-elevation and subalpine forests. Whitebark pine (*Pinus albicaulis*) and subalpine larch (*Larix lyalli*) dominate the highest subalpine stands. About 70 percent of this wilderness is subalpine forest (Rollins et al. 2001, 2002).

Lower elevations of the SBW burn with a range of severities, depending on fire weather and the dominant tree species, and upper elevations burn less frequently, often with high levels of mortality (Brown et al. 1994; Rollins et al. 2002). The fire season, which reaches a peak in July and August, extends from June through September, and large thunderstorms are common (Finklin 1983; Rollins et al. 2000).

Bob Marshall Wilderness Complex

Located entirely in northwestern Montana, the Bob Marshall Wilderness Complex (BMWC) comprises three contiguous wilderness areas: the Bob Marshall Wilderness, the Great Bear Wilderness to the north, and the Scapegoat Wilderness to the south. Combined with the surrounding 1 million ac (400,000 ha) of roadless land, the BMWC constitutes one of the most remote areas in the conterminous United States. The Great Bear Wilderness is managed completely by the Flathead National Forest; the Bob Marshall Wilderness by the Flathead and the Lewis and Clark National Forests; and the Scapegoat Wilderness by the Helena, Lewis and Clark, and Lolo National Forests (fig. 2b). The complex as a whole is characterized by mountainous terrain dissected by river drainages that are generally oriented north to south (Keane at al. 1994).

The BMWC straddles the Continental Divide, which strongly influences the climate of the complex. West of the divide, the climate is modified maritime, with cool wet winters

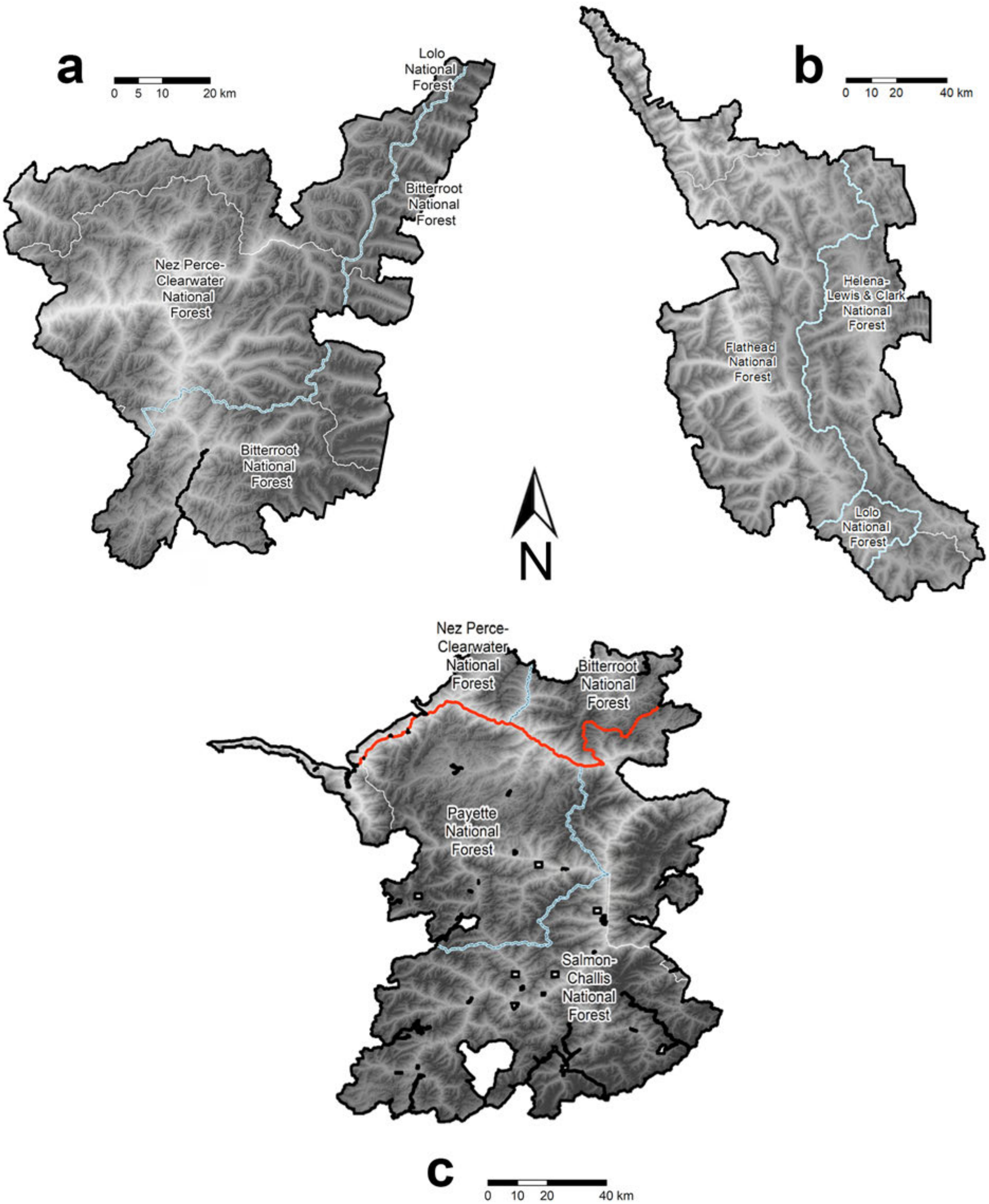


Figure 2—Administrative boundaries for a) the Selway-Bitterroot Wilderness, b) the Bob Marshall Wilderness Complex, and c) the Frank Church-River of No Return Wilderness. Light blue lines indicate a national forest boundary; thin white lines indicate a ranger district boundary. In map (c), the boundary between Region 1 to the north and Region 4 to the south is indicated by a red line.

and warm dry summers. Precipitation here can vary from 500 mm (20 in) per year in some valleys to 2,750 mm (108 in) per year on the Swan Front just west of the Bob Marshall Wilderness (Keane et al. 1994). To the east of the divide, the climate is continental, with generally colder winters and warm dry summers. Winter temperatures vary widely, and high winds occur throughout the year. On the east side, precipitation ranges from 400 mm (16 in) to 1,500 mm (59 in) per year (Keane et al. 1994).

Douglas-fir and lodgepole pine *(Pinus contorta*) tend to dominate forest stands in the low elevations of the BMWC. Western larch is also common in low-elevation forests west of the Continental Divide, whereas aspen (*Populus tremuloides*) becomes much more prevalent east of the divide. In very moist, low-elevation areas in the far northwest of the complex, western hemlock (*Tsuga heterophylla*) and western redcedar are also common. At higher elevations, lodgepole pine, subalpine fir, and Engelmann spruce become more prevalent. The highest elevation stands contain whitebark pine and subalpine larch at tree line (Cansler et al. 2018).

Most of the BMWC is cold moist forests with only small patches of ponderosa pine stands in the drier valleys and river terraces (Östlund et al. 2005). The predominant fire regime is one of mixed- to high-severity burns occurring with variable frequency (Keane et al. 2006; Teske et al. 2012). The fire season typically runs from mid-July through September (USDA-FS 2013). Near the end of the season, the polar vortex will frequently migrate south, bringing strong winds that can cause quick increases in the size and severity of fires (Goens 1990).

Frank Church-River of No Return Wilderness

The Frank Church-River of No Return Wilderness (FCRNRW) is located entirely within Idaho, just to the south of the Selway-Bitterroot Wilderness. The two wilderness areas are separated only by a narrow road, the Magruder Corridor. The FCRNRW is the largest contiguous wilderness area in the conterminous United States. Management of the FCRNRW is split between four national forests: the Salmon-Challis, Payette, Bitterroot, and Nez Perce-Clearwater (fig. 2c). As the most southerly of the Northern Rockies wilderness areas covered in this review, it is typically drier than either the SBW or the BMWC (Teske et al. 2012).

The FCRNRW is defined by extreme environmental gradients. River breaks and canyons dissect the wilderness, with dry ponderosa pine savannas, grasslands, and sagebrush dominating the lower elevations at the canyon bottoms, and lodgepole pine, subalpine fir, and Engelmann spruce characterizing the upper elevations (Teske et al. 2012). Overall, ponderosa pine-Douglas-fir forests make up most of the wilderness area (Barrett and Arno 1988). Precipitation in this rugged wilderness ranges from 380 to 430 mm (15–17 in) at the lowest elevations to between 1,300 and 1,500 mm (51–59 in) at the highest elevations in the western mountains (Finklin 1988). This precipitation falls mostly as snow (Finklin 1988).

A mixed-severity fire regime characterizes the majority of the FCRNRW. However, because it is drier than the SBW and BMWC, it has a correspondingly higher proportion of the low-severity, high-frequency fire regime (Arno 1980). The fire season tends to run from early July to mid-September (USDA-FS 2013). The lightning season runs from May to September and peaks in June through August (Teske et al. 2012). Lightning-caused fires are especially common in the river breaks where dry conditions and fine fuels are prevalent (Arno 1980). Fire management within the FCRNRW is complicated by the presence of multiple large inholdings, which are primarily located along the major river corridors (Irey 2014).

Wilderness Fire Management Timeline

We divided the history of fire management for each wilderness area into four eras: Pre-exclusion, Exclusion, Transition, and Fire Management. These eras are delineated by changes in fire management policies but are accompanied by covarying shifts in climate (Higuera et al. 2015; Morgan et al. 2008) (fig. 3). During the Pre-exclusion Era, defined as the period through 1934, fire suppression activities did occur but were largely ineffective due to the lack of personnel and technology (Koch 1935; Morgan et al. 2008; Pyne 1982) (fig. 3). This was especially true during the fire seasons of 1910, 1919, 1926, 1929, 1931, and 1934. These years were “regional fire years,” or years when area burned in the Northern Rockies region exceeded the 90th percentile due to climate and weather factors (Morgan et al. 2008).

The Exclusion Era begins in 1935, with the installation of the 10 a.m. policy, and ends between 1970 and 1979, depending on the wilderness (fig. 3). During this time, funding and equipment for firefighting were plentiful, and national policy demanded aggressive fire suppression of all new ignitions (Loveridge 1944; Pyne 1982). As a result, no regional fire years occurred during this period, and the maximum area burned in the Northern Rockies in any year was approximately 168,000 ac (68,000 ha) (Morgan 2008). An interacting effect of fire management and climate probably contributed to this relatively low acreage burned, as this period also had cooler springs and few very dry summers (Morgan et al. 2008).

The Transition Era represents a period when thinking on fire management began to shift. During this time, more wilderness and fire managers began to recognize the

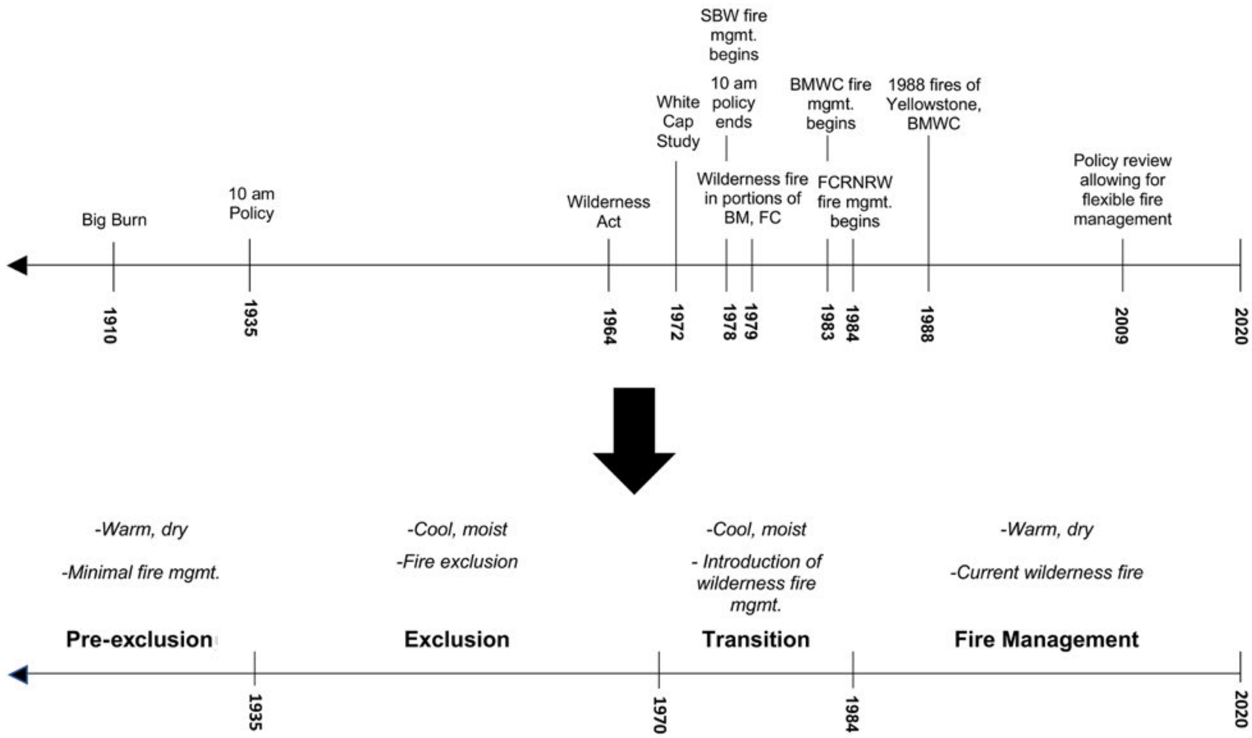


Figure 3—Timeline showing major fire events of the Northern Rockies, as well as shifts in Federal policy and forest land management plans that affected wilderness fire management in the Selway-Bitterroot Wilderness, Bob Marshall Wilderness Complex, and Frank Church-River of No Return Wilderness. These events help mark four major fire management eras: Pre-exclusion, Exclusion, Transition, and Fire Management. The timing of the shift between Exclusion and Fire Management varies by wilderness depending on when a wilderness fire management plan was drafted for the entire wilderness.

ecological importance of fire to the forests of the West (Habeck and Mutch 1973; Wright and Heinselman 1973b). The beginning dates for this period vary among the wilderness areas, depending on when each enacted a plan for wilderness fire management within a portion of the wilderness area (fig. 3). In each case, this process depended on a few key land managers recognizing the ecological role of fire and then conducting the necessary studies and planning processes to allow for fire. This period is distinct from the Fire Management Era, however, because only a small portion of each wilderness area allowed for fire management during the transition period. As a result, very little acreage burned, and for this reason we include the Transition Era with the Exclusion Era when calculating fire rotation periods.

The introduction of wilderness fire to the entire SBW in 1978 ushered in the Fire Management Era. The Fire Management Era for each wilderness begins at a different time, depending on when a wilderness fire plan was enacted for the entire wilderness area. Overall, however, this era was marked by increasing flexibility in fire management policy, allowing for increased fire management for resource benefit. Early in the fire management period, the climate remained cool and moist, which kept fire activity low and allowed wilderness fire programs to develop with relatively few large fire events. As a result, there were no regionally large fire years from 1978 through 1987, a period also marked by a dramatic increase in the wilderness land area in the Northern Rockies where natural fire was allowed (Morgan et al. 2008; van Wagtendonk 2007).

Since 2000, a hotter, drier climate has increased the length of fire seasons in the Northern Rockies, resulting in a larger annual area burned (Abatzoglou and Williams 2016; Higuera et al. 2015; Holden et al. 2018; Jolly et al. 2015; McKenzie and Littell 2017; Westerling 2016). At the same time, fire management policy has continued to evolve to allow for more management of fire for resource benefit. Most recently, a Federal policy review in 2009 removed the distinction between a suppression fire event and a fire that is managed for resource benefit. Instead, more than one objective is permissible for an individual fire, which has allowed for more flexibility in fire management both inside and outside wilderness areas (USDA and USDOI 2009).

Before 2009, however, fires managed for resource benefit were first called prescribed natural fires (PNFs) and then wildland fire use events (WFUs) (Hunter et al. 2014; van Wagtendonk 2007; Zimmerman 2018). Since 2009, any wildland fire managed with non-suppression strategies is typically called a fire managed for resource benefit (Harbour 2010). With the many changes in policies and terminology, it can be confusing to talk about fires that burn in wilderness areas. Therefore, for this review, all fires managed within a wilderness using a strategy other than full suppression will be referred to as a "wilderness fire."

NATIONAL HISTORICAL CONTEXT (Pre-1972)

The expansion of Euro-American settlement across the western United States during the late 19th and early 20th centuries drastically altered the fire regime of North America. With settlers came an initial increase in burning, partly because of fires set for land clearing—but also because of the increased spark production that accompanied expanding railroad use (Marlon et al. 2012; van Wagtendonk 2007). In addition, increased forest harvesting during this time altered fuel loads, further raising fire activity (Hessburg and Agee 2003; van Wagtendonk 2007), although domestic livestock grazing is thought to have reduced fire frequency in grassland and dry, open forest types (Hessburg and Agee 2003). Fires were fought only when they threatened settlements, so wildland fire management did not become a national issue until the establishment of the first national parks in the late 1800s. The U.S. Army assumed responsibility for fire suppression in the first national parks, such as Yellowstone, Yosemite, and Sequoia, and fire suppression remained the default option with the formation of the National Park Service in 1916 (van Wagtendonk 2007). When the Forest Service was established in 1905, fire suppression became an even higher priority, as the nascent organization viewed fires as a waste of valuable timber (Pyne 1982; van Wagtendonk 2007).

The Forest Service faced early threats to its mission from Congress members who favored utilization over conservation of natural resources; for example, the legislature tried to limit creation of additional Federal forest reserves (Egan 2009; Steen 1976). The extensive and deadly fires of 1910 gave the young organization a renewed purpose and made fire suppression a primary objective of forest management nation-wide (Arno and Allison-Bunnell 2002; Pyne 1982, 2016). The belief that all fires are bad, however, was never universally embraced. As early as 1916, the assistant district forester for California, Roy Headley, instituted a program that allowed for low-intensity fires in remote areas. He argued that unless fire threatened high-value timber, the cost of suppressing these remote fires was too high to justify compared to the economic value of the resource saved (Pyne 1982; van Wagtendonk 2007).

This debate over fire suppression in backcountry, or "low value" lands, continued throughout the first half of the 20th century. During this time, the Forest Service and other land management agencies were pursuing fire suppression. The efficacy of this approach was limited in the backcountry, however, due to the high cost of moving firefighters and equipment into the more remote areas. The Forest Service therefore organized the Low Value Land Expedition in 1932. For this trip, several Forest Service representatives from the national office and regional foresters rode through central Idaho wilderness areas on an extended pack trip. Accompanied by the forest supervisors and district rangers who managed these remote areas, the group debated whether to continue with full suppression in the backcountry or adopt the more moderate approach of allowing some fires to burn where natural barriers would contain fire spread (Larson 2016; USDA-FS 1932).

Around the same time, a similar debate was happening in the professional forestry literature. On one side was Elers Koch, who by 1935 was serving as the assistant regional forester for the National Forest System's Northern Region (Larson 2016). Koch had worked in the Northern Rockies for nearly his whole career, and helped fight the fires of 1910, 1919, 1929, and 1934. After seeing first-hand the futility of attempting to suppress big backcountry blowups, Koch opposed the buildup of roads, airplane landing fields, and telephone lines in backcountry areas in his essay The Passing of the Lolo Trail (Koch 1935). In this essay, which was published in the Journal of Forestry with support from wilderness advocates such as Bob Marshall and Aldo Leopold (Pyne 1982), Koch argued that low-value areas would be best managed without further development or fire control. Instead, they should be left "pretty much to the forces of nature" (Koch 1935).

In a rebuttal to Koch's article, published in the same issue of the Journal of Forestry (Loveridge 1935), Loveridge proposed a fire management policy at the other end of the spectrum. His proposal was to put out all fires by 10 a.m. the day after detection, an approach that was entirely possible, he argued, with the correct techniques, policies, and resources (Loveridge 1935; Pyne 1982). Eventually, Loveridge's argument prevailed. The buildup of firefighting crews and equipment that accompanied the New Deal, combined with the recent memory of the 242,000 ac (98,000 ha) that burned in the Selway Fires of 1934, led to establishment of the 10 a.m. policy in 1935 (Silcox 1935; Pyne 1982).

The National Park Service was the first agency to reconsider the policy of fire suppression on all Federally managed lands (van Wagtendonk 2007). First, in 1950, the Kaweah Basin in Sequoia National Park was designated as a research area where some fires would be allowed to burn (Rothman 2007). Then, about a decade later, in Yosemite National Park, the assistant chief ranger wrote a recommendation to allow fires to burn at elevations greater than 8,000 ft (2,400 m) because fuel loads at these elevations were rarely heavy enough to produce large fire events (van Wagtendonk 2007). Although neither of these management shifts resulted in many acres burned, they did reveal a shift in thinking. For both, the rationale expanded beyond the economics of firefighting to include the ecological benefits of fire (van Wagtendonk 2007).

This change in thinking was echoed in the 1963 Leopold Report, in which an advisory committee commissioned by the Secretary of the Interior recommended that national parks take an ecosystem approach to park management (Leopold et al. 1963). This recommendation opened the door for fire management beyond suppression, and by 1972 Sequoia, Kings Canyon, Saguaro, and Yosemite National Parks had all adopted some form of wildland fire management for resource benefit (Hunter et al. 2014; van Wagtendonk 2007).

Around the same time, researchers began exploring the ecological role of fire in wilderness areas and documenting the importance of fire to vegetation communities (Gabriel 1976; Mutch 1970; Romme 1982). A special issue of Quaternary Research in 1973, based on a series of papers presented in a symposium at the joint Ecological Society of America and American Institute of Biological Sciences annual meetings in August 1972, was dedicated to the role of fire as an ecosystem process and the future of fire management in wilderness ecosystems (Wright and Heinselman 1973b). The introduction to this special issue outlined the critical role of fire in reducing fuel accumulation, shaping vegetation communities, and regulating ecosystem processes such as nutrient cycling, and culminated in an appeal to integrate prescribed and naturally ignited fire into management of wilderness areas (Wright and Heinselman 1973a).

This larger shift in how fire and fire management were viewed, combined with the passage of the 1964 Wilderness Act, paved the way for the Forest Service to begin reconsidering the 10 a.m. policy. In 1969, a wilderness workshop was assembled in Missoula, Montana to discuss the possibility of allowing fire in wilderness areas (van Wagtendonk 2007). The White Cap Study in the Selway-Bitterroot Wilderness, contemporaneous with this movement in the scientific community, was the beginning of fire management for resource benefit in Forest Service wilderness areas across the United States.

Selway-Bitterroot Wilderness

Pre-exclusion (through 1934)

A variety of data sources have been used to reconstruct the fire regime of the Selway-Bitterroot Wilderness prior to aggressive fire exclusion. In 1898, the U.S. Geological Survey (USGS) awarded John B. Leiberg a contract to survey the Bitterroot Forest Reserve. Leiberg's report details the geology, vegetation, and fire history of the area, which encompasses the modern-day SBW. A map of fire-affected areas within the reserve, which is much larger than the current wilderness, suggests that very little of the area was unburned from 1719 to 1898 (Leiberg 1900). From Leiberg's maps, Habeck (1977) determined that approximately 35 percent of the Selway River drainage burned between the 1860s and 1898.

Fire scar studies in this area also reveal the dominant role of fire in shaping this landscape. Within the Bitterroot National Forest, tree scars provide evidence of a frequent fire return interval for both ponderosa pine and Douglas-fir habitats (averaging once every 6–20 years), whereas vegetation types found on higher-elevation, moister sites burned less frequently (averaging once every 20–40 years) (Arno 1976).

Geospatial data for the SBW also indicate extensive fire during the Pre-exclusion Era (fig. 4). The fire atlas data indicate that 1,095,203 ac (443,213 ha) burned between 1889 and 1934 (Gibson 2014; Morgan et al. 2017). This geospatial fire history suggests that the fire rotation period (FRP), or the time necessary to burn an area equal in size

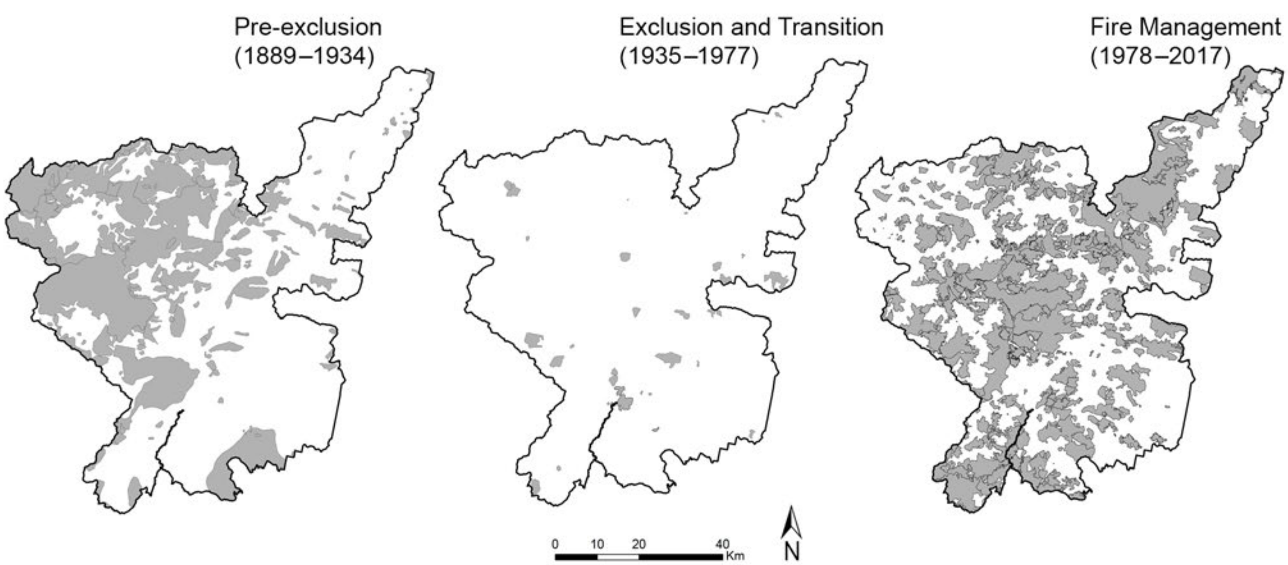


Figure 4—Fire perimeters for the three fire management periods in the Selway-Bitterroot Wilderness in northwestern Montana and central Idaho.

to the study area, was 55 years for the entire SBW during the pre-exclusion period (table 1).

Native American populations in the Northern Rockies region were probably largest during the Pre-exclusion Era, especially before Euro-Americans arrived in greater numbers in the 1860s (Barrett and Arno 1999). Native American land use within this wilderness area can be identified from studies of bark-peeled trees. These trees bear a distinctive scar from the Native Americans' harvesting of the inner bark, which provided an important source of fiber and vitamin C in a diet otherwise heavy in animal protein (Östlund et al. 2005, 2009). In the Bitterroot Mountains, sampling of trees containing these bark peel scars revealed Native American resource use in the area as recently as the 1930s, thereby suggesting that Native Americans may have shaped the fire ecology of the low-elevation forests into the early 20th century (Josefsson et al. 2012). Barrett's (1981) research into the primary Native American living and traveling areas suggests that Native American influence on fire activity was very likely greatest along the east slope of the Bitterroot Mountains.

Table 1—Area burned (acres) and fire rotation period (years) for the three wilderness areas of interest, by management era, according to the fire perimeter data available from existing fire atlases. Fire rotation period is defined as the number of years required to burn an area equivalent to the total wilderness area.

	Pre-exclusion[1]	Exclusion[2]	Fire Management[3]
Acres			
Selway-Bitterroot Wilderness	1,095,203	25,795	1,427,457
Bob Marshall Wilderness Complex	999,208	5,140	1,168,455
Frank Church-River of No Return Wilderness	370,322	178,289	6,622,778
Fire rotation period (years)			
Selway-Bitterroot Wilderness	55	2,194	37
Bob Marshall Wilderness Complex	46	9,230	29
Frank Church-River of No Return Wilderness	293	635	12

1 Pre-exclusion dates for each wilderness are: 1889–1934 for the Selway-Bitterroot Wilderness (SBW), Bob Marshall Wilderness Complex (BMWC), and Frank Church-River of No Return (FCRNRW).

2 Exclusion dates for each wilderness area include Transition period and are: 1935–1977 (SBW), 1935–1982 (BMWC), 1935–1983 (FCRNRW).

3 Fire management dates for each wilderness area are: 1978–2017 (SBW), 1983–2017 (BMWC), 1984–2017 (FCRNRW).

Fire Exclusion (1935–1969)

The SBW had dramatically less fire activity after implementation of the 10 a.m. policy, coupled with the cooler, wetter weather and climate typified by the fire-exclusion period (fig. 4). During this period, only 25,795 ac (10,439 ha) of wilderness area burned, resulting in a dramatically increased FRP of 2,194 years (table 1). Forest Service fire records indicate that lightning-ignited fires were still common, but most were suppressed before exceeding an acre (Habeck 1977). Fire suppression resulted in greater vegetation homogeneity, as denser, older forest stands replaced various early-successional stages (Habeck 1977).

Transition (1970–1977)

The concept of wilderness fire management in national forests was born in the SBW. Specifically, wilderness fire management began with some radical thinking by a few Forest Service employees who were questioning the wisdom, practicality, and ethical implications of suppressing fire in wilderness areas, and saw the SBW as a good testing ground for a new approach to wilderness fire management.

The spark of the idea came from William "Bud" Moore, director of fire control for the Northern Region between 1967 and 1974. Moore had grown up and lived nearly his whole life in western Montana (Moore 1996). He had no formal training in forest or fire ecology, but he recognized from his hunting and trapping trips that the exclusion of fire from the Northern Rockies had fundamentally changed the forest and fuels structure of the region (Smith 2014). He also recognized that the Wilderness Act of 1964 made fire suppression in the wilderness "practically illegal" (USDA-FS 2002b), as it called for wilderness areas to be "affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable" (Wilderness Act 1964). He therefore began to push for a more ecologically informed view of wilderness fire management in the Northern Rockies.

To achieve this goal, Moore gathered a team that, including him, became known as the "White Cap Five." On the team was Bill Worf, chief of recreation and lands for the Northern Region. Worf had argued for an end to complete fire exclusion on the premise that it was ecologically unnatural (Smith 2014). The team also included Orville Daniels, who at the time was the forest supervisor for the Bitterroot National Forest. Daniels had an interest in the ecological role of fire and was willing to take the risk of allowing a nonsuppression approach to fire within his jurisdiction (USDA-FS 2002b). Rounding out the team were Dave Aldrich and Bob Mutch, whom Daniels hired to co-lead the field and research component of the project. Aldrich had worked in fire control in Idaho, and Mutch had been a smokejumper and then a research scientist at the Fire Sciences Laboratory (Fire Lab) in Missoula. While at the Fire Lab, Mutch had conducted research showing that some plant communities actually depended on fire for survival and reproduction, and therefore burned more readily than other plant communities (Mutch 1970). This team was fully assembled by the summer of 1970 (Smith 2014).

Moore and Daniels selected the White Cap and Bad Luck drainages of the SBW as the location for what became known as the White Cap Study because they represented a microcosm of the wilderness in terms of topographical features and vegetation communities. These drainages had the additional advantage of a “granite firewall” to the east; these high rock outcrops made it easier to contain fires within the drainage (USDA-FS 2017).

Beginning in August 1970, Aldrich and Mutch conducted extensive surveys of the vegetation and fuels within the White Cap Study area. They established 380 plots for these surveys, many of which were remeasured each year over the 3-year planning period. In addition to the vegetation and fuels surveys, Aldrich and Mutch listed every plant species within the study area, conducted bird species inventories, and collected and described the hydrologic and geologic features of the drainage (Smith 2014).

After these years of data collection and planning, Aldrich and Mutch devised a fire management plan for the White Cap Study area. They divided the area into five ecological land units (ELUs), which were defined based on similarities in topography, vegetation, fuels, and fire potential (Mutch 1974; USDA-FS 2002b). Each ELU received its own fire management prescription, which provided rules for when to allow fire in each of the zones (Mutch 1974) (table 2). Beyond providing a management plan for the White Cap Study area, these guidelines were intended as a model for fire prescription development in wilderness areas across the United States (Aldrich and Mutch 1973; Moore 1974; Smith 2014).

Following the approval of the White Cap fire management plan by the Forest Service’s national office in August 1972, a lightning strike ignited a fire in the shrubfield unit of the Bad Luck drainage. Because it was within the “observation” prescription for that area, the fire was allowed to burn with no suppression or direct management actions. The wet conditions of that season helped the Bad Luck Fire to burn itself out at a size of approximately 24 ft by 24 ft (7 m by 7 m) (Mutch 1974) (fig. 5).

The summer of 1973, however, was much hotter and drier than the year before. Lightning struck this time on August 10 in the ponderosa pine-savanna zone within the Fitz Creek drainage. The prescription for this ignition, named the Fitz Creek Fire, was suppression along the east flank of the fire where it threatened to cross the study area boundary, while the rest of the fire would be observed (Daniels 1974; Mutch 1974) (fig. 5).

Table 2—Prescription for each ecological land unit (ELU) within the White Cap Study area in the Selway-Bitterroot Wilderness, as it was developed in 1972. The BUI refers to buildup index, a fire danger metric used to measure fuel dryness. Reproduced, with minor modifications, with permission from Mutch (1974).

ELU	Description (from Yurich 1976)	Suppression	Observation	Observation + Suppression
Shrubfield	Warm, dry ecosystem Composed of shrub vegetation and herbaceous understories Results from repeated, short interval, high intensity fires.	Hunting season: BUI > 170 Along study boundaries	Prehunting season Hunting season: BUI < 170 BUI < 170	Fires approaching Wapiti Creek Range
Ponderosa pine savanna	Hot, dry ecosystem Low elevations, most commonly on steep south and southwest aspects PIPO is the dominant, climax tree species with an understory composed of grass, forb, and shrub species. Most flammable unit: low intensity, high frequency regime.		BUI < 170	BUI > 170
Ponderosa pine–Douglas-fir	Warm, dry ecosystem South facing slopes PIPO tends to be skewed to older aged trees, whereas PSME trees tend to be found in all age classes. Open and diverse shrub layer	< 4500’ elevation	> 4,500’ elevation, BUI < 170	> 4,500’ elevation, BUI > 170
North slope	Warm, wet ecosystem North facing slopes up to 6,000 feet Composed of very diverse vegetation communities and relatively continuous cover High fuel loadings; is defined by a low frequency, stand replacement fire regime.	Along study boundaries BUI > 170 at Peach Creek drainage	West of Peach Creek drainage Upper White Cap unit	BUI > 170 when fires approaching Peach Creek buffer
Subalpine	Cold, wet ecosystem Dominated by alpine fir and Engelmann spruce, with whitebark pine and alpine larch also present. Hosts a low frequency fire regime, fires will range from low intensity spot fires to high intensity, stand replacing fires	Along study boundaries BUI > 170 at Bitterroot Crest passes	Season-long	BUI < 170 when fires approaching Bitterroot Crest passes

On August 15, wind conditions caused the Fitz Creek Fire to ignite outside the main perimeter across White Cap Creek, which served as the boundary for the White Cap Study area. This new spot fire was outside the study area and therefore not included

Figure 5—Early wilderness fires in the Selway-Bitterroot Wilderness: a) the Bad Luck Fire and b) the Fitz Creek Fire (USDA Forest Service photos by Bob Mutch,).

under the fire management plan. It was given its own name, the Snake Creek Fire, and was managed with full suppression tactics (Daniels 1974). Ultimately, Snake Creek was contained and controlled at 1,600 ac (650 ha) on August 21. Fall rains extinguished the Fitz Creek Fire on September 21 at approximately 1,200 ac (500 ha) (Daniels 1974). The Fitz Creek Fire burned across the ponderosa pine savanna, shrubfield, and ponderosa pine–Douglas-fir ELUs (Mutch 1974). Five other fires were ignited by lightning that summer and were managed with observation, observation and suppression, or suppression. All remained under 0.25 ac (0.10 ha) (Mutch 1974).

The fires of 1973 were the first big test of the White Cap fire management plan. That summer provided informative data on wildfire impacts on vegetation structure, fuel loads, and wildlife habitat, as well as important lessons for wilderness fire managers. The Fitz Creek Fire created heterogeneity on the landscape; unburned islands of forest were interspersed among patches burned with low to high severity (Daniels 1974). Within the burned areas, fuel loads were generally reduced immediately after the fire except in young Douglas-fir stands, where scorched needles more than doubled surface litter loads (Mutch 1974). Shrubs quickly resprouted, and both mammals and birds were observed within the burn perimeter during and immediately after the fire (Mutch 1974).

Field crews sampled fuel levels and vegetation data from 1973 through 1977, and again in 1980, on permanent plots within the burn perimeter (Smith 2014). Of the initial 380 plots sampled to produce the fire prescriptions, 100 were resampled after the reintroduction of fire. These surveys increased understanding of the long-term effects of wildland fire in fire-dependent ecosystems, both for fire managers and the public (Smith 2014).

The 1973 fire season also provided the first example of a successful Forest Service wilderness fire management approach. The Fitz Creek Fire and the Snake Creek Fire boosted land managers' confidence in the prescriptions assigned to the ELUs, as these two fires had burned through four of the five vegetation types in the White Cap Study area (Daniels 1974). They also learned that in fire management decisions, fire behavior predictions allowed for a better assessment of risk than consideration of only the number of acres burned (Daniels 1974).

After the 1973 fire season, the White Cap managers were able to make recommendations to managers of other wilderness areas who were attempting to institute a fire management plan. They recommended: (1) integrating the fire management plan into the overall land-use plan, (2) promoting interagency cooperation when managing wildfires, (3) informing the public on the natural role of fire, (4) educating fire specialists and land managers on the ecological role of fire, and (5) incorporating current knowledge on fire ecology into institutional guidelines and policies (Moore 1974).

Fire Management (1978–present)

In 1976, the Bitterroot, Clearwater, Lolo, and Nez Perce National Forest managers relied on the lessons learned from the 1973 fire season in their draft of a fire management plan for the entire SBW (Yurich 1976). This plan was approved in 1978, the same year that the 10 a.m. policy was abandoned at the national level (Pyne 1982). The new Forest Service policy on wildfire allowed for managing active fires for resource benefit, rather than implementing a suppression-only approach, especially in wilderness and backcountry areas.

The 1979 fire season, and the Independence Fire on the Moose Creek Ranger District in particular, provided the first big test of the new SBW fire management plan (Keown 1985). During the summer of 1979, 59 fires ignited on the Moose Creek Ranger District, 55 of which were lightning caused. The Independence Fire, one of the 10 lightning-ignited fires that were then designated as "prescribed natural fires," eventually burned more than 16,300 ac (6,600 ha) over 106 days (Keown 1985).

The sheer size and duration of the Independence Fire tested the ability of the SBW fire managers to manage a wilderness fire. Within the projected fire perimeter, three trail bridges and a private landholding were threatened, requiring suppression tactics

(Keown 1985). Rothermel fire models, which were used to predict fire intensity and rate of spread, proved to be crucial to planning suppression actions and burnouts for point protection (i.e., areas burned to allow for protection of highly valued resources), thereby strengthening managers' confidence in these models (Keown 1985). Management of the Independence Fire also met the ecological goals outlined in the fire management plan, as vegetation diversity subsequently increased in response to the varied timing and severity of the fire (Keown 1985).

Moreover, the Independence Fire taught managers the importance of humility when dealing with wilderness fire events (George Weldon, retired Forest Service, Missoula, MT, personal communication, December 5, 2018). Although the fire models helped with planning some suppression activity, there was ultimately no way to predict the large size of the fire when it started in early July. Fire managers who worked on the Independence Fire gained the understanding that fire is unpredictable, and that wilderness fire managers must both accept this risk and minimize it to the greatest extent possible with the tools available (George Weldon, retired Forest Service, Missoula, MT, personal communication, December 5, 2018).

The early years of fire management within the SBW were controversial but also provided the crucial testing ground for wilderness fire management. Not only did the program survive challenging events such as the escape of the Snake Creek Fire, but the early successes in managing relatively large fires with no loss of human life or property showed that allowing wilderness fire was not as heretical an idea as once thought. With these successes, other fire managers now had a roadmap for developing a wilderness fire management program that would be based on careful data collection and planning. In addition, the research in the White Cap Study area provided managers with data that showed wilderness fires could achieve the ecological objectives of increasing landscape heterogeneity and reducing fuels on the ground (Smith 2014). In short, this experiment within the SBW demonstrated to the fire management community and the public that fire did not mean death for forests—but renewal.

Little fire activity occurred in the SBW during the 1980s and 1990s, with two major exceptions. As was the case for most of the Northern Rockies, 1988 was a highly active fire year for the SBW. More than 49,000 ac (20,000 ha) burned (Brown et al. 1994)—an area more than double the total amount burned since the introduction of wilderness fire management in 1972. In that same year, fire activity in Yellowstone National Park spurred a national fire policy review for the following year. This review introduced more complexity and deliberation into the decision-making process that determined whether to manage an ignition as a wilderness fire (Byron Bonney, retired Forest Service, Missoula, MT, personal communication, November 27, 2018). This complexity, however, was important for building the wilderness fire program, as it required fire managers to think through the possible consequences of fire behavior and more completely consider safety and values at risk (Byron Bonney, retired Forest Service, Missoula, MT, personal communication, November 27, 2018).

The public reaction to the 1988 fires led to greater hesitancy around wilderness fire management within the Forest Service's regional and national offices, especially during large fire years (Jack Kirkendall, retired Forest Service, Missoula, MT, personal communication, December 3, 2018). Until the mid-1990s, fire managers often labeled a fire as a suppression fire but took no direct management action against the fire, essentially treating it as a wilderness fire event (Byron Bonney, retired Forest Service, Missoula, MT, personal communication, November 27, 2018).

The summer of 1994 was another exceptional season during these otherwise quiet decades. This was the most active fire season to date for the Northern Region, and the high activity in the SBW during August came on the heels of the South Canyon Fire in the Grand Junction Bureau of Land Management District in Colorado. The South Canyon Fire started in July 1994 and would kill 14 firefighters, drawing greater national attention to firefighter safety (Bonney 1998; van Wagtendonk 2007). In response to the high national preparedness levels and drought conditions for the SBW, managers declared all ignitions in August 1994 to be suppression events. But because of the increased commitment to firefighter safety and the scarcity of firefighting resources across the Nation, many of these suppression events on the SBW were managed with alternative suppression strategies that largely let the fires burn within the wilderness boundary (Bonney 1998).

The South Canyon Fire prompted another major review and update of national wildland firefighting policy. The review, issued in 1995, reaffirmed management of wildfire for resource benefit while catalyzing the development of guidelines that emphasized the importance of planning explicitly for fire. These updated guidelines included recommendations that all Federal land units subject to wildland fire develop specific plans for appropriate fire response, as well as a description of the protocols and plans necessary for land management agencies to manage fire for resource benefit (USDA and USDOI 1995). Ultimately, having these guidelines in place revitalized wilderness fire management across the Nation because it gave managers an explicit and sanctioned pathway for decision making (van Wagtendonk 2007).

Wilderness fire management in the SBW, as in other Federal wildernesses, soon underwent a resurgence. When Dave Campbell took over as the district ranger for the West Fork Ranger District of the Bitterroot National Forest in 1997, he brought with him the vision of the White Cap Five, and that of Bud Moore in particular. Inspired by this vision, he felt compelled to continue Moore's legacy of letting some wilderness fires burn. This drive, combined with the revitalization of wilderness fire management following the policy review of 1995, resulted in management of many more fires for resource benefit on the SBW (Bob Mutch, retired Forest Service, Missoula, MT, personal communication, November 19, 2018).

According to Campbell, the number of fires or acres burned should not serve as a hard cut-off for the go/no-go decision that happened after each lightning ignition. Instead, he considered each fire individually as a potential tool to accomplish resource-management goals (Dave Campbell, retired Forest Service, Hamilton, MT, personal communication, November 28, 2018). Because of this commitment to fire as a natural part of the ecosystem, over 300 lightning-ignited fires were managed as wilderness fires in the SBW during Campbell's 17-year tenure (Bob Mutch, retired Forest Service, Missoula, MT, personal communication, November 19, 2018).

While Campbell served as district ranger, there were some large fire years that both challenged and changed wilderness fire management in the Northern Rockies. In 1998, for example, 20 fires were managed for resource benefit on the West Fork District alone (Dave Campbell, retired Forest Service, Hamilton, MT, personal communication, May 21, 2018). As these fires grew, questions emerged about how to deal with fires that crossed the Magruder Corridor, a road that separates the SBW from the FCRNRW and is classified as a nonwilderness area (Dave Campbell, retired Forest Service, Hamilton, MT, personal communication, May 21, 2018). Technically, these fires had "escaped" the wilderness, even if just briefly, making managers wonder whether the fires could still be managed as wilderness fire events.

Additionally, at the time every wilderness fire was assigned a "maximum manageable area" (MMA), which was defined as a geographic boundary that set the limits of a wilderness fire. Management plans required full suppression of a fire once it crossed the MMA boundary. The fires of 1998, however, caused managers such as Campbell to question why an MMA boundary should arbitrarily be placed at a wilderness boundary, especially when crossing that boundary posed little risk to human life or property. Campbell and others saw first-hand the limitations of using political boundaries, rather than physical ones such as ridgetops, to identify fire management goals and reduce overall risk.

The fire season of 2000 was another big year for the Northern Region, and particularly for the populated Bitterroot Valley of western Montana. The 2000 fire season followed 3 years of dry weather and above-average temperatures. That summer, many fires started, then spread quickly across the Northern Rockies following a series of lightning storms and strong winds (Harmon et al. 2001). In what became known as the Valley Fire Complex, 307,000 ac (124,200 ha) burned on the Bitterroot National Forest alone, of which 3,200 ac (1,300 ha) were in the SBW (USDA-FS 2000). Outside the forest, 49,000 ac (19,800 ha) burned, and 240 structures were destroyed (Backus 2005; USDA-FS 2000).

Fire behavior in 2000 differed dramatically between wilderness and nonwilderness areas. While most of the fires near Sula and Darby in the Bitterroot Valley were high-severity, plume-dominated events, the fires within the wilderness burned in a mosaic pattern (Stu Hoyt, retired Forest Service, Hamilton, MT, personal communication, November 28, 2018). In many cases, the 2000 fires ran into previously burned areas, which either slowed or stopped fire spread (USDA-FS 2000, 2002b). As a result, not a single fire escaped the wilderness boundary, which was a serious concern for those fighting fires in the valley (Orville Daniels, retired Forest Service, Missoula, MT, personal communication, November 5, 2018). These anecdotes from the Valley Fire Complex suggested that the wilderness fire program was effective at reducing fuel loads and fire spread, a preliminary finding that has since been supported by spatial analysis of the limiting effects of previous fire on subsequent wildland fire spread (Parks et al. 2014, 2015d; Teske et al. 2012).

The most active fire year in the SBW during Campbell's tenure as district ranger was 2005. Once again, Campbell placed a heavy emphasis on allowing fires to burn, and by the end of the fire season he had approved 50 fires as wilderness fires (USDA-FS 2017). The neighboring FCRNRW similarly had an active fire season, during which at least 20 fires were managed for wildland fire use (Parks 2006).

These dozens of fires brought to a head the questions about the efficacy of the MMA designation raised during and after the 1998 season. A working group on wildland fire use was called together in 2005 to address management decisions in the SBW, FCRNRW, and the portions of surrounding national forests that allowed for wildland fire management for resource benefit. The working group ultimately designated a "mega-MMA," or a boundary drawn around the approximately 4 million ac (1.6 million ha) of land between and surrounding the two wilderness areas that allowed for wildland fire management for resource benefit. With this large MMA, a fire would not be reclassified from a wilderness fire to a wildfire, and therefore suppressed, just because it crossed an administrative boundary (Parks 2006).

The decision to create the mega-MMA, however, also raised some concerns about how managers would make a no-go decision on a fire within such a large burnable area. Opponents of this approach felt that the situation could easily get out of hand (Parks

2006). Proponents of the mega-MMA emphasized that coordination and communication among the various administrative units, combined with careful consideration of each fire event individually, would ensure the success of this management approach (Parks 2006). Indeed, the mega-MMA proved useful in 2005 for the SBW and FCRNRW; it ultimately was a good precedent for management of wilderness fires that crossed boundaries and therefore required effective collaboration and communication (Parks 2006). Lessons learned from development and implementation of the mega-MMA classification were reflected in the 2009 Guidance for Implementation of Federal Wildland Fire Management Policy (USDA and USDOI 2009). Within this policy guideline, the distinction between a wildland fire use event and a wildfire was eliminated, leaving only two types of classification for fires: prescribed fire and wildfire (USDA and USDOI 2009). Additionally, any wildfire could be managed for multiple objectives, depending on the characteristics of the fire and the values at risk (USDA and USDOI 2009). As a result, fire management became more flexible, both inside and outside wilderness areas.

In the current era, fire management in the SBW requires acknowledging that not all fires will be small, low-intensity fires. Instead, large, high-severity fires like those that drew national attention during 1988 in Yellowstone National Park return periodically to the SBW. As a result, a considerable area burns within the SBW at least once every several years (Dave Campbell, retired Forest Service, Hamilton, MT, personal communication, May 21, 2018) (fig. 4). As longer-duration and larger wilderness fire events become more common, the SBW serves as an enduring example of fire management for resource benefit.

The SBW's long history of managing fire for resource benefit made wilderness fire management easier within its boundaries during the early 2000s, as previously burned areas often slowed or stopped the spread of active fires (Parks et al. 2014; Teske et al. 2012; USDA-FS 2017). Furthermore, the extensive experience with wilderness fire has created a culture within the SBW where the natural process of fire is valued, both as a land management tool and as an end unto itself. As a result, suppression is viewed as a missed opportunity to capitalize on the ecological role of fire (Beckman 2008). The rich history of wilderness fire in the SBW has made it an important laboratory, both for studying the effects of wilderness fire in a Northern Rockies ecosystem and for identifying best practices for managing fire within a wilderness area.

Current Conditions

Since the White Cap Study, fire has played a prominent role on the landscape of the SBW (figs. 4, 6). Almost half of the wilderness area burned at least once since 1978, and approximately 11 percent burned multiple times (table 3). Fire in this ecosystem has

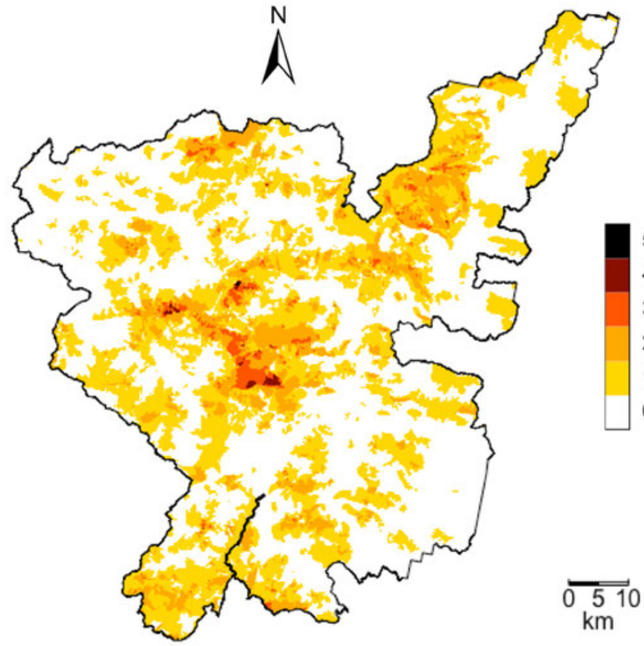


Figure 6—Number of burns on the landscape for the Selway-Bitterroot Wilderness from 1978 through 2017.

Table 3—Fire frequency analysis for the Selway-Bitterroot Wilderness (SBW), Bob Marshall Wilderness Complex (BMWC), and Frank Church-River of No Return Wilderness (FCRNRW) during the wilderness fire management period.

Times burned	Selway-Bitterroot Wilderness (1978–2017)	Bob Marshall Wilderness Complex (1983–2017)	Frank Church-River of No Return Wilderness (1984–2017)
Area burned (acres)			
0	745,465	999,971	522,831
1	445,042	509,126	367,073
2	135,975	93,421	954,487
3	19,484	9,279	304,901
4	2,204	153	159,082
≥5	77	-	50,985
Area burned (%)			
0	55	62	22
1	33	32	16
2	10	6	40
3	1	1	13
4	0.16	0.01	7
≥5	0.01	-	2

had a marked impact on vegetation composition, structure, and heterogeneity. At the landscape scale, vegetation mosaics in the SBW have replaced the even-aged, homogeneous stands that tend to dominate in the absence of fire. This heterogeneity is readily apparent within the White Cap Study area, which has had several fire events since 1972 (fig. 7a). Across the wilderness, the prevalence of vegetation mosaics is evident wherever wilderness fires have burned over the past several decades (fig. 7b).

Figure 7—Two views that illustrate the forest structural heterogeneity in the Selway-Bitterroot Wilderness promoted by five decades of wilderness fire management: a) within the White Cap drainage, where wilderness fire management within the USDA Forest Service was born; and b) a bird's-eye view of the landscape mosaics, taken during the active fire season of 2007 (USDA Forest Service photos by Carol Miller).

At the stand scale, the impacts of fire are also clearly evident, as it has created open, park-like stand structure in many ponderosa pine stands at low elevations (fig. 8a). Similarly, in western larch forests, where a mixed-severity fire regime has historically prevailed, the understory has been cleared out in many locations, while the large, fire-resistant trees tend to remain (fig. 8b).

Bob Marshall Wilderness Complex

Pre-exclusion (through 1934)

The Bob Marshall Wilderness Complex was surveyed as part of the Lewis and Clark Forest Reserve late in the 19th century for the USGS. H.B. Ayres, who conducted the survey in 1899, visually estimated that 914,000 ac (370,000 ha) of the 2,965,000-ac (1,200,000-ha) reserve had burned within the past 40 years. He acknowledged, however, that this number probably underestimated the total area affected by past fires. A report on forest fire in the Bob Marshall Wilderness written in the 1960s further underscores

Figure 8—The stand structure resulting from a resumed fire regime in a) ponderosa pine and b) mixed-conifer, ponderosa pine-western larch forests of the Selway-Bitterroot Wilderness (Courtesy photos by Anna Sala, University of Montana).

the importance of fire to the ecology of the BMWC. In the report, Steele (1960) highlights the effects of the large fires of 1889 and 1910, which he estimates burned 35 percent of the land in the Bob Marshall Wilderness.

As in the SBW, Native Americans very likely influenced the fire regime in the BMWC until the late 19th century and early 20th century. Ayres (1900) refers to Native Americans as a source of ignition for the fires he observed and noted that signs of burning were frequent along commonly used trails and campsites. In addition, dating of bark-peeled trees suggests that Native Americans actively used the BMWC between 1665 and 1938, with use peaking from 1851 through 1875 (Östlund et al. 2005). Again, fire use was typically clustered along high-use campsites and travel corridors.

A tree-ring analysis further supports the active role of fire in the BMWC prior to fire exclusion. Gabriel (1976) conducted this analysis using both fire scars and stand ages to determine the fire history of the Danaher Creek drainage in the southeastern portion of the Bob Marshall Wilderness. The analysis estimated that the natural FRP for the Danaher Creek drainage, from about 1749 through 1946, was approximately 150 to 200 years (Gabriel 1976). These fires were of mixed severity and variable extent; some years were characterized by large, severe fires and others by less severe, surface fires. A large fire occurred somewhere in the Danaher Creek drainage each decade of the 19th century (Gabriel 1976).

Our geographic information systems (GIS) analysis suggests similarly extensive fires in the pre-exclusion period (fig. 9), with a natural FRP of only 46 years (table 1). The lower estimate from the GIS analysis very likely reflects a difference in spatial extents. Our

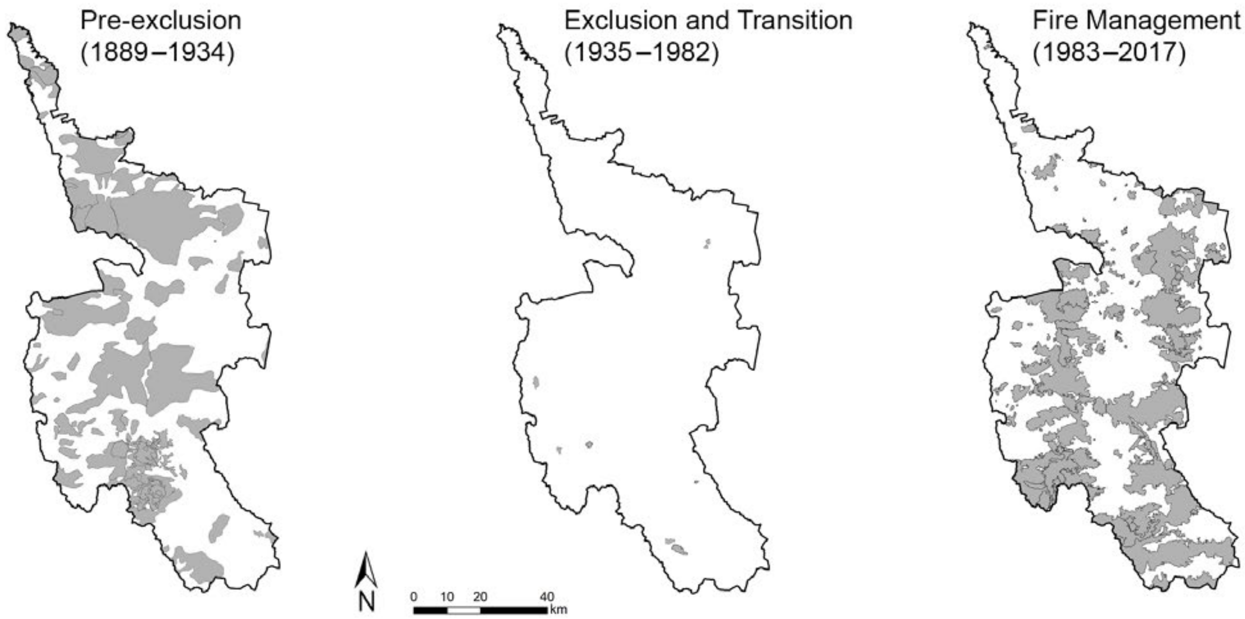


Figure 9—Fire perimeters for the three fire management periods in the Bob Marshall Wilderness Complex in northwestern Montana.

estimate applies to the entire BMWC, whereas Gabriel (1976) focused on the relatively cool and moist, and therefore less fire-prone, Danaher Creek drainage.

Fire Exclusion (1935–1973)

The BMWC had a dramatic decrease in area burned following the implementation of the 10 a.m. policy in 1935 (fig. 9). The policy was successful in the BMWC due to the buildup of trails, telephone lines, and lookouts (Steele 1960). Because of fire suppression efforts, combined with a cooler and wetter climate, only 5,140 ac (2,080 ha) burned in the BMWC from 1935 through 1982, resulting in an FRP of 9,230 years (table 1). Like the SBW, lightning ignitions remained common within the BMWC, with approximately 220 ignitions in the BMWC between 1940 and 1960 (Steele 1960). Of those, 188 were kept to less than 0.25 ac, and only 1 grew to over 100 ac (40 ha) (Steele 1960).

This exclusion of fire from the BMWC resulted in changes to forest structure in certain forest types. These changes were most dramatic on the east side of the Continental Divide, where fire exclusion promoted encroachment of extensive grasslands by lodgepole and limber pine (*Pinus flexilis*) (Steele 1960). Fire exclusion also led to a decline in the number of ponderosa pine parklands along the South Fork of the Flathead River west of the Continental Divide (Arno et al. 1995; Keane et al. 2006; Steele 1960). Frequent, low-severity fires, some of which Native Americans ignited, had previously maintained this forest type by burning through and reducing undergrowth density. With the exclusion of fire, lodgepole pine and Douglas-fir began to establish, and their presence increased the risk of crown fire reaching the older ponderosa pine trees (Larson et al. 2013). Overall, homogeneity of forest structure increased, as the fire-driven stand openings and mosaics were replaced by larger, even-aged stands of relatively shade-tolerant species (Arno et al. 2000; Steele 1960).

Transition Period (1974–1982)

In 1974, 2 years after the White Cap Study in the SBW, Orville Daniels migrated from the Bitterroot National Forest to take over as the forest supervisor for the Lolo National Forest. Building on the momentum and lessons from the White Cap Study, Daniels wrote a fire management plan for the Lolo National Forest, including the sections of the BMWC that fall within the national forest. In drawing up the plan, Daniels followed the steps prescribed by the White Cap Study, as the plan relied on extensive data collection and careful planning for each land management unit (Orville Daniels, retired Forest Service, Missoula, MT, personal communication, November 5, 2018).

The Lolo National Forest fire management plan was enacted in 1978, following the repeal of the 10 a.m. policy (Pyne 1982). In 1979, one fire outside the BMWC was managed for resource benefit under this plan. Ultimately, however, the fire was suppressed at a few thousand acres due to concerns that it would affect sensitive hydrologic areas (Orville Daniels, retired Forest Service, Missoula, MT, personal communication, November 5, 2018).

The shift in national policy that allowed for management of wildfire for resource benefit in 1978 inspired land managers within the BMWC to begin working on fire management plans for other portions of the wilderness complex. In 1981, the Scapegoat-Danaher fire management plan was put into effect for the southern portion of the wilderness complex, an area that included land from the Helena, Lewis and Clark, Flathead, and Lolo National Forests. Sonny Stiger, the fuels specialist for both the Helena and Lewis and Clark National Forests, conducted extensive ecological inventories in 1979 and 1980 that laid the groundwork for this plan (Norman Kamrud, retired Forest Service, Missoula, MT, personal communication, October 18, 2018). Stiger and John Robertson, a fire staff officer for the Flathead National Forest, together wrote most of the Scapegoat-Danaher plan. The four forest supervisors for this area approved the plan in 1981 (Norman Kamrud, retired Forest Service, Missoula, MT, personal communication, October 18, 2018).

The summer of 1981 was also the first time that a wilderness fire was allowed to burn within the BMWC. The Cigarette Creek Fire ignited on the Lewis and Clark National Forest in late July and initially smoldered before rising temperatures increased fire activity in early August (Norman Kamrud, retired Forest Service, Missoula, MT, personal communication, October 18, 2018). After detection, the fire received constant monitoring, both on the ground and in the air, which allowed the managers to continually predict potential fire activity and draft contingency plans. The Cigarette Creek Fire ultimately grew to 250 ac (101 ha) before it was extinguished by a fall rain event (Norman Kamrud, retired Forest Service, Missoula, MT, personal communication, October 18, 2018).

Fire Management (1983–present)

The Scapegoat-Danaher fire management plan was expanded in 1983 to include the rest of the Bob Marshall and Great Bear Wildernesses, thereby allowing for wilderness fire management throughout the BMWC (USDA Forest Service 1983). The next year, the Lodgepole Fire ignited late in the season on the Flathead National Forest. Initially, the forest supervisor and district rangers were tempted to suppress the fire because fire danger indices had been increasing and it had ignited near an airfield (Rich Lasko, retired Forest Service, Missoula, MT, personal communication, October 23, 2018). Nevertheless, the acting fire management officer (FMO) for the Flathead National Forest, Rich Lasko, advocated for managing the fire as a wilderness fire, and eventually he was allowed to proceed without taking suppression action. This approach largely entailed monitoring the fire from the Schafer Ranger Station next to the airfield (Rich Lasko, retired Forest Service, Missoula, MT, personal communication, October 23, 2018). It then burned as a slow-moving surface fire through a lodgepole pine stand that had established in the 1920s. The Lodgepole Fire eventually grew to 80 ac (32 ha) and was extinguished by rain events in the fall (Rich Lasko, retired Forest Service, Missoula, MT, personal communication, October 23, 2018).

The Cigarette Creek and Lodgepole Fires were ultimately considered examples of successful wilderness fire management. According to Norman Kamrud, the FMO for the Rocky Mountain Ranger District, these early fires allowed fire managers in the BMWC to better understand their individual roles and responsibilities within a long-term fire monitoring framework (retired Forest Service, Missoula, MT, personal communication, October 18, 2018). Furthermore, because both fires stayed within their MMA without any additional resources or funding, there were no serious complaints from the public or the larger land management community (Rich Lasko, retired Forest Service, Missoula, MT, personal communication, October 23, 2018). As the first wilderness fires in the BMWC, they demonstrated that replicating the fire management approach used in the White Cap Study area was a feasible strategy.

The most formative fire for early wilderness fire management in the BMWC, however, was the 1985 Charlotte Peak Fire on the Flathead National Forest. This lightning-ignited fire began in late June in a forest stand at 7,000 ft (2,100 m) (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). The spring of 1985 had been very dry, creating the conditions for such an early-season, high-elevation ignition. When fire behavior analysts were consulted, however, they determined that Charlotte Peak was not likely to spread to much more than a few thousand acres (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). Relying on their predictions, managers decided to manage the Charlotte Peak Fire as a wilderness fire.

The decision not to suppress the Charlotte Peak Fire was controversial. Dave Bunnell, who was the FMO for the Flathead National Forest at the time, remembers how both the regional and national offices considered the decision to be excessively risky given the high fire danger index values for the season (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). They became even more concerned when, after the fire had smoldered for the first few weeks of July, it was hit by a front with high winds. Combined with low humidity, these strong winds caused fire behavior to exceed the previous predictions. On July 23, the fire made a large run, burning 3,500 ac (1,400 ha) and producing a smoke column that was visible for many miles (Rich Lasko, retired Forest Service, Missoula, MT, personal communication, October 23, 2018).

In response to this heightened fire activity, the Forest Service's assistant national director of fire and aviation flew out from Washington, DC to inspect the scene. Supporting the decision to continue to allow the fire to burn, however, were Orville Daniels of the neighboring Lolo National Forest and Bob Mutch, now operating out of the Northern Region office as the regional fuels specialist (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). Backed by these experienced wilderness fire managers, Bunnell and other fire personnel on the Flathead National Forest were able to make the case that extinguishing the Charlotte Peak Fire was both incompatible with wilderness ethics and unsafe for firefighters, and they continued to manage it as a wilderness fire (Rich Lasko, retired Forest Service, Missoula, MT, personal communication, October 23, 2018).

The large run on July 23 did, however, make Bunnell and Mutch worry that the Charlotte Peak Fire would jump the South Fork of the Flathead River. At that point, fire behavior would become harder to predict and many more recreational users would be in danger (Smith 1986). Therefore, managers of the BMWC adopted a new approach to managing this fire, as the focus shifted from managing the actual perimeter of the Charlotte Peak Fire to managing the potential area that it might encompass (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018).

Given the heavy recreational use of the South Fork river corridor, the greatest risk of fire in the area was to public safety. As a result, managers on the Flathead National Forest developed thresholds of predicted fire danger or observed fire behavior, which, when exceeded, triggered the closing of trails to minimize the risk to wilderness users (Rich Lasko, retired Forest Service, Missoula, MT, personal communication, October 23, 2018). Implementation of this approach required accurate long-range fire behavior predictions, which at the time meant qualified and experienced individuals using a TI-89 calculator (Texas Instruments, Dallas, Texas) to predict fire spread and movement (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). In addition, personnel were placed on the ground to monitor the fire and wilderness users in the area (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). Ultimately, the Charlotte Peak Fire did not jump the South Fork of the river; instead, an early-season rain event during the first week of August extinguished the fire at 5,500 ac (2,220 ha) (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018).

Despite the successful management of these early fires, lack of funding and structural support constantly stymied wilderness fire management in the BMWC. For example, only $100,000 was allocated for wilderness fire management across all of the Northern Region, and moneys were distributed on a first-come-first-served basis (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). This allocation method stood in stark contrast to fires managed as suppression events, which received nearly unlimited funding and resources. There was often no money remaining to manage even the first ignition for resource benefit in the BMWC because the fire season in the BMWC typically started later than in the SBW. In addition, because wilderness fires were not funded in the same way as suppression wildfires, they received very few additional outside resources (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). Instead, early wilderness fires within the BMWC were managed completely by the local district or forest, with the fire managers often relying on highly inventive funding and management strategies in the absence of any outside resources. This lack of funds and resources forced managers within the BMWC to suppress most fires, regardless of the weather or fuels conditions (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018).

The strict limitations on wilderness fire funding were loosened in 1988 when two large fires ignited within the BMWC. The Gates Park Fire and Canyon Creek Fire became defining events for the BMWC wilderness fire program, but for different reasons. The Gates Park Fire was eventually hailed as an example of successful wilderness fire management, whereas the Canyon Creek Fire crossed the wilderness boundary. Nonetheless, the Canyon Creek Fire provided important lessons on the inherent complexity and risk of wilderness fire management.

The Gates Park Fire ignited on the Lewis and Clark National Forest in July 1988. Norman Kamrud recalls initially using a small crew composed of trail crew members, recreation technicians, and fire managers from the district to suppress localized growth of the fire and keep it away from the nearby Gates Park administrative cabin (retired Forest Service, Missoula, MT, personal communication, October 18, 2018). Given the size of this fire and high levels of fire activity in the region, however, Kamrud determined that keeping the fire within wilderness boundaries would require a larger, more specialized force.

Following Kamrud's recommendation, Bunnell took over management of the Gates Park Fire. This change in command allowed Kamrud to focus on the other fires within his district, while Bunnell was able to apply his considerable experience in wilderness fire management to this difficult fire event. Scraping together a small cooperative team from neighboring forests as well as the regional office (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018), Bunnell led this team for the duration of the Gates Park Fire. The regional budget allocated to wilderness fire ran out during the Gates Park Fire. Unwilling to switch to a suppression strategy, Bunnell instead worked with the regional office and the forest supervisors of the Lewis and Clark, Lolo, and Helena National Forests to cobble together the resources to continue to manage Gates Park as a wilderness fire (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018).

In early August, Bunnell determined that the southern flank of the Gates Park Fire required direct action to keep the fire within wilderness boundaries. He therefore called in a team of smokejumpers and hotshots to dig line (i.e., remove flammable vegetation) and burn out this portion of the fire perimeter. Such steps were typical for suppression events, but this was the first large, direct action during a nonsuppression wilderness fire event (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). These management actions, combined with a well-timed rain event and topographic features along the eastern flank, successfully contained the Gates Park Fire within the wilderness boundaries. The fire was extinguished naturally at the end of the season after burning 50,000 ac (20,200 ha) (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018).

In contrast to the Gates Park Fire, containment of the Canyon Creek Fire would prove impossible, and the fire escaped the wilderness boundary. Growing to over 200,000 ac (81,000 ha), this fire caused damage to private property and threatened the town of Augusta, Montana (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). When the fire started on June 25, a team of expert fire analysts predicted that total area burned would be limited to 3,000 ac (1,200 ha), an estimate that seemed accurate in the early weeks of the fire (Orville Daniels, retired Forest Service, Missoula, MT, personal communication, November 5, 2018). Even with a 2-day, 10,000-ac (4,000-ha) run starting on July 22, the Canyon Creek Fire remained within prescription and continued to burn with mixed fire behavior (Chaney 2013). All predictions, however, assumed that the typical seasonal rains would begin in mid- to late August (Chaney 2013; Soulé and Knapp 2008). When August came and went with no such rain, the situation became highly unpredictable.

To further complicate management of the Canyon Creek Fire, 1988 was a big fire year for much of the Northern Rockies. At the same time that the Gates Park and Canyon Creek Fires were burning in the BMWC, so too were fires in Yellowstone and Glacier National Parks, as well as several large fires along the Montana-Idaho border. Consequently, no resources remained to fight the now-large Canyon Creek Fire, which had increased to 51,000 ac (20,600 ha) after dry wind events on August 29 (Chaney 2013). The fire proceeded to cross the wilderness boundary and was declared a suppression wildfire. Suppression actions were taken both inside and outside the BMWC. Then, the morning of September 6, a low-level jet stream hit the fire, and in 16 hours the fire grew by another 180,000 ac (73,000 ha). At this point, Daniels recounts, “there was nothing I could do,” (Chaney 2013). Only a last-minute bulldozer line and some overgrazed pastures prevented the fire from burning into the town of Augusta (Orville Daniels, retired Forest Service, Missoula, MT, personal communication, November 5, 2018).

The Canyon Creek Fire was the first fire managed for resource benefit to escape wilderness boundaries, and many thought that it would mark the end of wilderness fire management. Instead, as described earlier, the Secretary of the Interior and Secretary of Agriculture convened a fire management policy review team to evaluate the 1988 fires that burned across the West (van Wagtendok 2007). The team concluded that although sound ecological premises supported the policy of wilderness fire management, some areas using wilderness fire lacked adequate plans to guide decision making (Wakimoto 1990). The team therefore recommended rewriting fire management plans, improving training for wilderness fire managers, and strengthening information dissemination to the media and the public (Wakimoto 1990).

The massive amount of attention that the media and elected officials paid to the Yellowstone Fires of 1988 largely kept the Canyon Creek Fire and the BMWC out of the national spotlight (van Wagtendonk 2007). The Forest Service thus had the opportunity to reflect on the shortcomings of its wilderness fire program and identify program needs without national scrutiny (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). This internal reflection, in combination with the recommendations provided by the fire management policy review team, would allow the BMWC and the Forest Service to learn and grow from the 1988 fires.

Reflection on both 1988 BMWC fires revealed a "rhythm" to long-term fire management that the short-term actions taken on suppression fires had never exposed. Of the 87 days that the Gates Park Fire burned, major growth occurred only during 7 days of extreme weather (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). On those days, the relative humidity, temperature, and wind conditions aligned to contribute to high fire activity. At all other times, direct management on the perimeter to control fire spread was relatively safe. Ultimately, better understanding these controls of fire growth has allowed for more successful fire management outside of a suppression context.

The 1988 fire season was also the first to demonstrate that not all wilderness fires would be small fires easily managed with observation alone (Dave Campbell, retired Forest Service, Hamilton, MT, personal communication, November 28, 2018; Chaney 2013). Upon reflection, it became clear that such large fire seasons, and large-fire events, are normal for the BMWC. For example, historical documents such as the Ayres report and newspaper accounts from the late 19th century contained stories of similarly large blazes (Chaney 2013), including the well-known fire years of 1889 and 1910. Around this same time, some of the first tree-ring records of fire history also indicated that the large fires of 1988 were consistent with the fire history in the Northern Rockies (Romme 1982).

With this new realization, wilderness fire managers concluded that greater consideration of resources available would be crucial to making decisions on wilderness fire management (Orville Daniels, retired Forest Service, Missoula, MT, personal communication, November 5, 2018). These fires also pointed to the importance of considering drought indices, as 1988 came on the heels of 3 years of drought (Chaney 2013; USDA-FS 2002a). Therefore, the decision to manage a fire as a wilderness fire from 1988 onward placed greater weight on what resources were available, at both the local and the national level. That go/no-go decision also emphasized the impact of drought conditions on wildland fire behavior, as it became increasingly clear that there would be years when these large, active fires were the norm.

Finally, the Gates Park and Canyon Creek Fires highlighted the importance of clear, open, and early communication with the public (Orville Daniels, retired Forest Service, Missoula, MT, personal communication, November 5, 2018). Although much trust was lost with the neighboring communities, especially with Augusta, the Forest Service was able to regain some public trust and support for the program by admitting to the mistake and working with local ranchers to buy hay and rebuild fences (Orville Daniels, retired Forest Service, Missoula, MT, personal communication, November 5, 2018). The need for transparent communication was highlighted once more with the Biggs Flat Fire of 2001. This fire again burned portions of the landscape that the 1988 fires had burned and revealed a lingering lack of support and trust by residents of Augusta—a direct result of the Canyon Creek Fire's impacts on the town. The dramatic and negative public response during the Biggs Flat Fire reinforced the need for clear and early communication around wilderness fire management. It also demonstrated that rebuilding trust and support can take years or even decades if not readily and continually addressed (Tom Zimmerman, retired Forest Service, Kuna, ID, personal communication, July 10, 2020).

In the long run, however, the 1988 fires put wilderness fire management on more solid footing. Although the 1989 Federal review placed the program on hold for several years, decision makers were able to use this time to review fire management plans and fix potential shortcomings (Orville Daniels, retired Forest Service, Missoula, MT, personal communication, November 5, 2018). According to Bunnell, fire management for resource benefit gained greater acceptance as a fire management strategy within the Forest Service (retired Forest Service, Missoula, MT, personal communication, October 10, 2018). In an early indication of this shift in priorities, the Northern Region office had allocated emergency funds for continued management of the Gates Park and Canyon Creek Fires, despite running out of funding for the wilderness fire program by mid-August. This, and the creation of a specific team to manage the Gates Park Fire, set a new precedent for wilderness fire (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). The Forest Service had reestablished itself as a leader in wilderness fire management, and the BMWC had strengthened its fire prescriptions.

Ultimately, the fires of 1988, both within the BMWC and across the Northern Rockies, fundamentally changed opinions on what could be done to affect fire perimeters and control fire behavior. It became clear to wilderness fire managers that there would be wilderness fires for which more active management of the fire, beyond just passive monitoring, would be required (Orville Daniels, retired Forest Service, Missoula, MT, personal communication, November 5, 2018). Therefore, keeping wilderness fire management alive would involve increased investment in the program (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018).

Fire activity in the BMWC was lower during the 1990s, largely due to cooler, wet fire seasons, which kept the fires that did ignite relatively small (Dave Bunnell, retired Forest Service, Missoula, MT, personal communication, October 10, 2018). As with the SBW, however, fire events occurring elsewhere had a profound impact on the BMWC, including the 1994 South Canyon incident in Colorado and the 1994 Howling Fire in neighboring Glacier National Park. Management of the Howling Fire was eventually heralded as a success and inspired recommendations for the expansion of fire management for resource benefit. In stark contrast, the death of the 14 firefighters during the South Canyon incident resulted in the 1995 policy review that placed greater emphasis on advance planning for appropriate fire response (USDA and USDOI 1995).

The BMWC further refined fire management plans following the national review in 1995. That year, Bunnell teamed up with Tom Zimmerman, who had managed the Howling Fire, to better define the needs of wilderness fire management teams (Zimmerman and Bunnell 2000). Zimmerman would later create prescribed fire support crews, which developed into the modern-day wildland fire use modules. These crews provided personnel specially trained to meet wilderness and long-term fire management needs (Zimmerman et al. 2011).

In 2003, 41 fires burned approximately 100,000 ac (40,400 ha) in the BMWC, marking a new watershed moment for the wilderness (Borrie et al. 2006). Seth Carbonari, who served as the FMO for the Spotted Bear Ranger District, notes that the larger fire seasons, such as 2003, have forced wilderness fire managers in the BMWC to think on longer timescales (Forest Service, Hamilton, MT, personal communication, November 28, 2018). For example, fires in 2003 threatened a number of structures within the wilderness. Since it was a high-activity year outside of the wilderness as well, firefighting resources were scarce. As a result, management personnel within the BMWC used packstock to carry equipment into remote locations so they could put point protection measures into place weeks ahead of when the flame front was predicted to reach these high-value resources. Some administrative cabins were wrapped in fire-resistant material for months (Seth Carbonari, Forest Service, Hamilton, MT, personal communication, November 28, 2018). In addition, public safety considerations demanded that wilderness managers close many trailheads and trails within the BMWC (Borrie et al. 2006). Many of these preemptive measures were also taken in later regional fire years, such as 2007, 2015, and 2017 (fig. 10).

The 2003 fire season was also the first year that the BMWC conducted a prescribed burn within wilderness boundaries to support wilderness fire management. According to Mike Munoz, the district ranger for the Rocky Mountain Ranger District since 1999, prescribed burns were conducted along the South Fork of the Sun River and involved

Figure 10—A field crew watching the 2013 Damnation Fire burn in the Bob Marshall Wilderness Complex (Courtesy photo by Lily Clarke, University of Montana).

burning 16,000 ac (6,500 ha) over the course of 2003, 2009, and 2011 (Forest Service, Choteau, MT, personal communication, December 7, 2018). Before the prescribed burns, very few wilderness fires had been allowed in this area because of the high risk of escape from the wilderness boundary. The goal of this multiyear project, therefore, was to provide a fuel break for fires and protect structures at risk along the wilderness boundary. Perhaps surprisingly, the community of Augusta was very supportive of this mitigation action. Munoz argues, however, that community members were motivated to reduce the risk of fire escape because the last three summers had included wildfires that nearly escaped wilderness boundaries (Forest Service, Choteau, MT, personal communication, December 7, 2018). Since completion of this prescription in 2011, Munoz and his fire management team have been able to safely manage more lightning-ignited fires in the area.

The benefits of wilderness fire management have become more apparent in the BMWC with the increased frequency of large fire years in the 2010s (Deb Mucklow-Starling, retired Forest Service, Kalispell, MT, personal communication, January 16, 2019). The 2003 season revealed the utility of previous burns when managing wilderness fire, as reduced flame lengths and decreased fire intensities were observed in the areas burning within the footprints of the Charlotte Peak Fire and the 2000 Lewis Creek II Fire (USDA-FS 2003). The fires from this year were also incorporated into the 2003 *Guidebook on Wildland Fire Use* for the BMWC, which identified certain fires of that year as potential future fuel breaks along the wilderness boundary (USDA-FS 2003).

Munoz similarly identifies 2007 as an important year for "lessons learned" (Forest Service, Choteau, MT, personal communication, December 7, 2018). During that season, three fires burned on the Rocky Mountain Ranger District, one of which was managed as a wilderness fire while the other two were managed as suppression events. Each of the suppression events was four times as expensive as the wilderness fire, yet those suppression actions ultimately proved ineffective in controlling fire extent. In addition, Munoz notes that as repeat burns become more common in his district, he sees increased public support for wilderness fire management. This increased support largely reflects the increased accessibility, due to thinned-out vegetation, of areas that experienced repeat burns, as well as the reduced smoke levels that reburns produce (Mike Munoz, Forest Service, Choteau, MT, personal communication, December 7, 2018).

Since the 1988 escape of the Canyon Creek Fire, clear and open communication has repeatedly proven to be an essential component of wilderness fire management within the BMWC. For example, in 2015 the Peak Fire Complex escaped the BMWC boundary and forced the evacuation of the town of Heart Butte. Munoz was deeply concerned about the potential impacts of this fire on the community (Forest Service, Choteau, MT, personal communication, December 7, 2018). Therefore, when the Crucifixion Creek Fire burned the same area in 2017, he allocated more resources and personnel to community engagement. These efforts included conducting weekly public meetings in Heart Butte, as well as designating a public affairs officer, in order to keep the town informed of all fire updates and management decisions. As a result, the community had greater trust in the decisions made by Munoz and his management team. Community members also better understood that the two fire entries had made their community more resilient to future fires (Mike Munoz, Forest Service, Choteau, MT, personal communication, December 7, 2018).

Communication with the public and communication across administrative boundaries have been equally important to the BMWC wilderness fire program. Once large fire years became the new normal, the district rangers within the complex began setting up a weekly meeting to talk about current fires and discuss possible future events (Deb Mucklow-Starling, retired Forest Service, Kalispell, MT, personal communication, January 16, 2019). These phone meetings let the rangers talk through decisions with their peers, share knowledge and resources, and plan for future ignitions (Deb Mucklow-Starling, retired Forest Service, Kalispell, MT, personal communication, January 16, 2019).

With the increased frequency of large fires in the BMWC, however, maintenance of trails and campsites has emerged as a major challenge to wilderness fire management. Maintaining access to the backcountry is essential for continued support of wilderness fire management, as support tends to dwindle when fire continually limits access to the wilderness area (Mike Munoz, U.S. Forest Service, Choteau, MT, personal communication, July 10, 2019). Additionally, these trails and campsites allow visitors to view the positive ecological effects of the fire (Deb Mucklow-Starling, retired Forest Service, Kalispell, MT, personal communication, January 16, 2019). Funding for trail and campsite restoration following fire, however, is often hard to obtain. Therefore, when districts are able to secure funding for trail work post-fire, making the decision to manage a wilderness fire often becomes easier.

Although a later adopter of wilderness fire management than the SBW, the BMWC nevertheless played a crucial role in developing policy and management strategies for long-term fire management, both within the Northern Region and nationally. For example, from events such as the Gates Park and Canyon Creek Fires, fire management personnel learned how to manage large, long-term fire events, as well as the limitations of fire management under extreme fire weather conditions. Many of these managers later held positions at the regional and national offices. They helped shape national fire management policy and continue to serve as mentors to future fire managers. The opportunity to share their expertise—particularly in light of the great uncertainty inherent in long-term fire management, combined with the often high levels of immediate risk—is invaluable as the Forest Service continues to expand fire management for resource benefit.

Current Conditions

In the past 34 years, nearly a third of the BMWC has burned once, and almost 7 percent has burned multiple times (table 3, fig. 11). Many of the low-elevation ponderosa pine stands of the BMWC have experienced multiple fires, which have removed undergrowth and reduced fuel loads within these stands (Flanary and Keane 2020; Larson et al. 2013) (fig. 12b). In mixed conifer-western larch stands, there has been a similar effect of fire on forest structure, creating a more open understory while the large, fire-resistant western larch trees persist following fire (Belote et al. 2015; Hopkins et al. 2014). In contrast, stands that remain unburned typically have high levels of ladder fuels and greater uniformity of vertical and horizontal forest structure (fig. 12a). Fuel loads tend to further decrease with repeat burns, while patch structural complexity tends to increase across the landscape as these fires interact with the biophysical environment (Berkey et al. 2020; Larson et al. 2020).

In higher-elevation, subalpine forests, many stands have experienced a high-severity fire in recent decades, often resulting in almost complete overstory mortality. In many of these stands within the BMWC, however, regeneration densities are high, particularly where lodgepole pine is present (Berkey et al. 2020) (fig. 12c). Furthermore, research into fire effects on alpine treeline suggests that variations in fuel moisture and fuel connectivity create variability in tree survival and vegetation structure following wildland fire (Cansler et al. 2018).

The cumulative effect of fire in these various forest types has been high levels of landscape diversity, especially where short-interval fires are common (figs. 13b,c). In the BMWC, the moderating effects of a previous fire on subsequent fire behavior have also been evident, as fire behavior is often reduced when a current fire encounters a previously burned area (Parks et al. 2015d) (fig. 13a). As a result, fire management has become easier over time, as the high landscape heterogeneity helps temper fire intensity and rate of spread under most weather conditions.

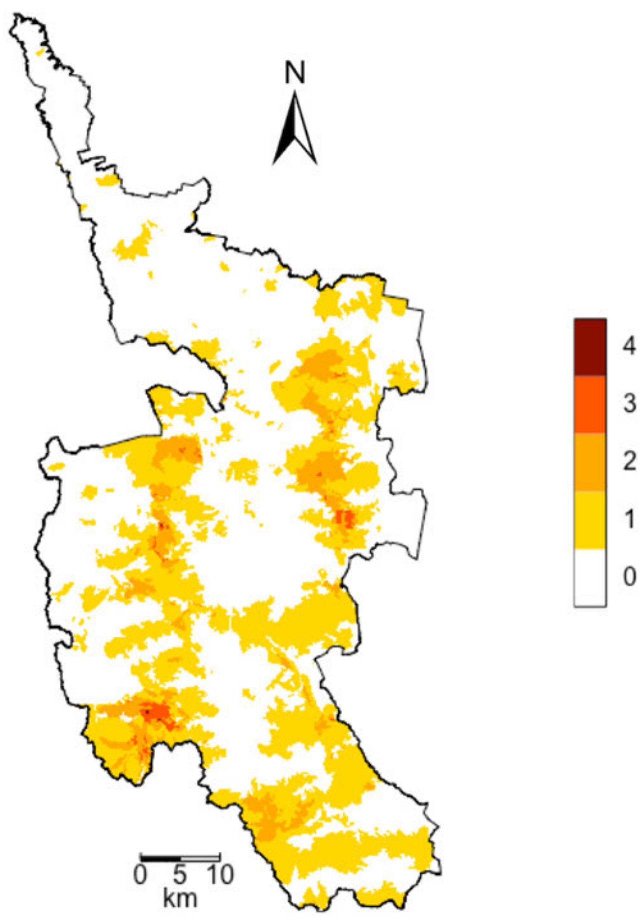


Figure 11—Number of burns on the landscape for the Bob Marshall Wilderness Complex from 1983 through 2017.

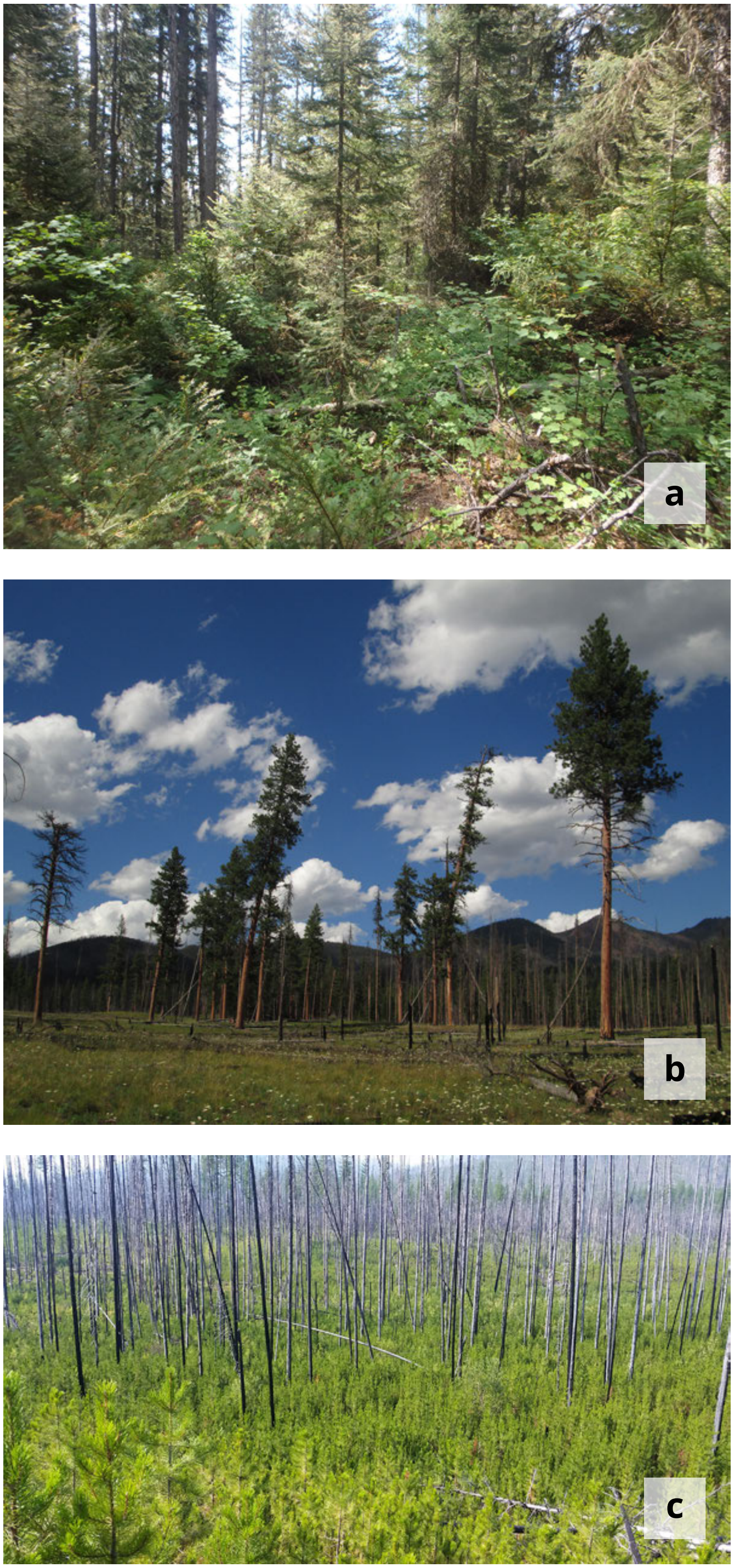


Figure 12—Stand structure in a) an unburned mixed-conifer stand (Courtesy photo by Eryn Schneider, University of Montana), b) a twice-burned ponderosa pine stand, and c) a lodgepole pine stand burned at high severity within the Bob Marshall Wilderness (Courtesy photos b and c by Andrew J. Larson, University of Montana).

Figure 13—The landscape mosaics resulting from wilderness fire management in the Bob Marshall Wilderness: a) the 2013 Damnation Fire burning through the mosaic left from the 2003 Little Salmon Complex at Mud Lake Mountain (USDA Forest Service photo by Seth Carbonari), b) considerable forest structural diversity at the confluence of the White River and South Fork of the Flathead River (Courtesy photo by Julia Berkey, University of Montana), and c) current forest structure within the perimeter of the 1985 Charlotte Peak fire (Courtesy photo by Andrew J. Larson, University of Montana).

Frank Church-River of No Return Wilderness

Pre-exclusion (through 1934)

Unlike the Selway-Bitterroot Wilderness and Bob Marshall Wilderness Complex, the Forest Reserve for the area that now makes up the Frank Church-River of No Return Wilderness was not established until 1906. Since all Forest Reserves were converted to management under the Forest Service in 1907, no USGS survey was conducted for this area. Therefore, there was no on-the-ground estimate of area recently burned for the FCRNRW. Nevertheless, a tree ring fire-scar study conducted in the ponderosa pine-Douglas-fir River Breaks zone of the Salmon River drainage indicates that, for these low-elevation forest types, the mean fire-return interval (MFI) from about 1647 to 1935 ranged from 10 to 48 years across nine sampled stands. The MFI for major fires (>1,000 ac) within the same drainage was 41 years (Barrett 1984). The study also notes that stand-replacing fire within the River Breaks zone appears to be common on the north-facing, predominantly Douglas-fir dominated sites, where some stands are more than 150 years old (Barrett 1984).

For the entire FCRNRW, the GIS analysis conducted for this review indicates an FRP of 293 years, with 370,322 ac (149,864 ha) of burned area within the FCRNRW from 1880 through 1934 (table 1, fig. 14). This FRP is much longer than that of the SBW or BMWC for the same period (table 1). Sheep grazing may have reduced fire frequency in the area in the early 1900s (Steele et al. 1981). In the absence of a formal, commissioned survey of the area, the resulting lack of fire records may also explain the longer-than-expected FRP.

Before the arrival of Euro-American settlers, the Nez Perce and Shoshone tribes primarily inhabited the FCRNRW (Cannaday 2016; Cochrell 1960). Although we could not find an ethnography that was conducted at the time, and no bark peeling analysis has been done for this area, it seems highly likely that Native Americans affected the fire history of the area, especially prior to the era of Euro-American mining (Steele et al. 1986). This influence would be expected especially in the lower-elevation sites and passes within the FCRNRW, where Native American land use would have been most concentrated.

Fire Exclusion (1935–1978)

The tree-ring study of the Salmon River Breaks zone was unable to calculate a meaningful MFI for the fire exclusion period in the FCRNRW, due to an absence of evidence for fire. Across all stands sampled, the MFI ranged from 57 to 61 years (Barrett 1984). This lack of fire was significantly outside the historical range of variation. While ponderosa pine regeneration still dominated on the very dry south-facing slopes, the lack of fire allowed Douglas-fir to regenerate and dominate on moist sites (Barrett 1984). Even where ponderosa pine regeneration continued to dominate, however, litter and duff depths became greater than what would be expected under historical fire frequencies (Barrett 1984).

The fire atlas data suggest that fire exclusion lowered fire activity in the FCRNRW. Like the rest of the Northern Rockies, the FCRNRW had generally lower fire danger over this time due to climate trends. In the more than four decades of the exclusion period, only 178,289 ac (72,151 ha) burned (fig. 14), corresponding to an FRP of 635 years, more than twice as long as the pre-exclusion period (table 1).

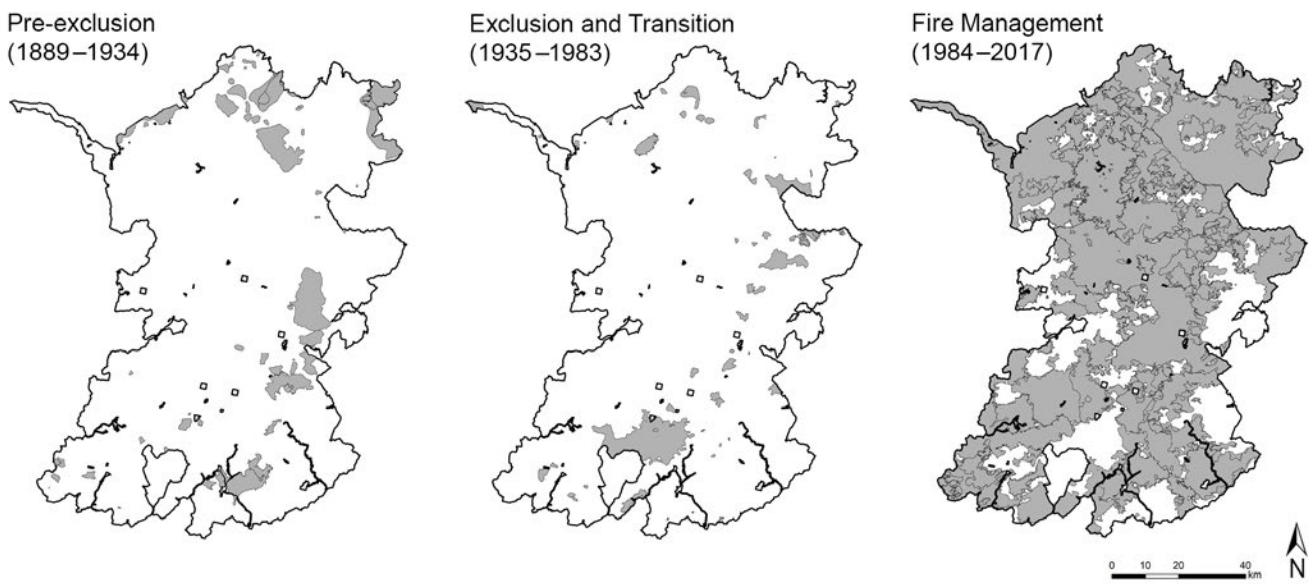


Figure 14—Fire perimeters for the three fire management periods in the Frank Church-River of No Return Wilderness in central Idaho.

Transition Period (1979–1983)

Before wilderness designation of the FCRNRW in 1980 (Central Idaho Wilderness Act 1980), managed wildfires were allowed in a portion of the Payette National Forest, which covers 33.5 percent of what is now the FCRNRW. Gene Benedict, who served as FMO for the Payette National Forest from 1979 to 2000, led the way in introducing wild-land fire management for resource benefit to the forest. Benedict had a background in silviculture and ecology, and he strongly believed that fire was an integral part of the ecosystem (Gene Benedict, retired Forest Service, McCall, ID, personal communication, June 14, 2018). Benedict was determined to put the fire management lessons learned from the White Cap Study into practice on the Payette National Forest.

After the repeal of the 10 a.m. policy in 1978, Benedict collaborated with the supervisor of the Payette National Forest, Sonny LaSalle, to write a Forest Fire Action Plan (Benedict et al. 1991). This plan, which was enacted in 1979, allowed for "appropriate suppression response" in select areas of the Payette National Forest (Benedict et al. 1991). This approach meant that, although all fires in this area would still be considered wildfires, they would not all have to be managed with full suppression. Instead, depending on values at risk, risk to firefighters, and cost of suppression, a fire under the fire action plan could be managed with flexible response options. The options included confinement with primarily natural barriers and minimal direct action, containment only at spots or areas of high risk, or the traditional approach of complete control (Benedict et al. 1991). The area included in this original plan was a high-elevation forest, where the historical fire regime was infrequent, high-severity fires that often remained small due to the sparse vegetation (Benedict et al. 1991).

Fire Management (1984–present)

Congress designated the FCRNRW a wilderness in 1980 and four years later, a fire management plan was developed for the entire wilderness area. Since the FCRNRW spanned two Forest Service regions and four national forests (fig. 2c), much collaboration was necessary to produce this plan. The authors therefore attempted to have both regions and all forests "playing off the same script" (Bob Mutch, retired Forest Service, Missoula, MT, personal communication, November 19, 2018). The resulting plan allowed for wilderness fire within the FCRNRW and continued to allow for appropriate suppression response in remote nonwilderness areas such as those included in the fire action plan on the Payette National Forest (Benedict et al. 1991).

The next year, in 1985, the benefits of appropriate suppression response on the Payette National Forest became evident (Benedict et al. 1991). That year, the Savage Creek Fire ignited outside the wilderness but was managed primarily with the confinement strategy, which allowed for observation only. At the same time, portions of the fire that were threatening private lands and areas of high timber value were controlled with fire line (Benedict et al. 1991). This approach, novel at the time for nonwilderness areas, was estimated to have cut firefighting costs by $2 million, reduced the risk to firefighters, and protected sensitive habitat types (Benedict et al. 1991).

The 1989 fire season was another active fire year on the Payette National Forest, and many fires were managed as wilderness fires. According to LaSalle, one lightning storm that summer resulted in 244 fire starts, 17 of which were designated for management as wilderness fire events (retired Forest Service, Powell, ID, personal communication, June 21, 2018). Given that these ignitions were coming on the heels of the 1988 fires in

Yellowstone National Park and the BMWC, the Northern Region office was concerned that these fires could have negative outcomes that would consequently threaten the wilderness fire program as a whole. To alleviate these fears and foster support, LaSalle flew some of the regional office employees over the wilderness so that they could observe first-hand the relatively low risk that these fires posed to the public. Once these regional office employees saw the patterns and effects of wilderness fire, as well as the vast area within which these fires were burning, support for wilderness fire in the FCRNRW grew (Sonny LaSalle, retired Forest Service, Powell, ID, personal communication, June 21, 2018).

The large number of fires during the 1989 fire season taught FCRNRW personnel that, during such a high-activity year, not all fires could receive equal priority for the resource allocation necessary to manage a wilderness fire (Jack Kirkendall, retired Forest Service, Missoula, MT, personal communication, December 3, 2018). Instead, managers developed a process for setting priorities, which included factors to consider when determining which fires were best suited for management for resource benefit. This approach involved deciding which fires were most likely to be successfully suppressed and which fires were better suited to help reach goals related to ecological processes (Jack Kirkendall, retired Forest Service, Missoula, MT, personal communication, December 3, 2018). This decision-making process was written into future fire management plans so that management decisions were more straightforward and could be made by more personnel on the forest, rather than just the forest supervisor or FMO (Jack Kirkendall, retired Forest Service, Missoula, MT, personal communication, December 3, 2018).

The 1994, 1998, and 2000 fire seasons were also very active, not just for the FCRNRW but nationally as well. In 1994, three fires that each burned over 100,000 ac occurred within the FCRNRW and provided a sense of how large wilderness fire events could become under changing climate conditions (Gene Benedict, retired Forest Service, McCall, ID, personal communication, June 14, 2018). In 1998, the Main Salmon Complex burned nearly 22,000 ac (8,900 ha) within the FCRNRW. As the first large complex of wilderness fires following the 1995 policy revision, it presented the first test for those policy modifications that required specific plans for fire response within individual land units (USDA and USDOI 1995; Tom Zimmerman, retired Forest Service, Kuna, ID, personal communication, July 10, 2020). Fires in the Main Salmon Complex ignited in an area that had already been identified as a candidate for wilderness fire. Since 14 of these ignitions met all other criteria identified in the FCRNRW Fire Management Plan, a detailed implementation plan was prepared that allowed land managers to manage these fires for resource benefit (Tom Zimmerman, retired Forest Service, Kuna, ID, personal communication, July 10, 2020). The plan identified a maximum manageable area

(MMA) boundary, threats to this boundary as well as threats to life and property, and the actions necessary to mitigate these threats. Those fires that did not meet the criteria for fire use were suppressed. To keep the public informed, the Forest Service proactively issued communications about the fire to a broad audience (Tom Zimmerman, retired Forest Service, Kuna, ID, personal communication, July 10, 2020).

The Main Salmon Complex was also the first example of multiple fires being managed within a single MMA, and the first time that multiple fires were managed within the same organization for different objectives (Tom Zimmerman, retired Forest Service, Kuna, ID, personal communication, July 10, 2020). Along with the fires that burned in the SBW in 1998, the Main Salmon Complex set the stage for the later designations of "mega-MMAs." This complex preceded the 2009 fire management policy by over a decade, yet it served as an example of how fires would eventually be managed with the flexibility allowed by the 2009 policy change (Tom Zimmerman, retired Forest Service, Kuna, ID, personal communication, July 10, 2020).

In 2000, the Burgdorf Junction Fire burned nearly 50,000 ac (20,200 ha), most of which was in either wilderness or roadless areas (Morrison et al. 2000). Because of severe fire activity nation-wide, military troops were called in to help with firefighting efforts on this fire. The high fire activity and rugged nature of the FCRNRW, however, made controlling the blaze impossible. Instead, fire management activity was largely limited to steering the fire away from values at risk and reducing threats to public safety (Booth 2000).

During high-activity fire seasons such as these, a lack of available resources at the regional and national level left many fire managers in these offices reluctant to commit to long-term wilderness fire management strategies. Resources available locally for suppression actions on fires in the FCRNRW were similarly limited (Gene Benedict, retired Forest Service, McCall, ID, personal communication, June 14, 2018). Therefore, although nearly every fire was declared a suppression event, managers on the FCRNRW often prioritized scarce resources toward fires that threatened homes, infrastructure, and safety in the front country (Sonny LaSalle, retired Forest Service, Powell, ID, personal communication, June 21, 2018).

Under the constraint of limited resources, fires that did receive a strong initial attack within the FCRNRW were often those that threatened inholdings (Gene Benedict, retired Forest Service, McCall, ID, personal communication, June 14, 2018). As of 2009, there were 61 private or State-owned inholdings within the FCRNRW, as well as 24 airfields (USDA-FS 2009). The large number of inholdings calls for wilderness fire management decisions nearly every year to be made by balancing the values at risk inside the wilderness against the scarcity of resources available. For Benedict, the highly qualified personnel on the Payette National Forest, as well as the support that he enjoyed from employees on neighboring national forests near the end of his career, made such wilderness fire management decisions easier because he could rely on their feedback and help (Gene Benedict, retired Forest Service, McCall, ID, personal communication, June 14, 2018).

Management of fires across administrative boundaries has been an ongoing challenge to wilderness fire management in the FCRNRW. The Salmon River is the boundary between the National Forest System's Northern Region and Intermountain Region inside the wilderness. In the early years of the FCRNRW fire program, LaSalle and his forest personnel often referred to this river as the "iron curtain" (Sonny LaSalle, retired Forest Service, Powell, ID, personal communication, June 21, 2018) because of their perception that the Northern Region was unwilling to accept any more fires beyond what it was already managing within the SBW and BMWC. Therefore, many resources and funds had to be channeled into suppressing fires at this boundary (Sonny LaSalle, retired Forest Service, Powell, ID, personal communication, June 21, 2018).

Within the Intermountain Region, the boundaries between individual forests could be equally challenging, as there were differing levels of comfort in managing long-term fire events between the forests (Jack Kirkendall, retired Forest Service, Missoula, MT, personal communication, December 3, 2018). As a result, fire management decisions in the FCRNRW were occasionally based on politics and relationships between land managers across jurisdictional boundaries, rather than actual fire risk. In particular, some managers believed that boundaries posed more of an issue when personalities differed, especially in the early years of fire management when suppression was still the dominant paradigm in the Forest Service (Byron Bonney, retired Forest Service, Missoula, MT, personal communication, November 27, 2018).

Over time, processes for managing fires across administrative boundaries within the FCRNRW were smoothed out. At first, this improvement was largely a result of increased acceptance of wilderness fire management and better relations across these boundaries (Jack Kirkendall, retired Forest Service, Missoula, MT, personal communication, December 3, 2018). For example, in 1992 Jack Kirkendall moved from his position as the district FMO on the Payette National Forest under LaSalle and Benedict to take over as the Bitterroot National Forest FMO. Kirkendall's established relationship with Benedict resulted in greater willingness to share resources and responsibility between the forests. This cooperative approach, combined with the increased acceptance of wilderness fire management within the Northern and Intermountain Regions, made managing fires across their shared boundary much easier (Jack Kirkendall, retired Forest Service, Missoula, MT, personal communication, December 3, 2018).

As wilderness fire management became more widely accepted and closer interpersonal relationships were established, fire management guidebooks for the FCRNRW were amended to include more comprehensive risk assessment plans and processes. These improved plans helped with management across administrative boundaries, as more of the risk management process was laid out ahead of time (Jack Kirkendall, retired Forest Service, Missoula, MT, personal communication, December 3, 2018). As a result, there is currently a system in place to help with coordination of fire management across jurisdictional boundaries in the FCRNRW. According to Chuck Mark, the current forest supervisor for the Salmon-Challis National Forest, conversations among the various forest and regional offices begin on the first day of a wilderness fire event (Forest Service, Salmon, ID, personal communication, November 26, 2018). These conversations involve identifying potential values at risk, plans for mitigating these risks, and planning for management strategies beyond the initial go/no-go decision.

More recently, large fire years continue to highlight the challenges inherent in managing fire during an era of increasing fire extent and severity. The Mustang Complex of 2012, for example, was extinguished at 336,028 ac (135,986 ha) on November 5 after more than 3 months of burning (USDA-FS 2013). Earlier in the 2012 fire season, the national office had issued a letter that many fire managers interpreted as a recommendation to suppress all fires that year (Seielstad 2015; USDA-FS 2012). The Salmon-Challis National Forest called the lightning-ignited Mustang Fire, which would eventually merge with five other ignitions, a wildfire. Initial attack from a rappel crew, however, was unsuccessful due to extreme fire behavior (USDA-FS 2013). As the fire grew and extreme fire behavior intensified, the incident management teams (IMTs) largely limited suppression activities to fire activity outside the wilderness (Bob Mutch, retired Forest Service, Missoula, Montana, November 19, 2018).

The size and duration of the Mustang Fire presented unique management challenges. For example, five different IMTs managed the fire (USDA-FS 2013). The next year, a Forest Service review of the Mustang Fire concluded that the changeover in IMTs had some negative consequences, including failure to maintain a consistent management strategy or public communication strategy (USDA Forest Service 2013). The review team contrasted this fire with the Halstead Fire, which burned the same summer in a remote area of the FCRNRW. One National Incident Management Organization (NIMO) team managed the Halstead Fire for 44 consecutive days, or half the duration of the fire, which minimized the number of team turnovers. This lack of changeover resulted in a more cohesive approach to fire management as well as stronger relationships between the NIMO team, local land managers, and the public. The review ultimately concluded that such consistency improved management of the Halstead Fire (USDA-FS 2013).

Perhaps the most controversial fire in recent years was the 2013 Gold Pan Fire. Shortly after it ignited within the FCRNRW boundaries, Dave Campbell, who was still serving as district ranger for the West Fork of the Bitterroot National Forest, flew over the fire. Given its location, he and Stu Hoyt, the FMO of the Bitterroot National Forest, concluded that it was likely to burn downhill to the Selway River, which would limit the size of the fire to around 15,000 ac (6,000 ha) within the FCRNRW (Blois 2017). The computer models supported this prediction, and Campbell made the decision to manage the Gold Pan Fire as a wilderness fire (Blois 2017).

The week after the original flight, however, saw unpredicted record-breaking temperatures and extremely low humidity (Dave Campbell, Forest Service, personal communication, Hamilton, Montana, May 21, 2018). These conditions resulted in extreme fire behavior; the Gold Pan Fire ultimately jumped the Selway River and grew to over 40,000 ac (16,200 ha) (Blois 2017) (fig. 15). It threatened several campgrounds and came very close to the historic Magruder Ranger Station. But the area burned by the Haystack Fire of 2005 created a fuel break that slowed and redirected the Gold Pan Fire, sparing the ranger station (Campbell and Mutch 2016).

Figure 15—The 2013 Gold Pan Fire in the Frank Church-River of No Return Wilderness, as viewed from a) Hells Half Acre Lookout (Courtesy photo by Mark Moak, Rocky Mountain College) and b) Magruder Ranger Station (Licensed photo by Leah Moak, Understand.com).

Whether fire managers ultimately considered the Gold Pan Fire a disaster or a success highlights the importance of personality in wilderness fire management. In retrospect, Campbell argued that it was a success because no structures were lost and he made the appropriate call with the information he had at the time (retired Forest Service, personal communication, Hamilton, MT, May 21, 2018). Those comfortable with wilderness fire management tend to agree with Campbell. Those with a more conservative view of wilderness fire typically see the Gold Pan Fire as a disaster.

The severe consequences and unpredictability of the record-breaking weather that caused the Gold Pan Fire to jump the Selway River underscored one of the major lessons learned from the Canyon Creek Fire of 1988. Extreme weather can make accurate fire behavior predictions impossible. The Gold Pan Fire provides another example of how it is impossible to avoid risk when managing fire for resource benefit, even with the best possible plans and people in place (Dave Campbell, retired Forest Service, personal communication, Hamilton, MT, May 21, 2018).

One of the biggest challenges for contemporary wilderness fire managers within the FCRNRW is managing wilderness recreation around the fires (Chuck Mark, Forest Service, Salmon, ID, personal communication, November 26, 2018). Rafting on the Middle Fork Salmon and Main Salmon Rivers is a popular activity, and the local economy depends on keeping these rivers open and accessible to the public (George and Minor 2003). The importance of the recreation economy became apparent during the Teepee Springs Fire of 2016, which burned across the Salmon River near Riggins, Idaho. The fire forced wilderness managers to close the river to the public and to evacuate rafters (Associated Press 2015). The public reaction to these fires was mostly negative, especially among the rafting guides in the area (Chuck Mark, Forest Service, Salmon, ID, personal communication, November 26, 2018).

In addition to immediate impacts of fire on recreational users and tourism, however, there are fire effects that linger well past the initial event. Like fire managers in the BMWC, Mark identifies trail and campsite maintenance as a major challenge to wilderness fire management (Chuck Mark, Forest Service, Salmon, ID, personal communication, November 26, 2018). This matter came to a head in the FCRNRW in 2013, when the Idaho legislature passed a nonbinding resolution that declared the FCRNRW a disaster area because of the lack of trail maintenance in areas affected by fire (Dvorak 2013). This resolution highlights public frustration with the loss of wilderness access. When the public is denied access to wilderness, popular support may consequently wain not just for wilderness fire management, but also for wilderness management more broadly. For example, public comments in response to the 2017 Salmon-Challis Forest Plan revision, which included a proposal to designate new wilderness areas, indicated a lack of support for these additional wilderness designations because the national forest could not maintain trails in the existing wilderness areas (Chuck Mark, Forest Service, Salmon, ID, personal communication, November 26, 2018).

Although the FCRNRW was the last of the three large wilderness areas in the Northern Rockies to adopt fire management, it has faced some unique challenges, providing another case study in wilderness fire management. More so than either the SBW or the BMWC, fire managers in the FCRNRW have had to address high values at risk such as inholdings within the wilderness, frequent fire management across administrative boundaries, and fire impacts on recreation. As a result, managers within the FCRNRW have built on the lessons learned from the SBW and the BMWC even as they adapt to their unique circumstances.

Current Conditions

Of the three wilderness areas considered here, the FCRNRW has had the most fire activity since the introduction of wilderness fire management in the mid-1980s. Only 22 percent of the wilderness remains unburned, 40 percent has been burned twice, and over 20 percent has burned three or more times (table 3). Some areas of the wilderness have even burned up to nine times, by far the highest frequency of fire in the wilderness areas covered in this review (fig. 16).

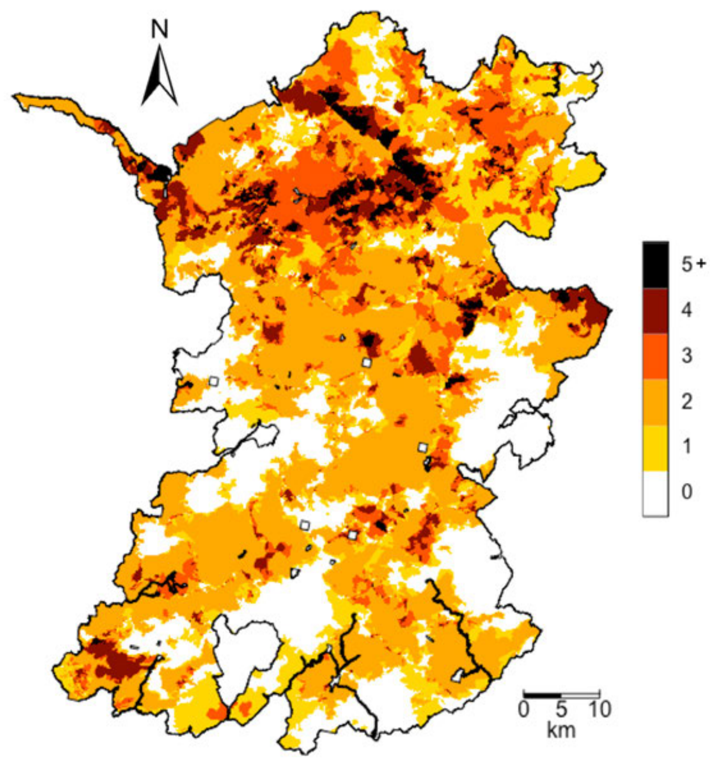


Figure 16—Number of burns on the landscape for the Frank Church-River of No Return Wilderness from 1984 through 2017.

As a result, many ponderosa pine stands are now characterized by the open, park-like forest structure that probably existed before the Exclusion Era (Lloret et al. 2011). Similarly, structural heterogeneity has been restored in many mixed-conifer forest stands (fig. 17a). In addition, across the wilderness, there has been a dramatic reduction in tree densities generally, often resulting in conversion (either temporary or permanent) to shrub or grass vegetation (figs. 17b,c). Despite the frequent occurrence of fire within this wilderness, fire in the FCRNRW has created high levels of landscape heterogeneity, which is evident in major watersheds including those of the Salmon River (fig. 18a,b) and Selway River (fig. 18c).

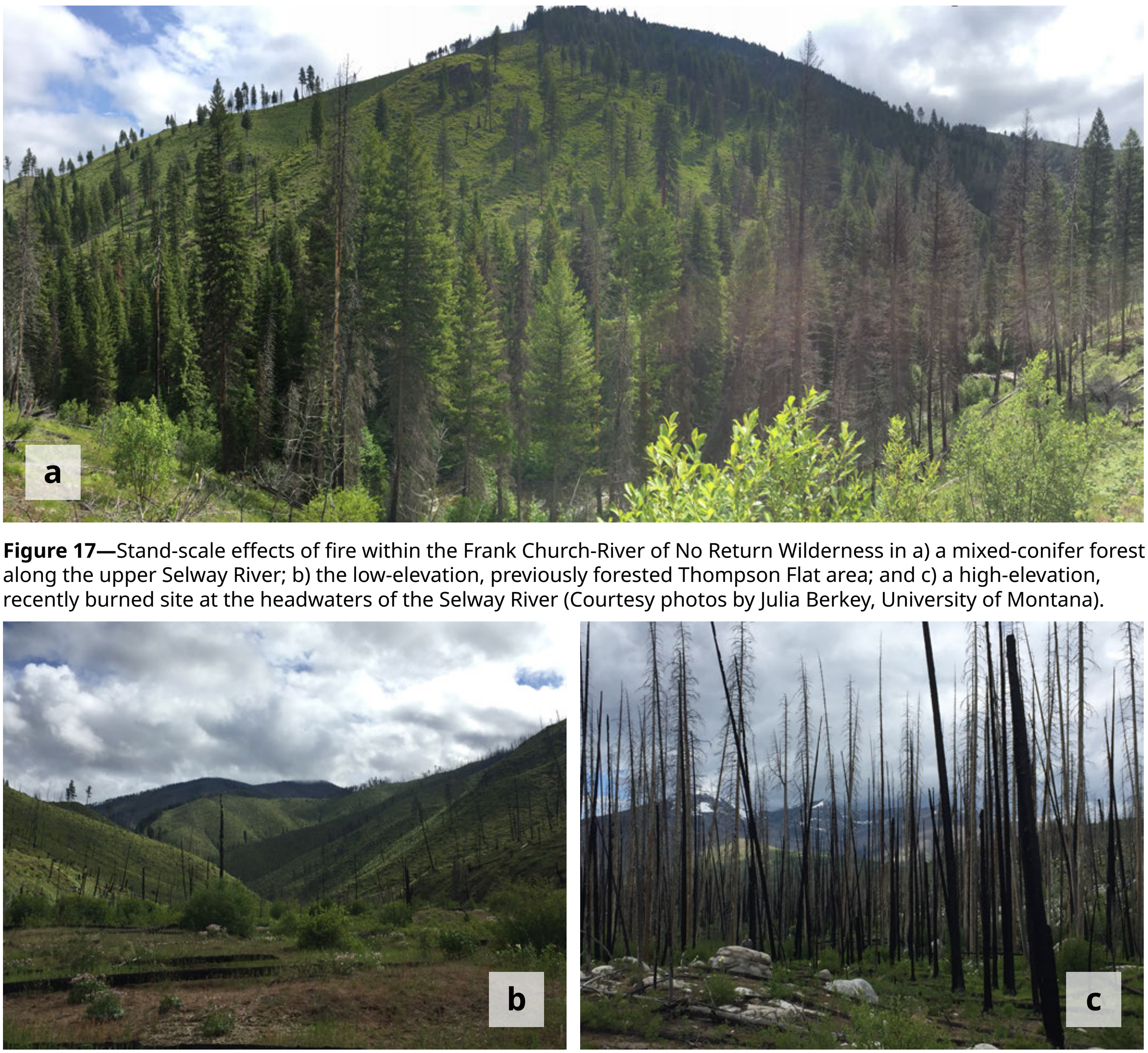
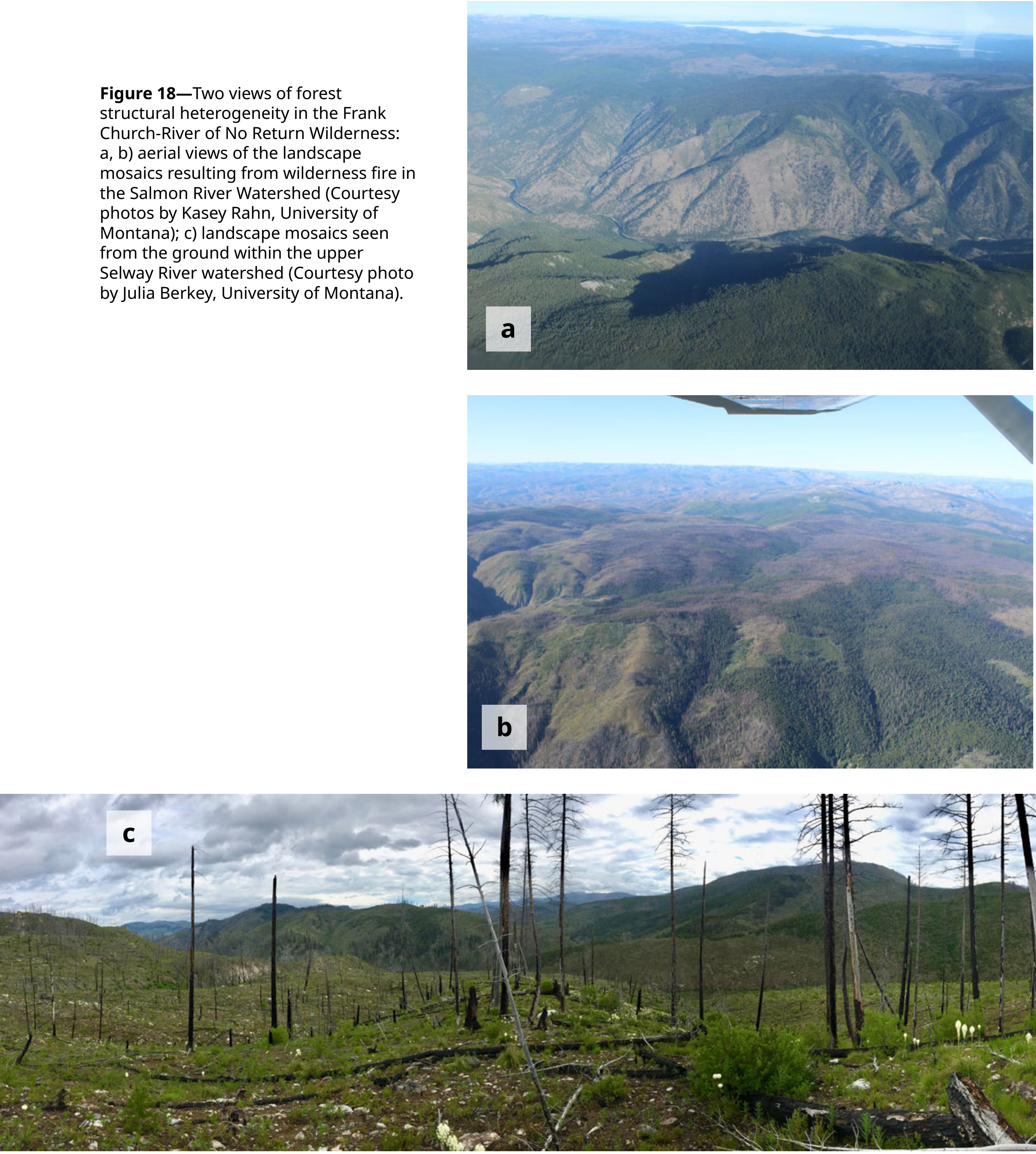


Figure 17—Stand-scale effects of fire within the Frank Church-River of No Return Wilderness in a) a mixed-conifer forest along the upper Selway River; b) the low-elevation, previously forested Thompson Flat area; and c) a high-elevation, recently burned site at the headwaters of the Selway River (Courtesy photos by Julia Berkey, University of Montana).

Figure 18—Two views of forest structural heterogeneity in the Frank Church-River of No Return Wilderness: a, b) aerial views of the landscape mosaics resulting from wilderness fire in the Salmon River Watershed (Courtesy photos by Kasey Rahn, University of Montana); c) landscape mosaics seen from the ground within the upper Selway River watershed (Courtesy photo by Julia Berkey, University of Montana).



DISCUSSION

This review uses the existing literature combined with new interviews to recount the history of and the lessons learned from wilderness fire management in the Northern Rockies. Fire management in this region has had a great influence on the shaping of national fire policy and fire management decisions since 1910. Beginning with the White Cap Study of the Selway-Bitterroot Wilderness in 1970, the management of wilderness fire within Northern Rockies wilderness areas paved the way for national policies that allowed for fire management for resource benefit. Thanks in part to the change set in motion by the Northern Rockies wilderness fire experiments, the 2009 guidance for implementation of Federal wildland fire management policy currently allows for high levels of flexibility around wildland fire management and includes specific language on managing fire for ecosystem health (USDA and USDOI 2009).

Implementing this flexible and ecologically informed approach, however, continues to challenge many land and fire managers inside and outside wilderness areas, in part due to the lingering effects of a culture of fire suppression within Federal land management agencies (Schultz et al. 2019; Steelman and McCaffrey 2011; Thompson et al. 2018). Moreover, the 2009 guidance for implementation of Federal wildland fire management policy has also had some unintended consequences that have potentially limited wilderness fire management. For example, removing the distinction between suppression wildfire and wildland fire use also made it more challenging for land management agencies to plan for and record the effects of "good" wildfire (Seielstad 2015; Thompson et al. 2018). As a result, there is concern that many of the wildfires that have burned since the 2009 policy change are those that have resisted suppression and burn only under extremely hot and dry conditions with higher-severity effects (Seielstad 2015). Therefore, they may not be fulfilling the natural ecological role that fire would normally play under a range of biophysical conditions.

This continual default to fire suppression has had some devastating consequences, both ecologically and on human populations (McWethy et al. 2019; Schoennagel et al. 2017). Attempting to keep fire largely removed from the landscape has resulted in increased fuel loads and more homogeneous landscape structure in those ecosystems that historically burned once every few years to decades, such as low-elevation ponderosa pine stands and mid-elevation mixed-conifer stands. Consequently, the risk of large, high-severity wildfires has increased in landscapes where fire has been excluded (Covington and Moore 1994; Larson and Churchill 2012; Lydersen et al. 2013).

Furthermore, fire suppression is typically effective under all but the most extreme conditions, so most acres burn in fires that escape primary and secondary attack under extreme weather conditions. This combination increases the risk of high-intensity, high-severity fires, as well as the risk of catastrophic outcomes on human populations.

Given these consequences, there is a growing momentum around reforming forest fire management to manage more fire for resource benefit (North et al. 2015; O'Connor et al. 2016). The lessons learned from wilderness fire management in the Northern Rockies can guide Federal land managers on how to best implement such reforms.

Fire Management Lessons Learned

The lessons learned from wilderness fire management in the Northern Rockies highlight the importance of even one person's commitment to including fire as a fundamental component of the wilderness ecosystems. The White Cap Study alone highlights the influence of an individual, as it was the vision and persistence of Bud Moore that launched the study and catalyzed the shift away from fire suppression (USDA-FS 2002b). Following in Moore's footsteps were the fire and land managers interviewed for this review, all of whom prioritized the role of fire on the wilderness landscape over the existing culture of fire suppression, often at risk to their own careers (Canton-Thompson et al. 2008; Stephens et al. 2016). Interviewees often referred to their dedication as a strong "wilderness ethic," or a commitment to the "untrammeled" nature of wilderness areas as described in the Wilderness Act (1964). Although a wilderness ethic is hard to foster because of its many intangible qualities, attempts to do so with more classes and training that specifically link fire with wilderness management have the potential to strengthen land managers' willingness to manage fire for resource benefit (Williamson 2007).

More tangible than the concept of a wilderness ethic is the importance of long-term planning to successful wilderness fire management. Again, this connection was highlighted early on with the White Cap Study. The 2 years of surveying and planning before the introduction of fire on that landscape allowed informed management decisions to be made following the early ignitions. This deliberate process ultimately demonstrated to the larger land management community that wilderness fire management could be conducted in a way that reduced the overall risk of negative impacts of fires on human lives and infrastructure.

As longer fire seasons with larger area burned become more common (Abatzoglou and Williams 2016; Holden et al. 2018; McKenzie and Littell 2017), the complexity of wilderness fire management continues to escalate as wildfire risk and scarcity of fire-fighting resources also increases (Calkin et al. 2015; Seielstad 2015). Under such conditions, long-term planning becomes increasingly important, as was highlighted with the 1989 fire season in the Frank Church-River of No Return Wilderness and the 2003 fire season in the Bob Marshall Wilderness Complex. In both these examples, fire managers recognized that limited resources would require determining priorities and allocating resources early in the fire season to avoid later shortages. Such planning has been relied upon repeatedly since and is typically carried out by highly trained and skilled personnel (Doane et al. 2006; Schultz et al. 2019). The heavy reliance on such people in the wilderness areas of the Northern Rockies indicates that the ability to prepare and implement these long-term plans is a valuable skill set.

Even with the best plans and people, however, there is a level of risk inherent in wilderness fire management (Thompson and Calkin 2011). This lesson was highlighted in each of the wilderness areas, as the Independence Fire of 1976 in the SBW, the Canyon Creek Fire of 1988 in the BMWC, and the Gold Pan Fire of 2013 in the FCRNRW all exceeded initial predictions of fire behavior and extent and threatened values at risk. In each case, an extreme weather event—difficult to predict—caused the severe fire behavior. These fires therefore reinforce the validity of the assertion that a high level of short-term risk acceptance is necessary in wilderness fire management.

Although wilderness fire management is inherently risky in terms of immediate potential impacts, management of fire through suppression does not lessen overall risk. Rather, suppression defers risk until extreme weather makes continued suppression impossible, at which point fires burn at higher intensities and severities (Arno and Brown 1991; Calkin et al. 2015). Therefore, providing incentives to implement thoughtful fire management plans that allow for fire management for resource benefit, such as the wilderness fire plans covered in this review, would be expected to reduce wildfire risk in the long run.

Sustained public support for such plans, however, depends on increased public understanding and acceptance of large fire events, like the Canyon Creek and Gold Pan Fires (McWethy et al. 2019). Increasing public trust in and support for managing fires for resource benefit both inside and outside wilderness areas has been a constant challenge for land management agencies since the end of the 10 a.m. policy. People in fire management have the opportunity to draw on lessons learned from wilderness fire on this topic. In particular, wilderness fire management in the Northern Rockies over many decades suggests that communication between land management agencies and the broader public is a key component of wildland fire management. For example, the escape of the Canyon Creek Fire from the BMWC severely tested public support for the wilderness fire program. A concentrated public outreach campaign that focused on mitigating the negative impacts and rebuilding trust, however, was able to restore some of that support and reduce opposition to the program. This model of communication continues to be used in the Northern Rockies wilderness areas today, as Mike Munoz demonstrated with his handling of the Peak Complex Fire in 2015 and the Crucifixion Fire in 2017, both of which threatened the town of Heart Butte. These examples demonstrate the importance of transparent and open communication between wilderness fire managers and the public (Lachapelle and McCool 2012; Rasch and McCaffrey 2019).

Ongoing investment in wilderness access, particularly in trail and campsite maintenance, has also been important to building public support for wilderness fire. Funding for such restoration work, however, may be limited. Without this funding, support for wilderness fire often falters as both land managers and the public come to view wildland fire as having a negative effect on public lands and access. This waning support became evident when Idaho lawmakers declared the FCRNRW a disaster area following more than a decade of tightening trail maintenance budgets (Dvorak 2013). Many current wilderness fire managers continue to struggle to fund postfire trail restoration work.

Finally, these three wilderness areas highlight the importance of cooperation across administrative boundaries. The need for this collaborative approach became clear immediately after the White Cap Study, as Moore recommended strengthening interagency cooperation to increase the ability to manage wilderness fire (Moore 1974). Communication and cooperation, both across boundaries and between agencies, become increasingly important as fire seasons grow longer and fires grow larger (Meyer et al. 2015; North et al. 2015; Sneeuwjagt et al. 2013). Fire managers from all three wilderness areas describe relying heavily on meetings between districts or forests, such as the conversations that take place each year within the FCRNRW, to make fire management decisions. This increased cooperation and communication ensure that the decisions made regarding wilderness fire management are as well informed and safe as possible.

Ecological Lessons Learned

Beyond the fire management lessons learned, these three large wilderness areas in the Northern Rockies allow researchers to investigate fire and forest ecology questions that cannot be answered elsewhere (Agee 2000). The presence of fire on the landscape in areas like the SBW, BMWC, and FCRNRW has allowed for research into the ecological role of fire at the stand scale (e.g., Belote et al. 2015; Cansler et al. 2018; Keeling et al. 2006; Kipfmueller and Kupfer 2005; Larson et al. 2013) (figs. 8, 12, 17). For example, research into soil nutrient cycling in frequently burned ponderosa pine–Douglas-fir stands in the SBW and FCRNRW revealed an increase in inorganic nitrogen availability following fire, which provided the first field-based evidence of decreased nitrogen availability resulting from fire suppression (DeLuca and Sala 2006). Within the BMWC, short-interval fires were found to significantly increase charcoal on coarse woody debris, which suggests that short-interval fires may alter carbon storage in forested ecosystems (Ward et al. 2017). Data from wilderness areas have also improved our understanding of postfire tree regeneration dynamics under a changing climate (Kemp et al. 2016).

At the landscape scale, wilderness fire has revealed restoration of vegetation mosaics (Arno et al. 2000; Barrett et al. 1991) (figs. 7, 13, 18). As a result, wilderness fire has allowed for research into fire as a self-regulating process; geospatial analysis at this scale reveals that previously burned areas can moderate both the size and the severity of subsequent fires (Parks et al. 2014, 2015d; Teske et al. 2012). These wilderness areas that manage fire as an ecological process have allowed for research into forest and fire ecology that guides management outside of wilderness areas and thus essentially serve as laboratories for the natural role of fire at the landscape scale (Larson et al. 2020).

CONCLUSIONS

Wilderness fire management has paved the way for the continuation and restoration of fire as a fundamental ecosystem process within the large wilderness areas of the Northern Rockies. Fire is now fulfilling its role in this ecosystem largely because of the forward and innovative thinking of land managers who made the commitment to reintroduce fire as an ecosystem process. These individuals worked within an environment that strongly supported fire suppression. Once fire was reintroduced, each subsequent wildfire or fire season provided new insight into wilderness fire management approaches and techniques. This increased management capability, combined with the enhanced resilience of wilderness ecosystems following the reintroduction of fire, has made wildfire management for resource benefit within the Northern Rockies more feasible over time.

Management Implications

Increased use of wildfire management for resource benefit is crucial to resolving the current fire management crisis that plagues the West (Barros et al. 2018; North 2012, 2015). This potential solution may apply especially to the large roadless areas, which, though not designated wilderness, are remote enough to make fuels-reduction strategies such as thinning or prescribed burning logistically and financially impossible (North et al. 2014). Managing fire for resource benefit, however, can be politically and logistically difficult for managers given the immediate risks involved and the culture of suppression that persists in land management agencies (Schultz et al. 2019; Steelman and McCaffrey 2011; Thompson et al. 2018). As a result, a shift toward managing more fires for resource benefit both inside and outside wilderness areas has been and will continue to be challenging for all Federal land management agencies.

The practice of wilderness fire management in the Northern Rockies represents an innovative and relatively uncommon approach to fire management in the West. The long and vibrant history of this approach offers important lessons for land managers seeking strategies other than fire suppression. By providing these lessons and setting the stage for a cultural shift in how the Nation regards fire management for resource benefit, the Northern Rockies will continue to play a pivotal role in shaping national fire policy and management.

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