CHAPTER 13.

Reburns and their Impact on Carbon Pools, Site Productivity, and Recovery

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DEBORAH S. PAGE-DUMROESE
THERESA B. JAIN
JONATHAN E. SANDQUIST
JOANNE M. TIROCKE
JOHN ERRECART
MARTIN F. JURGENSEN

INTRODUCTION

Prior to fire suppression and exclusion, wildfires and other disturbances (e.g., insects, disease, and weather) sustained ecosystem processes in many landscapes of the Western United States. However, wildfires have been increasing in size, frequency, and intensity in recent years (Kellogg and others 2008). Recognizing the value of wildfire, scientists and land managers now promote allowing non-human-caused fires to burn in these landscapes, hoping fire can recreate the historical distribution and mosaic of presettlement, burned forests.

In some wilderness areas, these large natural fires are now burning multiple times in a given area, and the time between fires is decreasing (Halofsky and others 2011). Reburns have the potential to alter vegetation, fuel, and site and soil characteristics and can also alter landscape fire dynamics. Successive fires in a short amount of time can have major consequences for vegetation community structure and soil organic carbon.

The goal of this study was to quantify and characterize the vegetation, surface wood, and soil characteristics associated with successive fire events within the Scapegoat Wilderness, Montana. Our specific purpose was to address the following: How do multiple burns and their frequency influence (1) the extent and degree of changes in coarse wood (standing and down), aboveground carbon (C) pools, and surface and subsurface C and nitrogen (N) levels; and (2) changes in vegetation composition and structure?

METHODS

Site Description

Study sites were located in the Scapegoat Wilderness, Montana, near the Lake, Cabin, Canyon, and Dry Fork Creeks of the Blackfoot River Drainage. The area has burned multiple times (fig. 13.1). The first of the series of fires was the 240,000-acre (96 000 ha) Canyon Fire, started on June 25, 1988 from a lightning strike that burned 75 percent of the Wilderness. In October 1988 and the following summer, a total of 14 plots were established to monitor vegetation recovery after the fire.[1] Two more fires occurred after plot establishment: the Cabin Creek Fire in 2001 [13,300 acres (5338 ha)] and the Conger Creek Fire in 2007 [14,000 acres (5600 ha)]. In the summer of 2012, we revisited 13 of the 14 previously established plots that had burned in the 1988 Canyon Creek Fire. One plot had been previously burned in the Boy Scout Fire (burned in 1952) and this plot and the remaining 12 plots were subsequently burned in the Cabin Creek Fire (2001) and or Conger Creek Fire (2007). The years of individual fire events and their associated plots are shown in table 13.1.

Soils in this area have developed on glaciated uplands, glacial valley trains, or alluvial deposits. Most soils have developed in volcanic ash-influenced loess overlying metasedimentary rock. The area is generally

[1] Losensky, B.J. 1989. Canyon Creek fire vegetation study. 23 p. Unpublished report. On file with: Lolo National Forest, 24 Fort Missoula Road, Missoula, MT 59804.

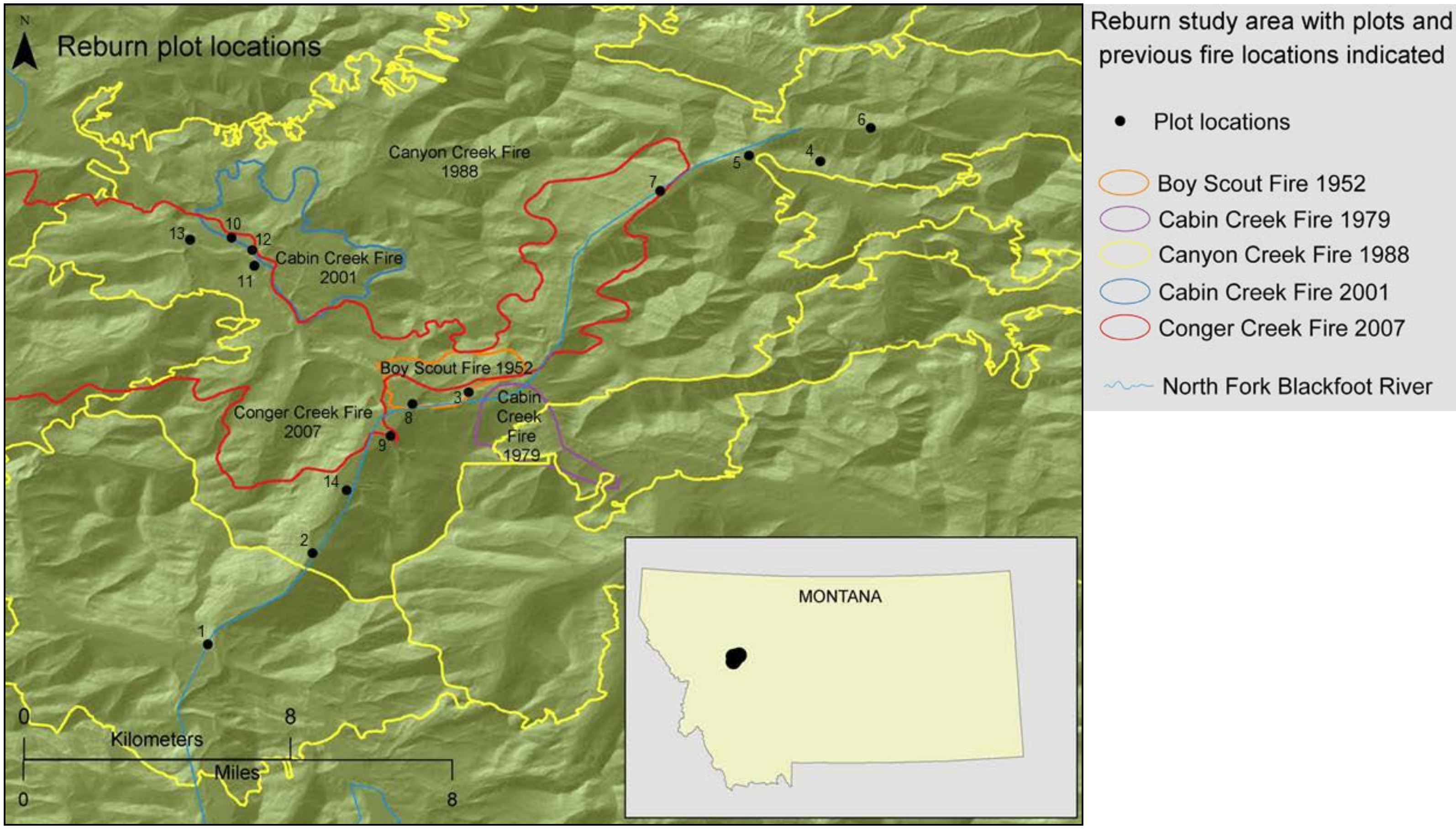

Figure 13.1—Scapegoat Wilderness reburn study area with plots and previous fire locations indicated.

Table 13.1—Plots numbers, year of burn(s), and recovery time after reburns of the Canyon Creek, Cabin Creek, Conger Creek, and Boy Scout Wildfire plots revisited in 2012 in the Scapegoat Wilderness, Montana

Plot numbers	Wildfire name	Year(s) of burn	Recovery time since last fire event
			years
1, 2, 4, 5, 6, 9, 14	Canyon Creek	1988	24
7, 13	Canyon Creek and Conger Creek	1988 and 2007	5
8	Boy Scout and Canyon Creek	1952 and 1988	24
10, 12	Canyon Creek, Cabin Creek, and Conger Creek	1988, 2001, and 2007	5
3	Boy Scout, Cabin Creek, and Conger Creek	1952, 1988, and 2007	5

Note: plot locations are shown in figure 13.1. Plot 11 was not revisited in 2012.

aligned in a north-south direction, and has a precipitation gradient decreasing from west to east. The western portion of the study area has a modified maritime climate, while the east side is continental; annual precipitation ranges from 40 cm in the valleys to 350 cm at high elevation (Keane and others 1994). Elevations range from 970 m to 3200 m.

Climax species include subalpine fir [*Abies lasiocarpa* (Hook.) Nutt.] and Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco], with some western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] or ponderosa pine (*Pinus ponderosa* Lawson and C. Lawson). Because of wildfire, many seral species, such as larch (*Larix occidentalis* Nutt.), lodgepole pine (*Pinus contorta* Douglas ex Louden), and aspen (*Populus tremuloides* Michx.), as well as some shrubfields, can be found across much of this area.

Field Methods

Data presented in this summary were collected in 2012. Only vegetation data were collected in the original sampling in 1988 and 1989. Coarse wood and ground cover biomass are not presented here.

Soil sampling—After postfire index category classification (as described below), the forest floor (if present) was sampled from each postfire index category present. Soil cores were collected from 0- to 10-cm and 10- to 20-cm depths with a small-diameter (2 cm by 10 cm) corer. Soil and forest floor samples were placed in zip-type bags for transport. In addition, digital photographs were taken at each point to systematically determine soil cover using the Cover Monitoring Assistant computer program (Steinfeld and others 2011). Soil C and N were analyzed on sieved (<2 mm) soil using an induction furnace. Soil nutrient concentrations were converted to a mass basis using the fine fraction bulk density (Page-Dumroese and others 1999). Woody material located on the soil surface was quantified by data collection on three transects. Small twigs and branches were tallied in three classes (0 to 60 mm, 61 to 250 mm, and 251 to 750 mm). All logs >750 mm had their diameter and decay class recorded (Sollins 1982).

Quantifying postfire conditions—Based on historical data collected, each plot was assigned an initial postfire index (PFI) as described by Jain and others (2012) to classify vegetation conditions immediately after the 1988 fire. This index is based on the amount of surface organic matter remaining postfire, with low index values indicating that larger amounts of vegetation remain on the site, and subsequently higher values indicating less organic matter remaining postfire. Each plot was revisited in 2012, and a new soil PFI was assigned for each of four sample points in the plot.

RESULTS AND DISCUSSION

Soil

Soil cover (percent) was surprisingly similar for most plots (table 13.2). However, there were a few exceptions. For example, there was 13 percent bare soil on plots burned three times with 5 years of recovery. Higher levels of bare soil likely indicate most of the forest floor was removed during the three burns, and vegetation has not recovered sufficiently to develop a uniform forest floor layer. In addition, total soil profile C and N pools were also relatively similar (table 13.3). The notable exception here is that plots with three burns and 5 years recovery had the least amount of soil C in the forest floor but the most C in the mineral soil horizons, indicating possible relocation of organic materials after a fire or decomposition of dead roots. Fire

Table 13.2—Ground cover (percent) and total amount of coarse wood as related to recovery time and number of reburns from the Canyon Creek, Cabin, Boy Scout, and Conger Wildfire plots revisited in 2012 in the Scapegoat Wilderness, Montana

Recovery time	Plot numbers	Number of burns	Bare soil	Charcoal	Forest floor	Forbs	Grass	Shrubs	Rocks	Total Coarse Wood (all size classes)
years			----------	----------	----------	*percent*	----------	----------	----------	*Mg/ha*
24	1, 2, 4, 5, 6, 9, 14	1	6	<1	18	28	20	21	2	193
24	8	2	4	<1	29	36	1	12	0	88
5	7, 13	2	8	1	22	38	25	3	1	134
5	3,[a] 10, 12	3	13	1	25	28	24	3	3	80

[a]Although plot 3 was burned by different fires, for these analyses it was combined with plots 10 and 12 with 3 burns.

Table 13.3—Forest floor and mineral soil C and N pools as affected by recovery time and number of reburns from the Canyon Creek, Cabin, Boy Scout, and Conger Wildfire plots revisited in 2012 in the Scapegoat Wilderness, Montana

Recovery time	Number of burns	Plot numbers	Forest floor C	Forest floor N	0-10 cm mineral soil C	0-10 cm mineral soil N	10-20 cm mineral soil C	10-20 cm mineral soil N	Total soil profile C	Total soil profile N
years			*Mg/ha*	*kg/ha*	*Mg/ha*	*kg/ha*	*Mg/ha*	*kg/ha*	*Mg/ha*	*kg/ha*
24	1	1, 2, 4, 5, 6, 9, 14	17.1 (1.8)	419 (37)	25.4 (2.0)	1316 (152)	16.4 (2.0)	889 (86)	58.9	2624
24	2	8	49.1 (4.5)	730 (74)	13.6 (1.5)	571 (87)	6.9 (1.0)	335 (41)	69.6	1636
5	2	7, 13	30.9 (3.2)	1186 (115)	17.5 (2.1)	860 (109)	10.9 (1.7)	572 (87)	59.3	2618
5	3	3,[a] 10, 12	12.3 (2.1)	197 (54)	29.6 (2.3)	1638 (156)	22.6 (2.7)	1284 (183)	64.5	3119

Values in parentheses are standard error of the mean.

[a]Although plot 3 was burned by different fires, for these analyses it was combined with plots 10 and 12 with 3 burns.

changes to soil surface conditions and mineral soil properties can cover a spectrum depending on burn intensity, duration, fuel loading, combustion type, vegetation type, fire climate, slope, topography, soil texture and moisture, and soil organic matter content (Neary and others 1999). Therefore, the relative lack of differences and variability we detected in 2012 for each of the fire recovery times and number of fires is to be expected. More detailed work is needed to elucidate cause and effect.

Vegetation

As noted earlier, vegetation coverage measurements were made as part of the original site data collected in 1988 and 1989. Based on these measurements, values of PFI were calculated for each plot for the 13 plots revisited in 2012. Four of these plots still had much of the forest floor cover (>85 percent) intact (soil PFI = 1.0), four plots averaged 61 percent forest floor cover (PFI = 2.1), and four plots averaged 15 percent forest floor cover (PFI > 3.0) (table 13.4). Jain and others (2012) related the PFI values on other postfire sites to the physical, chemical, and biological state of the soil at the Scapegoat Wilderness plots in 2012. These sites correlate with the C and N data we obtained from the soil samples and with the soil cover data derived from the digital photographs at the Scapegoat plots (table 13.2). Percentages of soil covered by gray and black ash were also calculated (table 13.4). Gray ash is used as an indicator that soil nutrients such as N were likely volatilized during the fire. A dominance of black ash indicates that some volatilization may have occurred, but much of the organic C is still present. The multiple fires since 1988 have resulted in a decrease in forest floor cover. However, the plots with soil PFI >3.0 have resulted in a trend toward a shrub response with additional leaf litter inputs; this is most likely contributing to increased forest floor cover.

Table 13.4—Soil Post-fire Index (PFI) based on forest floor and surface soil conditions immediately after 1988 Canyon Creek Wildfire along with forest floor and low shrub (<15 cm tall) covers observed in 2012, Scapegoat Wilderness, Montana

		Immediate post-burn (1988 Canyon Creek Fire)				2012	
PFI	No. of obs.	Forest floor	Black ash	White ash	Mineral soil	Forest floor	Low shrub
		percent					
1.0	4	85.9 (9.2)	2.3 (1.6)	3.1 (4.9)	0.3 (0.4)	26 (41)	6 (8)
2.1	4	60.8 (7.8)	13.4 (5.7)	8.5 (5.9)	3.1 (5.7)	26 (49)	8 (5)
> 3.0	4	15.4 (9.7)	0.8 (0.7)	42.7 (18.9)	0.8 (0.7)	45 (31)	19 (16)

Note: The index was developed by Jain and others (2012) and reflects a full range of post-fire outcomes. The post-fire classification consisted of no evidence of recent fire (0); evidence of fire with > 85% forest floor cover (1.0); evidence of fire with >40% forest floor cover and mineral soil is charred black (2.1), gray/white, or orange (2.2); evidence of fire with <40% forest floor and mineral soil is unburned (3.2), charred black (3.2), gray/white (3.3), or orange (3.4). For each PFI, average cover and standard deviation (in parentheses) are provided for forest floor characteristics immediately after the 1998 fire and in 2012. All values reported in percent cover.

After 24 years, the forest floor cover, canopy cover, shrub cover, and biomass were no longer different among the plots ($p > 0.05$).

Canopy cover and total biomass were related to time since fire (24 years versus 5 years, tested at $p = 0.05$) and not related to number of fires (one, two, or three; data not shown). This is not surprising, as longer recovery times after a disturbance provide an opportunity for the vegetation to respond. The reburns in 2007 killed many established seedlings and consumed much of the woody debris, leaving only grass and forbs with more mineral soil exposed (fig. 13.2A). In contrast, the plots that were 24 years postfire had more trees, shrubs, and overall biomass. Saplings, some above 2 m tall, were established; low shrubs dominated the understory with some forbs and grasses. In addition, there was more woody debris created from snags as they fell over time (fig. 13.2B).

CONCLUSIONS

Few differences in soil surface or mineral soil conditions were found between plots in our 2012 survey, and the similarity is likely due to terrain, soil, and climatic conditions at each plot at the time of each fire. It is notable that the plots with three burns and only 5 years of recovery time had the lowest C and N in the forest floor, highlighting the loss of forest floor mass and the short recovery time. This trend is similar to the results from our vegetation survey. At the same time, sites within these three wildfire burn areas, even after multiple burns, show some level of recovery.

CONTACT INFORMATION

Deborah S. Page-Dumroese: ddumroese@fs.fed.us.

(A)
(B)


Figure 13.2—(A) Recent reburn removing seedlings, shrubs and large downed wood; and (B) regeneration and large wood after site recovery. (Photos by Jonathan Sandquist, U.S. Department of Agriculture Forest Service)

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