The Scott Able Fire: Effects on select soil parameters within Sacramento Mountain salamander habitat

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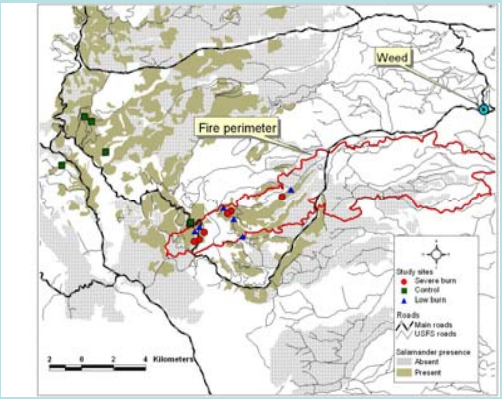
ABSTRACT The Scott Able Fire was initiated by a downed power line that sparked the wildfire on May 11, 2000 on the Lincoln National Forest in south-central New Mexico. The area is habitat for the Sacramento Mountain salamander, *Aneides hardii*, which is listed as a sensitive species. Because the salamander is active at the soil-litter interface and depends on a moist substrate for cutaneous respiration, any moisture loss due to fire could have significant ramifications for the salamander. We therefore measured soil pH, water-holding capacity, and organic matter, factors that may affect Sacramento Mountain salamander activity and distribution. These factors were measured over a five-year period in unburned areas (no fire in 30 years, control) and areas with light or heavy forest floor consumption and overstory mortality to evaluate if and how long differences in these soil parameters occurred. As expected, organic matter, water-holding capacity, and pH all showed significant treatment effects ($P < 0.0001$, greatest change in heavy burn sites), but also showed significant effects of the year of sampling and significant interaction effects between year and treatment ($P < 0.001$). With greater time since the fire, differences between treatments lessened for all soil parameters, resulting in no significant treatment differences for all the parameters 4 years after the fire. Thus, while others factors still show the effects of fire, the Scott Able Fire caused a short-term pulse of changes in these factors within the mineral soil that lasted for about 3 years.

Figure 1. Map of a portion of the Lincoln National Forest, Sacramento Mountains, indicating the area covered by the Scott Able Fire (Fire perimeter) and the study sites used to examine the impact of the Scott Able Fire on soil organic matter, water-holding capacity, and pH during the period from 2000-2005.



I. Introduction

The Scott Able Fire, started by a downed power line, burned 16,034 acres along a narrow stretch of forests ranging from pinon-juniper to spruce-fir and including almost 8,000 acres of high-elevation mixed coniferous forest (Fig. 1). The initial fire behavior was extreme, with crowning and spotting occurring miles ahead of the fire. Several U.S. Forest Service-funded studies investigated the effects of the fire on a variety of plants and animals listed as sensitive by the Southwest Region, including the Sacramento Mountain salamander, *Aneides hardii*. As part of a study of potentially critical aspects for salamander activity and distribution, this study quantified the fire's effects on soils relative to water absorption and retention, and soil pH.

II. Methods

- **3 Treatments:** Control (**CNTL**), no known record of fire in last 30 years; severely burned (**BURN**), no live trees (10%tree kill), no litter, most downed logs completely burned on outside; and lightly burned (**LOWB**), not fewer than 75% live (green) trees, some litter present, generally located at the edge of the fire due to burn intensity (see Figure 1 and Table 1).
- **6 sites/treatment; 4 soil samples/site:** Mineral soil to a depth of 155 mm was collected at the ends of 2 randomly-arranged 50-m long pitfall lines at each site.
- **Soil Analyses: Organic Matter**-loss upon ignition; **water-holding capacity**-water retention after 30-minutes draining following saturation; **pH**-electrode.

Table 1. Site characteristics (Control (CNTL); Severely (BURN) and Lightly bu Sites were established in 2000, except those with an asterisk (*) were established

Site	UTM	Elevation (m)	Aspect	Slope	Overstory Cover 2000	Overstory Cover 2005
CNTL 1	13 04 33 183 E 36 23 038 N	2835	E	36%	83%	91%
CNTL 2	13 04 33 248 E 36 23 145 N	2835	S	25%	83%	89%
CNTL 3	13 04 28 000 E 36 27 518 N	2850	N	34%	89%	89%
CNTL 4	13 04 27 158 E 36 29 394 N	2847	W	39%	93%	90%
CNTL 5	13 04 25 262 E 36 26 738 N	2743	NW	46%	75%	79%
CNTL 6	13 04 26 716 E 36 29 679 N	2829	E	39%	83%	95%
Mean				37%	84%	89%
BURN 1	13 04 35 766 E 36 23 786 N	2813	N	16%	61%	24%
BURN 2	13 04 35 544 E 36 23 656 N	2825	S	21%	49%	31%
BURN 3	13 04 38 941 E 36 24 660 N	2502	NW	73%	51%	57%
BURN 4	13 04 33 760 E 36 21 078 N	2761	W	28%	43%	23%
BURN 5	13 04 33 449 E 36 21 948 N	2743	E	29%	47%	60%
BURN 6*	13 04 37 097 E 36 23 976 N	2694	SE	43%	68%	39%
Mean				38%	53%	39%
LOWB 1	13 04 36 478 E 36 22 244 N	2737	N	32%	80%	57%
LOWB 2	13 04 35 929 E 36 23 324 N	2777	N	29%	66%	77%
LOWB 3	13 04 39 518 E 36 25 114 N	2469	N	49%	81%	63%
LOWB 4*	13 04 35 151 E 36 23 072 N	2774	NW	63%	88%	76%
LOWB 5*	13 04 33 907 E 36 23 199 N	2768	SW	26%	93%	93%
LOWB 6*	13 04 32 977 E 36 22 717 N	2835	E	30%	91%	84%
Mean				38%	83%	75%

III. Results

As expected in heterogeneous landscapes, significant within-treatment variation occurred between the sites and year of sampling for most soil analyses (Tables 2). However, even with significant within-treatment variation, the treatments were significantly different along with the year of collection (Tables 3). Also as expected, the severely burned treatment showed the greatest change from the control, especially in the first collection (Tables 4, 5, and 6).

Table 2. Within treatments, probabilities associated with the effects of the factors (site, their interactions) on soil characteristics.

Treatment	Factor	Degrees of Freedom	Organic Matter percent (%)	Water-holding Capacity (ml/g)	pH
CNTL	Site	5	0.2333	0.3121	**0.0001**
	Year	4	**0.0001**	**0.0001**	**0.0001**
	Site X Year	20	**0.0006**	**0.0006**	**0.0417**
	Error	90			
LOWB	Site	5	**0.0046**	**0.0002**	0.1125
	Year	4	**0.0001**	**0.0001**	**0.0001**
	Site X Year	20	**0.0028**	**0.0003**	0.1021
	Error	90			
BURN	Site	5	**0.0001**	**0.0001**	**0.0001**
	Year	4	**0.0001**	0.1426	**0.0001**
	Site X Year	20	**0.0005**	**0.01**	**0.0005**
	Error	90			

[1]DF's vary from indicated for some analyses due to missing sa
*For pH, there were 5 years of data, which increased DF's to 5, 5, 25, and

Table 3. Probabilities associated with the effects of the factors treatment, y and the interaction of treatment and year on soil character

Soil Characteristic	Factor	Degrees of Freedom	Probability
Organic Matter	Treatment	2	**0.0001**
	Year	4	**0.0001**
	Treatment X Y	8	**0.0001**
	Error	337	
Water-holding Capacity	Treatment	2	**0.0001**
	Year	4	**0.0001**
	Treatment X Y	8	**0.0001**
	Error	337	
pH	Treatment	2	**0.0001**
	Year	5	**0.0001**
	Treatment X Y	10	**0.0001**
	Error	389	

Table 4. Hydrogen ion concentration (mean of 6 sites converted to pH) for treatm indicated sampling year. Within a given year (column), treatments with means followed by a different lower-case letter are significantly different ($p < 0.05$). Within a treatment (row), years with different capital letters indicate the years of collection were significantly different ($p < 0.05$).

Treatment	Year 2000	2001	2002	2003	2004	2005
CNTL	5.73a A	6.02a B	5.88a AB	6.44a C	6.43a C	6.56a C
LOWB	6.46b AB	6.26a A	6.19b A	6.63a B	6.68a B	6.78a B
BURN	6.76c B	6.65b AB	6.43c A	7.14b C	6.49a A	6.74a B

Table 5. Organic matter (percentage dry soil; mean and standard error, S and year. Within a given year (column), means followed by different lo significantly different ($p < 0.05$). Within a treatment, different capital le the S.E. indicate that the years are significantly different ($p < 0.05$).

Treatment	Statistic	Year 2001	2002	2003	2004	2005
CNTL	Mean	20.48a	25.93a	15.97a	11.25a	9.87ab
	S. E.	2.293AB	2.34A	1.04B	0.62C	0.47C
LOWB	Mean	14.57b	18.65b	12.58b	10.3ab	8.5b
	S. E.	0.88B	1.88A	0.86BC	0.76CD	0.42D
BURN	Mean	12.94b	12.30c	11.70b	8.62b	10.34a
	S. E.	0.66A	0.86A	0.62AB	0.47C	0.56BC

Table 6. Water-holding capacity (ml water/g soil; mean and stand and year. Within a given year (column), means followed by a di significantly different ($p < 0.05$). Within a treatment (row), diffe the standard errors indicate that the year is significantly differe

Treatment	Statistic	Year 2001	2002	2003	2004	2005
CNTL	Mean	1.15a	1.40a	0.97a	0.73a	0.73a
	S. E.	0.09AB	0.14A	0.03B	0.01C	0.01C
LOWB	Mean	0.88b	0.90b	0.82b	0.70a	0.69b
	S. E.	0.04A	0.05A	0.03A	0.02B	0.01B
BURN	Mean	0.77b	0.74b	0.76b	0.72a	0.71ab
	S. E.	0.02A	0.03A	0.02A	0.01A	0.01A

Results (cont.) However, differences between the control and burned plots diminished over time and were not significantly different 4 to 5 years after the fire (Tables 4, 5, and 6). Also, the greatest change in soil characteristics during the collection period occurred in the control soils rather than burned soils, with the controls approaching the burned, rather than the burned recovering to control conditions. These results were not expected; and they show how dynamic soil characteristics can be over time, which are conditions the salamanders must endure.

IV. Conclusions

The Scott Able Fire lowered soil organic matter and water-holding capacity while raising soil pH, with the greatest change occurring in the severely burned sites, which was expected. However, within 4 to 5 years, the burned sites were not different than the control sites; a short period of time given the fire severity. The rather dramatic change in characteristics of the control soil dramatize the range of conditions with which the salamanders must contend.

Example of "Control"

Example of "LowB" site.

Example of high intensity "Burn" site; note that even scorched needles are not present.

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