Ashland Forest Resiliency Project 2017 Prescribed Burn Fire Effects Monitoring Report

Keith Perchemlides, The Nature Conservancy, March 2018

Units: USFS AFR underburn units 28n, 28s, 28y, and 31c
Burn Dates: May-June 2017: 28n - 5/4/2017; 31c - 5/23/2017; 28y - 5/26/2017; 28s - 6/6/2017.
Acres Burned: 220 acres total: 28n 19 ac; 28s- 58ac; 28y - 66 ac; 31c - 77ac.
Fuel Type: Timber litter, timber understory
Fuel Model: TL3 – TL4
Burn Boss: Robert Marshall (28y, 31c) and Brett Brown (28n, 28s), Forest Service
FEMO: Keith Perchemlides

Purpose and Resource Management Goals

This report covers prescribed burn implementation, objective attainment, and fire effects monitoring for four adjacent Forest Service units burned in May and early June 2017, comprising 220 total acres within the Ashland watershed and Siskiyou Mountain Ranger District (SMRD) of the Rogue River Siskiyou National Forest: Units 28n, 28s, 28y, and 31c. These burns are part of the Ashland Forest Resiliency (AFR) project, a partnership of the U.S. Forest Service (USFS), City of Ashland (COA), Lomakatsi Restoration Project (LRP), and The Nature Conservancy (TNC). With high-level input from the partnership, all burns were planned and led by Forest Service staff and implemented by mixed crews of Forest Service and contracted Grayback Forestry, Inc. personnel. AFR prescribed burns are intended to meet both fire management and ecological goals by reducing fuel loads and fire risk, and reintroducing beneficial fire for forest restoration while protecting sensitive wildlife habitat.

Prescribed Fire Objectives

All four units were covered under a single USFS burn plan (Unit 28 2017 burn plan) containing a set of resource and prescribed fire objectives approved in 2016 by the AFR partnership for all burns in the Ashland watershed:

1. Reduce litter and light surface fuels (1 to 100-hr) by 30 - 80%
2. Reduce understory trees (< 5" DBH) and shrubs by 30 - 80%
3. Limit mortality of intermediate trees (5-12" DBH) to < 40%
4. Retain > 90% dominant/codominant trees (> 12" DBH)
5. Minimize mortality of legacy trees *(large, old trees with complex form, providing important habitat value)*
6. Retain overall effective ground cover (EGC) for the unit based on soil erosion hazard class: Moderate (< 35% gradient), > 60% year-1, > 70% year-2; Severe or higher (> 35% gradient), > 70% year-1, > 85% year-2
7. Retain approximately 90% large down logs or snags (>20" diameter)
8. Minimize fire intensity in leave areas
9. Retain an unburned strip of duff 25’-50’ wide and coarse woody material within 50’ of perennial streams.

Fire Effects Overview

This report provides monitoring input for the adaptive management of future AFR burn planning and implementation, including possible adjustments to burn objectives and prescription parameters. The report follows-up on initial post-burn observation notes circulated within the partnership by TNC in June 2017, and partner comments during the July 2017 After Action Review (AAR) meeting (AFR 2017 AAR notes). The 2017 burns were an important increase in the scale of AFR prescribed burning, were safely conducted, successfully dispersed smoke, substantially reduced fuel loads, and returned many benefits of fire to the forest habitat. At the same time, these burns exceeded the upper thresholds of several burn objectives. Heat generated in units 28s, 28y, and 31c led to unanticipated levels of crown scorch, fire damage, and mortality from the understory through to the upper canopy trees. Fire effects include stress and likely mortality for a substantial number of the legacy trees that are one of the core values which AFR forest restoration work seeks to promote. In marked contrast, the cool, patchy fire in the early-season 28n burn avoided damage to trees yet fell short of meeting fuel and understory reduction objectives.

Unit Descriptions

Units 28n, 28s, 28y and 31c cover a continuous area of 220 acres at an average of 4700' elevation along the western edge of the Ashland watershed. Slopes are variable and typically steep, averaging a 30% gradient, and the units span all aspects; generalized by unit, aspects are: 28n east, 28s northeast, 28y southeast, and 31c primarily northwest (Map 1). The units are characterized by mid-elevation dry mixed conifer forest composed mainly of Douglas-fir, white fir, ponderosa pine, and sugar pine, with pacific madrone and golden chinquapin in the lower canopy and understory. All units had been previously treated with surface and ladder fuel reduction and density management thinning in 2012. Activity fuels were piled and burned, with pile burn dates ranging from 2013 through 2016. Thinning left the understory of the units open and sparse (approximately 5% average cover), except for limited patches of shrub or madrone regeneration. The pre-burn canopy closure was an average of 65%, somewhat higher in units 28n and 28y, and lower overall in 31c. See Table 1 below for a summary of unit conditions.

Natural fuel accumulations on these relatively productive units combined with remaining activity fuels and frequent unburned piles from recent thinning resulted in a heavier surface fuel load than in recent AFR prescribed burns (see prior reports for unit 12, AFR 2015 FEMO report, and unit 14b, AFR 2016 FEMO report). Moderate timber litter with coarse fuels and small-diameter logs equivalent to a Timber Litter 4 (TL4) or higher (TL5, TL6, TL8) fuel model (Scott and Burgan 2005) was the most widespread and common pre-burn fuel bed, covering about two-thirds of the total area. The remaining third was primarily Timber Litter 3 (TL3), moderate litter with a light load of coarse fuels. See Table 1 for a summary of pre- and post-burn fuel models by unit. Timber Understory fuel models TU1 and TU2, with shrubs and grasses in addition to forest litter, were a minor presence in the units, especially along the old shaded fuel-break on the ridge in 31c. These higher-elevation burn units were selected in 2017 largely due to early green-up in the fuel-bed at lower elevation units and in response to smoke management concerns with units closer to town.

Unit 31c is bounded on all sides by unpaved forest road 400 and its side-spur, and the gravel-surface 2060 road forms the downslope east boundary of 28s and the east and south boundary of 28y (Map 1). The "No Candies" trail, popular with mountain bikers, was used as the western line for units 28s and 28y, and traverses unit 31c. A handline was installed to separate units 28s and 28y on their shared boundary, and along the north boundary of 28s as needed. Forest road 400 forms the west edge of 28n, but otherwise the unit had no perimeter line given high adjacent fuel moisture at the time of burning. A large log-landing at the intersection of units 31c and 28s was used as the staging area for all four burns. Map 1 shows the final unit perimeters, acres, topography, forest roads, and staging area.

Burn Implementation and Fire Behavior Summary

This section presents an overall summary of operations and fire behavior for units 28s, 28y and 31c, and references a separate report covering unit 28n. Units 28s, 28y, and 31c contained 201 of the 220 acres burned in 2017 and are similar in timing, operations, and fire effects. In contrast, unit 28n (19 acres) was burned earlier as a training activity and characterized by ignitions not carrying or low intensity fire. Prescribed burns were generally one-day operations for units 28n, 28s, and 28y, with ignitions conducted between 1000 and 1700. For unit 31c a second half-day of operations was needed to complete the planned area. On unit 28y, a second day of operations responded to and contained a 5-acre slop-over burn. According to Forest Service leads, smoke management concerns set a target timeframe for completing ignitions prior to an advised 1600 afternoon cutoff, to avoid problematic smoke dropping into town at night. The Burn Implementation Unit Logs section below provides specific timelines and details of important events, decisions, fire behavior, smoke, holding issues, and ignition patterns for units 31c, 28y and 28s. Table 2 summarizes hourly fire weather recorded by Forest Service staff and calculated fuel metrics (fine dead fuel moisture and probability of ignition) for each of these burns. For reference, Tables 3a and 3b provide copies of the burn plan prescription ranges for weather, fuel moistures and fire behavior. At end of this report, selected photographs provide representative images of fire effects and behavior.

Units 28s, 28y, and 31c:

For units 28s, 28y, and 31c, operations were conducted by agency and Grayback Forestry crews under the leadership of Forest Service burn bosses Robert Marshall (31c, 28y) or Brett Brown (28s). The typical ignitions pattern was dot firing on staggered lines 10'-20' apart with crews of 4 to 6 lighters working along slope contours. Strip firing or a dot-dash pattern were also used at times. For operational efficiency and because of the complex topography in these units, often two ignitions crews worked in parallel using a "bump-and-flow" pattern to bring fire down two different slope aspects in tandem. These crews were coordinated but lead separately by the firing boss and firing trainee.

During the burns, fire weather remained within prescription, with air temperature in the desired range and RH and mid-flame winds typically in the low intensity range. Fine dead fuels (1-hour) were typically in the mid- to high-intensity prescription range for shaded fuels (see Tables 2 and 3a). However, prior drying in the units may have left larger fuels with moistures at or drier than the high-intensity prescription range. Fuel moisture probe measurements taken between 1000 and 1300 in 28y found that 10 and 100-hour fuels were 5-8% and 7-12% moisture respectively, compared to the high-intensity prescription limits of 9-11% (10 hour) and 11-13% (100 hour). Supporting this observation, 1000-hour (3-8" diameter) and larger fuels were actively involved and significantly consumed in each of the burns, especially in accumulations of natural or activity fuels.

The probability of ignition (POI) for shaded fuels remained in the desired range, but fire behavior was often more intense than planned (Tables 2 and 3b). The fire's rate of spread (ROS) was highly variable but ranged up to and beyond the upper threshold of the prescription. Flame lengths (FL) and bole scorch heights that exceeded the prescription range were widespread, especially during the afternoons and where fuel loadings were heavy. Spotting over the line, slop-over, and limited torching occurred in unit 28y, and substantial nighttime spread and consumption was reported for 31c. Overall, fire behavior across these units ranged from moderate to high-intensity and spanned outside of prescription bounds. There were also some limited areas of low intensity fire due to lighter fuel loads or abundant live cover in the fuel bed. See Table 3b and the Burn Implementation Unit Logs section for more information on prescription parameters and unit-specific fire behavior.

Throughout the units, fire was carried primarily by a continuous bed of litter and 10 to 100-hour fuels. Initially the fire burned mildly at 1-2' flame lengths and spread slowly. When ignitions moved onto aspects with greater sun and wind exposure, and as daytime temperature climbed and humidity dropped, the fire intensity stepped up. Especially where down logs, fuel accumulations and piles burned, the intensity and persistence of the fire increased over large areas. Flame lengths reaching 3'-6' average (10'-15' maximum), ROS > 5'/minute, and scorch heights >25' were widespread. Across large areas of units 28s, 28y, and 31c, consumption of surface fuels, understory, and herbaceous cover approached 100%. Surface heat contributed strongly to tree mortality by killing the cambium of especially younger or thin-barked trees (conifer regeneration, madrone, and chinquapin), as well as some large and thick-barked individuals. However, duff moisture levels were apparently high enough to limit duff consumption and areas of high soil burn severity were limited (< 5%).

The cumulative heat and duration of fire appears to have generated intense updrafts of convective heating, scorching tree crowns across large areas and to over 100' canopy heights. Torching and crown fire were practically absent, yet 25% of the total unit acres had high to severe levels of crown scorch (Map 1, high crown scorch areas defined as roughly ≥90% of trees having ≥70% crown scorch). Some of the most severe crown scorch was at the top of slopes or drainage gullies, where fire downslope burned intensely in fuel accumulations. Slope and wind driven convective heating resulted in some areas having a striking combination of severe canopy effects yet only low or moderate intensity fire evident at the base of the same trees. The timing of the burn relative to tree phenology may have exacerbated crown scorch; trees were in spring growth and crowns were full of tender new shoots ("candles") not yet hardened to heat or moisture stress (Bill Schaupp, USFS, pers. comm.).

During the AAR, Brown observed that crews conducting bump-and-flow ignition in 28s sometimes progressed at a pace that built more heat than desired and along lines that angled downslope in a zig-zag rather than horizontal sweep pattern, leading to large pulses of heat coming together. Similarly, in unit 31c the burn boss trainee noted a concern with a "chevron" pattern occurring between firing crews that would amplify heat at the upslope convergence. Where larger and heavier fuels were involved, the fire intensity, duration, and total heat generated all increased. Especially in larger or accumulated fuels, there was a time delay as the fire built from moderate to intense heat, and ignitions crews may have left the immediate area before that fire behavior was apparent. As lighters swept back across downslope, the accumulation of converged fire and prolonged burn duration sometimes interacted to build a deep flaming front spanning >50' back upslope. Direct observation of this more intense range of fire behavior often required doubling back into the heat and smoke of the active burn, making it impractical or unsafe. Adaptations to firing pace and pattern during these burns likely reduced fire intensity, but not sufficiently to keep fire behavior and effects consistently within the intended ranges.

Unit 28n:

Burn implementation for Unit 28n and a small 4-acre sub-area of 31c (Map 1) was completed on May 3-4, during the 2017 Ashland prescribed fire training exchange (TREX). Operations, fire behavior, and performance on objectives for those burn areas are covered by a fire effects monitoring (FEMO) report produced as part of the TREX in June 2017 by Doug Kreutzer (TNC) and Jena Volpe (BLM) – available at (initial TREX 28n/31c 2017 FEMO report).

Fire Effects Monitoring Method

Established fire effects monitoring directly tracks the standard set of AFR-partnership prescribed fire and resource objectives listed above (page 1). Each objective is linked to a specific monitoring indicator recorded in pre- and post-burn plots, with additional metrics to characterize the unit or inform fire or smoke modeling, and repeat photographs to document fire effects. Monitoring plots were 0.1 acre, circular, and distributed throughout the units to capture the range of fuels, topographic settings, stand types, and fire effects (Map 1, plot locations). Pre-treatment plot data were collected shortly before the burns, followed by records of fire weather, behavior, and ignitions pattern during the burn. For units 28s, 28y, and 31c, Forest Service staff recorded and shared fire weather as well as unit log notes on of fire behavior and burn operations. Notes and records from the Forest Service staff were combined with TNC FEMO field-notes to complete the Burn Implementation Unit Logs below. Post-burn data and photos were collected in the fall to allow time for tree mortality and ground cover conditions to develop. Post-burn unit walk-throughs were used to assess objectives not captured at the plot scale, and to verify that plot data were adequately representative. For the Ashland watershed, where loose granitic soils and steep slopes create erosion risk, ground cover retention (EGC) monitoring was developed with the Forest Soil Scientist, measuring effective ground cover (EGC) pre- and post-burn. The full monitoring method for these AFR FEMO plots is available at: AFR 2017 Fire Effects Monitoring Method.

Each burn unit perimeter was GPS-mapped post-burn. And patches of high severity crown scorch, defined as ≥70% crown scorch on ≥90% of canopy trees, were field-mapped, then refined using aerial imagery from Google Earth. Responding to stakeholder and partnership concerns, supplemental monitoring was developed and interpreted in collaboration with Forest Service ecologists to better track and quantify fire impacts to legacy trees. Sixty-nine legacy trees were sampled for fire effects and mortality indicators across all units and species during the summer and fall of 2017. The full method and results of that legacy tree monitoring are reported separately (AFR Legacy Tree 2017 Burn Monitoring Report). Unit-scale results from predictive mortality modeling are used here to assess the burn objective for legacy tree survival.

Monitoring Results and Performance on Objectives

Although fire effects varied over a wide range, overall the 2017 AFR units burned more intensely than intended with fire behavior up to or beyond the upper bounds of the burn plan prescription. Fire intensity pushed surface and understory consumption and tree mortality beyond the target range for multiple burn objectives. Table 1 provides a side-by-side summary of pre- and post-burn unit conditions followed by fire effects monitoring results for all objectives by unit, summed for all units, and summed for the sub-set of higher intensity units: 28s, 28y and 31c.

General fire effects: Excluding the early-and-cool burn in unit 28n, fire actively burned through >90% of the unit area. Intense convection heat caused high levels of canopy scorch across 25% (55 acres) of the high intensity units, with the greatest impact on Unit 28s (38%), less in 28y (15%), and none in 28n (Map 1). Widespread crown scorch reduced canopy closure by an average of 11% in units 28s, 28y and 31c, even during the same season while most brown leaves and needles were retained. With high levels of surface fuel consumption, the dominant fuel model across these units shifted from TL4 to TL1 (low load of compact conifer litter) – a major reduction in fuel load.

Generalized results for units 28s, 28y, and 31c – refer to Table 1 for unit-specific results:

Prescribed fire objectives:

1. Surface fuel reduction: Low moisture and intense heat from burning heavier fuels resulted in surface fuel consumption up to and exceeding the high end of the target range.

2. Understory tree/shrub reduction: Intense heat reduced understory beyond the objective range, except in 28y. Given the sparse pre-burn understory, this level of reduction effectively removed that strata from most of the burn area. Post-burn madrone basal sprouting offset immediate fire effects by the time of monitoring. The loss of conifer regeneration combined with hardwood re-sprouting has the potential to shift long-term species composition.

3 and 4. Intermediate and dominant/co-dominant tree mortality: Mortality of trees 5"-12" and >12" exceeded the limits set by objectives. Fall 2017 monitoring likely underestimates actual mortality because it applied a simple rule of 100% crown scorch in identifying post-burn tree mortality. The effects of root and cambium kill and insect attack will likely add to mortality. Apparent mortality was greatest in high scorch areas, but not limited to them. Thin-barked hardwoods, madrone and chinquapin, and small-diameter conifers were disproportionately impacted.

5. Minimize legacy tree mortality: Although "minimize" is not a measurable quantity, 16% average (range of 11%-25%, Table 1) estimated legacy mortality likely exceeds the intent of this objective. Mortality estimates here are based on predictive models incorporating the indicators of crown scorch, cambium kill, insect attack, species and diameter (analysis guided by Bill Schaupp, USFS). A separate report will provide more information on methods and initial results by unit and species. Follow-up monitoring in 2018 will provide more definitive results.

Resource objectives:

6. Retain effective ground cover (EGC): This objective was fully met. Although consumption of surface cover was widespread, high levels of duff moisture at the time of the burn followed by heavy post-burn litter fall from scorched canopies fully offset fire effects on EGC.

7. Retain large logs and snags: Objective met. Large diameter down wood and snags (>20" diameter) were relatively sparse pre-burn. Despite some consumption, internal fuel moisture in these structures sufficient to allow them to persist with limited losses. Significant future large log and snag recruitment is anticipated with tree mortality.

8. Minimize fire intensity in leave areas: Where applicable, the burns met this objective. The relevant leave areas are Pacific Fisher habitat blocks (Map 1). These do not occur in units 31c or 28n. In unit 28s, the leave area partially overlaps the northern boundary where fire intensity was low due to fuel conditions. In 28y three Fisher blocks are fully within the unit, but were not identified in the morning briefing or flagged in the unit. However, the leave areas are in locations of relatively high moisture and live surface fuels, and generally had lower intensity fire.

9. Perennial stream retention buffer: Met by unit delimitation. Unit boundaries did not overlap perennial stream buffers.

Unit 28n results – refer to Table 1: Fire effects in the 19-acre Unit 28n differ strongly from the other units and are reported here to give a complete picture of the 2017 results. Due to higher fuel moistures, low intensity fire weather, a high proportion of live surface fuels, and lower dead fuel loading, consumption and carry were low in 28n. Low to moderate intensity fire was patchy and large areas remain essentially unburned. Objectives for fuel and understory reduction fall short or barely meet target ranges, while objectives for tree retention, ground cover, and large wood retention were easily met. Results for this unit are covered fully in an earlier 2017 report (initial TREX 28n/31c 2017 FEMO report).

Table 1. Summary of before-and-after burn unit conditions and burn objective accomplishment for AFR Units 28n, 28s, 28y and 31c, including area-weighted cumulative summary across all units, and for the three units with high crown scorch.

	Unit 28n	Unit 31c	Unit 28y	Unit 28s	Units 28s, 28y, 31c[8]	All Units[8]
Burn Date	5/4/2017	5/23/2017	5/26/2017	6/6/2017	2017	2017
Unit Acres [1]	19	77	66	58	201	220
Primary Aspect [1]	E	NW	SE	NE		
Average % Slope [2]	28%	24%	31%	36%	30%	30%
% Unit Area Burned	50%	87%	96%	98%	93%	89%
% Unit Area in High Scorch [1]	0%	25%	15%	38%	25%	23%
Fuel Model Proportions pre-Burn [2]	TL3 : TL4 2 : 1	TL3 : TL4 1 : 3	TL3 : TL4 2 : 3	TL3 : TL4 1 : 2	TL3 : TL4 1 : 2	TL3 : TL4 1 : 2
Fuel Model Proportions post-Burn	TL1 : TL3 1 : 2	TL1 : TL3 9 : 1	TL1 : TL3 9 : 1	TL1 : TL3 9 : 1	TL1 : TL3 9 : 1	TL1 : TL3 9 : 1
Average % Canopy Closure pre-Burn [3]	64%	60%	69%	67%	65%	65%
Average % Canopy Closure post-Burn	64%	53%	61%	48%	54%	55%
FEMO Monitoring Plot Sample Size	3	9	6	6	21	24

Burn Objective	**Target**	**Unit 28n**	**Unit 31c**	**Unit 28y**	**Unit 28s**	**Units 28s, 28y, 31c[8]**	**All Units[8]**
1. Litter and light surface fuel (1 - 100 hour) reduction [4]	30% - 80%	30%	70%	**86%**	**93%**	**82%**	78%
2. Understory tree (< 5" DBH) and shrub cover reduction [5]	30% - 80%	**25%**	**80%**	55%	**86%**	74%	70%
3. Limit intermediate tree (5 - 12" DBH) mortality [6]	< 40%	0%	**46%**	**56%**	**61%**	**54%**	**49%**
4. Retain dominant/ codominant trees (> 12" DBH) [6]	> 90%	100%	**89%**	93%	**80%**	**88%**	**89%**
5. Minimize mortality of legacy trees [7]	< 5%	0%	**11%**	**13%**	**25%**	**16%**	**14%**
6. Retain effective ground cover targets for the relevant slope and year post-burn [4]	> 60% yr-1 (< 35% slope)	93%	97%	96%		96%	95%
	> 70% yr-1 (> 35% slope)				93%	96%	95%
7. Retain large down logs or snags (>20" diameter)	> 90%	> 95%	> 90%	> 90%	> 90%	> 90%	> 90%
8. Minimize fire intensity in leave areas	low severity	n/a	n/a	**no**	yes		
9. Retain duff and coarse wood next to perennial streams	50' buffer	n/a	n/a	n/a	n/a		

Footnotes: 1 - Field-measured and calculated in GIS. 2 - Includes additional data from 69 legacy tree monitoring samples. 3 - From 2013 post-density-management, pre-burn sample data.
4 - Includes post-burn litter-fall from scorched canopy. 5 - Includes post-burn cover from re-sprouting hardwoods. 6 - Post-burn mortality field-interpreted as trees with 100% crown scorch.
7 - Post-burn legacy mortality estimated by predictive models. 8 - Cumulative averages are area-weighted by unit acres.

Table 2. Hourly fire weather observations (recorded by Forest Service), and calculated fine fuel moisture and ignition probability for Units 31c, 28y and 28s in order of burn date. See Tables 3a and 3b below for reference copies of the burn plan prescription ranges for fire weather, fuels, and fire behavior.

Unit: **AFR 31c**			Burn Date: **5/23-24/2017**			Observer: **Forest Service**	
Unit Aspect: **NW**			Average Slope: **24%**			Canopy Closure: **>50%**	
TIME	DRY BULB (F)	RELATIVE HUMIDITY %	ASPECT	EXPOSED/ SHADED	FINE DEAD FUEL % MOISTURE	PROBABILITY OF IGNITION %	WINDS (mph)
5/23	**Day 1**						
1000	73	46	N	E/S	8/11	40/30	2-3 Northeast
1100	75	44	N	E/S	7/10	50/30	3-6 North
1200	72	44	N	E/S	6/9	60/30	0-3 Northeast; gusts 6-8
1300	72	44	N	E/S	6/9	60/30	0-3 Northeast; gusts 6-8
1400	78	37	N	E/S	5/8	60/30	0-3 Northeast; gusts 6-8
1500	80	32	N	E/S	5/8	70/40	0-3 Northeast; gusts 6-8
1600	80	32	N	E/S	6/10	60/30	0-5 Northeast; gusts 6-8
5/24	**Day 2**						
1030	52	66	N	E/S	10/13	30/20	4-6 North
1100	53	66	N	E/S	10/13	30/20	4-6 North
1200	59	65	N	E/S	9/12	30/20	
1300	64	54	N	E/S	7/10	50/30	
1400	66	48	N	E/S	7/10	50/30	4-6 North
1500	65	36	N	E/S	6/9	50/30	2-5 North/NW; gusts 10-15

Unit: **AFR 28y**			Burn Date: **5/26-27/2017**			Observer: **Forest Service**	
Unit Aspect: **SE**			Average Slope: **31%**			Canopy Closure: **>50%**	
TIME	DRY BULB (F)	RELATIVE HUMIDITY %	ASPECT	EXPOSED/ SHADED	FINE DEAD FUEL % MOISTURE	PROBABILITY OF IGNITION %	WINDS (mph)
1000	57	49	W	E/S	10/11	30/20	0-3 North
1100	60	47	W	E/S	10/11	30/20	0-3 North
1200	60	47	E	E/S	7/10	50/30	0-3 North
1300	62	45	E	E/S	7/10	50/30	0-3 West
1400	64	43	S	E/S	7/9	50/30	2-5 West
1500	66	40	S	E/S	7/9	50/30	2-5 West
1600	64	43	S	E/S	7/10	50/30	2-5 West
1700	64	43	S	E/S	7/10	50/30	2-5 West
1800	64	43	S	E/S	9/11	30/20	0-3 West

Unit: **AFR 28s**			Burn Date: **6/6/2017**			Observer: **Forest Service**	
Unit Aspect: **NE**			Average Slope: **36%**			Canopy Closure: **>50%**	
TIME	DRY BULB (F)	RELATIVE HUMIDITY %	ASPECT	EXPOSED/ SHADED	FINE DEAD FUEL % MOISTURE	PROBABILITY OF IGNITION %	WINDS (mph)
1000	64	53	W	E/S	10/11	30/20	Calm
1100	64	53	W	E/S	10/11	30/20	Calm
1200	65	46	E	E/S	7/11	50/20	Calm West/Upslope 1-2
1300	70	42	E	E/S	6/9	60/30	1-2 Upslope (NE)
1400	73	37	E	E/S	6/9	60/30	2-4 Upslope (SE)
1500	71	39	E	E/S	6/9	60/30	Calm West/Upslope 1-2
1600	71	39	E	E/S	8/9	40/30	- -

Table 3a. Fire weather and fuel moisture prescription range parameters from the 2017 burn plan. Bold font indicates typical range of conditions during the burns in 28s, 28y and 31c.

	Acceptable Prescription Range		
	Low Fire Intensity	Desired Fire Intensity	High Fire Intensity
Temperature (°F)	45-55	**56-75**	76-86
Relative humidity (%)	**45-35**	34-25	24-20
Mid-flame wind speed (mph)	**0-3**	**4-7**	8-12
Wind direction (azimuth°)	N, W, E	**N, W, E**	N, W, E
1-hr fuel moisture (%)	15-13	**12-10**	**9-7**
10-hr fuel moisture (%)	17-15	14-12	**11-9**
100-hr fuel moisture (%)	19-17	16-14	**13-11**
1000-hr fuel moisture (%)	>20	19-17	**16-14**

Table 3b. Fire behavior prescription acceptable range parameters from the 2017 burn plan. Bold font indicates typical range of conditions during operations in 28s, 28y and 31c.

	Acceptable Fire Behavior Range		
	Low Fire Intensity	Desired Fire Intensity	High Fire Intensity
Fuel Model(s): __TL3__			
Rate of Spread (chains/hour)	<1.5	**1.6 – 2.5**	**2.6 – 3**
Flame Length (in feet)	< 1	1-2	**2-3**
Scorch Height (in feet)	<1	2-10	**11-15**
Probability of Ignition (%)	<15	**16-30**	31-60
Spotting Distance (in miles)	**<0.1**	0.2	0.2

Burn Implementation Unit Logs – Timelines and information below are a compilation of burn boss and burn boss trainee notes and fire behavior records provided by Forest Service, and FEMO unit log notes.

AFR Unit 31c, 5/23/2017 – day 1

Log compiled from notes by Forest Service RXB2(t). No FEMO on this burn.

Burn boss, RXB2: Rob Marshall, Scott Wickham (trainee)

1120 – Briefing with group.
1126 – Notify dispatch of test fire ignition. South end of unit near briefing/landing area.
1139 – Test fire FL 0.5'-2', ROS 1 chain/hour. Smoke dispersing S-SE. Notify dispatch test fire complete. Decision to continue ignition.
1206 – Talk to FIRB(t), FIRB about changing tactics of firing on east side of unit.
1213 – Spoke with Adam Forga about smoke dispersion. He says no concern but column is slightly east of unit vs. south.
1240 – Spoke with holding about sending Hawkins to observe smoke.
1247 – Spoke with RXB2 actual about smoke forecaster call at future ignitions.
1248 – Spoke with FIRB and FIRB(t) about new firing pattern. More lighters on west side of unit, less lighters on east side.
1252 – FIRB(t) talks to holding about new plan for firing, RXB2 about Chief1 coming to burn.
1317 – Spoke with holding – no concerns at this time.
1340 – Walked around burned area of unit. Face to face with RXB2 and FIRB. Discussed chevron occurring between groups of lighters.
1345 – Talked to FIRB(t) about firing.
1400 – Talked to Chief 1 from RSF. Likes what he sees.
1408 – Discussion of ignition pattern with FIRB with regards to position and east draw.
1530 – Forga mentions winds at starting point out of W/S.
1553 – Discussion between RXB2, RXB2(t), FIRB, FIRB(t) and Hawkins about smoke. Decision to stop ignition due to smoke column heading east. Eight acres estimated remaining.
1558 – Called dispatch to say that we stopped ignitions. Claimed 55 acres.

AFR Unit 31c, 5/24/2017 – day 2

1300 – RXB2 notifies dispatch of test fire.
1325 – Brief resources.
1339 – Notify dispatch test fire is good. Start ignitions.
1355 – Re-line out burners to follow the road.
1416 – Two spot fires picked up, 1' x 1'. Heavy smoke across the road.
1506 – Ignitions complete. Notify dispatch. Resources turn to strictly holding.
1545 – Debrief with resources. Lomakatsi will monitor tomorrow, 5/25.

AFR Unit 28y, 5/26/2017 – day 1

Log compiled from notes by Forest Service RXB2(t) and TNC FEMO (through 1400)

Burn boss, RXB2: Rob Marshall, Kit Colbenson (trainee)

1000 – Briefing at staging area. Review of objectives and prescription ranges, spot weather forecast. No leave areas or stream buffer identified for the unit. Ignition plan: start at NW knob, dot firing on W aspect then around on main E/SE/S aspects, working along contours.

1030 – Crews set-up for test fire (dispatch notified). Fuel moisture check with probe: 10-hour fuels at 6.5% – 7%.

1045 – Test fire on W aspect of knob in NW quadrant of unit. Test fire and smoke dispersal deemed good.

1100 – Decision to continue ignitions on W aspect between knob and trail. Dot ignitions not carrying, switched to strips at 10' spacing. FL 0.5'-1', ROS < 1'/min. – strips not consistently closing. Smoke dispersing SW.

1120 – West aspect of unit ignitions continue, fire activity picks up, some heavier fuels (>100-hour) burning. FL 1'-2' but higher in fuel accumulations, ROS variable. Fuel probe: 10-hour fuels at 5% - 7%.

1140 – Ignitions reach top of knob. Dot and dash lighting, 10'-15' spacing. On NW aspect FL 1'-3', ROS 1'/min.

1145 – Ignitions cross onto E aspect slope into upslope winds. Fire activity picks up: FL 2'-6', ROS 5'-10'/min. Fire is intense in fuel accumulations and unburned piles, some bole scorch > 10'.

1150 – Mature and legacy PIPO N of knob summit have fire climbing 25'-50' up trunks adjacent to fuel accumulation. Some heavy fuels (>1000-hour) actively burning.

1200 – Burn leads determine fire is meeting Rx, continue ignitions. Smoke dispersing SW.

1230 – Ignitions continue along E/SE aspect of slope. Two firing crews divide slope roughly N-S with S crew bringing fire into SE aspect slope while N crew works down E aspect. Mainly dot firing at 10'-20' spacing. Surface dead fuel moisture from multiple dispersed probe readings: 10-hour fuels 5% - 8% (usually 6%); 100-hour fuels 7% – 12%, varies with age of wood, ground contact, and exposure. Snag burning to top >25' near saddle and W line.

1300 - 1400 – FEMO assists ignitions on E aspect, mid-to-lower slope. Crew of 4-6 carrying fire from N hand-line S to mid-unit ridge. Dot or dot-and-strip firing at 10'-20' spacing. Fire behavior was variable with fuel accumulations, shading, and amount of green understory/herbaceous, ranging from: (1) Creeping fire in litter, consuming 10 to 100-hour fuels, slowly or not closing entirely, FL 0.5'-2', ROS 1'-2'/min. To (2), active fire in hot zones with fuel accumulations, FL 2'-6', ROS 5'-10'/min, flames climbing boles >25', consumption of 100 and up to 1000-hour fuels, with larger fuels actively burning. Average FL 4'-6'. Smoke dispersing SW.

1430 – Fire behavior increases but assessed to still be meeting objectives. Ignitions continue. FEMO leaves unit, absent for remainder of operations.

1500 – FL 6' average, 10' maximum. Smoke dispersing SW.

1600 – FL 5' average, 10' maximum. Torching and spot fires observed. Smoke dispersing SW. Crews dig line to cut off switchbacks in fire line trail to protect accumulations of heavy fuel.

1700 – FL 5' average, 6' maximum. Spot fires above the trail fire line (NW of unit) less than 3'x3'. Smoke dispersal shifts to SE

1730 – Ignitions completed. Holding monitoring. Active fire continues, FL 3' average, 6' maximum. Smoke to SE.

1900 – All resources released from unit.

AFR Unit 28y, 5/27/2017 – day 2

Log compiled from notes by Forest Service RXB2(t)

0800 – Holding (E-311 and E-312) briefed and engaged on scene.

0828 – Noticed slop-over on SW corner above trail.

0900 – Grayback crews arrive briefed and engaged.

0907 – Call to Div 1 with update.

0930 – Crews digging line around slop-over.

1105 – Line complete rest of unit looks good, lines held.

1600 – All resources released from unit.

Unit monitored again on day-3, 5/28/2017, 0800 – 1500. Lines held. Snags felled on S flank of slop-over.

AFR Unit 28s, 6/6/2017

Log compiled from notes by Forest Service RXB2t and TNC FEMO (through 1230).

Burn boss, RXB2: Brett Brown, Scott Wickham (trainee)

1000 – Briefing at staging area. Review of objectives and prescription ranges, spot weather forecast. Riparian area at north edge of unit: leave unburned buffer and keep fuel out of creek. Ignition plan: two crews, bump and float dividing unit N-S, working along contours.

1040 – Test fire (dispatch notified) at top of knob in SE quadrant of unit, highest point (but within footprint of prior 2014 burn). Dot ignitions, FL 0.5'-1', ROS < 1'/min. Good mild/low fire behavior, not actively spreading.

1045 – Test fire is good. Decision to continue ignitions on W aspect of unit between knob and trail.

1109 – Lookout (Hawkins at Horn Gap) reports smoke from knob rising to 1000-1200' then dispersing, drifting SW.

1130 – Two firing crews bring ignitions even with top of knob and N-S ridge, competing W aspect of unit. Dot firing on 10'-15' spacing. In NW quadrant of unit dot firing gives 1'-3' FL, ROS variable, dots closing. Fire is intense in fuel accumulations and unburned piles, some bole scorch > 10'. Heavier fuels (>100-hour) burning.

1140 – Firing moves onto E aspect of unit working downslope. Continues with 2 ignitions crews, bump and float, dot or strip firing, 10'-20' spacing.

1220 – In the SW and S-central area of unit (E of prior 2014 burn): Dot ignitions. FL 1'-4', except higher in fuel accumulations and unburned piles. Flames climbing some boles >25'. ROS variable, closing. Heavy fuels (>1000 hour) getting engaged in fire, unburned piles flaring up > 10' FL, flaming area gaining depth.

1226 – Lookout reports smoke rising well, then heading E.

1230 – Center of unit near old track roadbed: Fire persisting in larger fuels behind firing crews. Firing slows pace, using dot and strip ignitions. FL 1'-5', ROS variable, closing in brown litter/fuels but not consistently carrying in green understory/groundcover. Unburned piles torching 10'-15' FL, scorching trees upslope and downwind to W.

1245 – FEMO leaves unit, absent for remainder of operations. Fire behavior and ignitions implementation observations not available after this time.

1330 – Firing holds at old track roadbed approximately mid-way down east-facing slope of unit (lunch). Discussion between RXB2, RXB2(t), FIRB, FIRB(t) on intensity. Discussion of smoke with DIV1 and lookout. Clearance from smoke forecasters to continue with unit. Plan to be done by 1600.

1400 – Large snag falls on north firing area. All resources check-in.

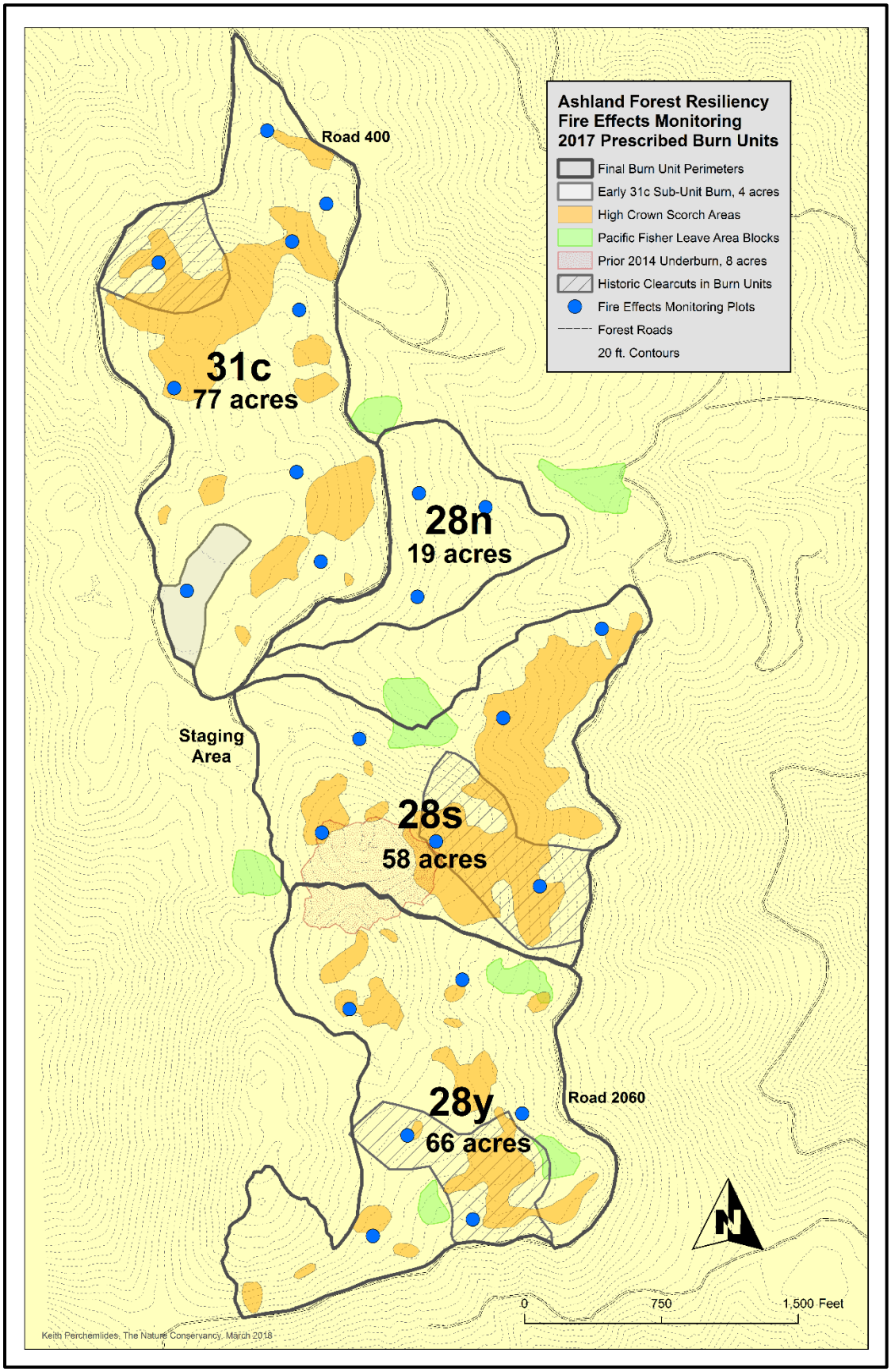
1435 – Lookout reports smoke not rising as much but still good column direction, not into Reeder Reservoir.

1505 – Lookout reports smoke still good.

1545 – Ignition completed on unit.

1620 – Lookout reports smoke still dispersing but not rising. Smoke settling. Lookout leaves Horn Gap.

1655 – Debrief at staging area.



Map 1. Final perimeters of AFR 2017 burn units with extents of prior underburns, historic clearcuts, forest roads, burn operations staging area, and 20' contour topography. Areas of high crown scorch are mapped as orange polygons and Fisher block leave areas are green. Blue dots show locations of 2017 fire effects monitoring plots providing the main data for this report.

Representative fire effects and behavior photographs from Units 28s, 28y and 31c

All photographs, Keith Perchemlides, except first two (below), Evan Barrientos. More repeat monitoring photographs for these units are available at: AFR 2017 FEMO Repeat Photos.

Series of before (top left), immediately after burn (top right), and in late fall 2017 (bottom) repeat photos showing surface fuel consumption, understory removal, stand mortality, and crown-scorch litter-fall in a high-intensity and high crown scorch area of Unit 31c. Note the heavy litter-fall coverage and same-season growth of madrone and Oregon grape sprouts in the last image.

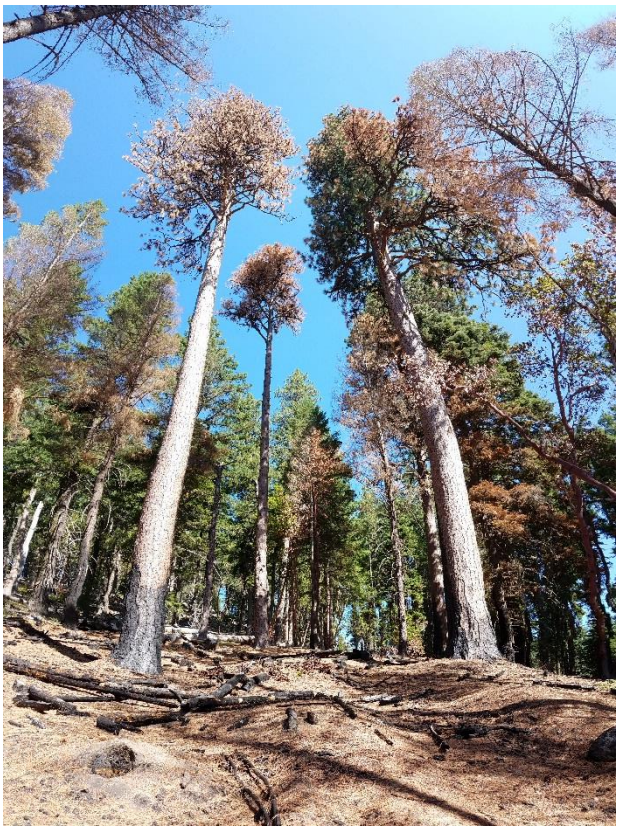
Repeat photographs showing heavy fuel loading and consumption, foreground, and high crown scorch, background, in unit 28s


Repeat photographs of effective surface fuel reduction with moderate bole char and crown scorch in a ponderosa pine stand, unit 28y.


Repeat photographs of heavy ground fuels, including unburned piles, >90% consumption, and madrone top-kill mortality with hardwood basal sprouting exceeding the pre-burn understory cover for this plot in unit 28y.


Repeat photographs of high level live understory reduction combined with canopy scorch and tree mortality in unit 28s.


Upslope depth of field for persistent active fire as the ignition crew makes another downslope pass, unit 28y (left). Intense heat and flame length as previously unburned piles consume in unit 28s (right)

Legacy ponderosa pine standing green post-burn above an understory of fully crown scorched madrone and fir, unit 31c (left). Crown scorched mature fir and legacy Ponderosa pine with height to crown base >50', unit 28y (right).