COLORADO
Department of Public Safety
Executive Director's Office

Compliance & Professional Standards Office

Elkhorn Creek Unit #4 Prescribed Fire Review

Requested by:

COLORADO
Division of Fire Prevention & Control
Department of Public Safety

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1. Executive Summary

Background

This is the formal review required by Colorado statute following the escape of the Elkhorn Creek Unit #4 Prescribed Fire. In accordance with the statute, the purpose of the review is “to identify the factors that contributed to the escape, including compliance with policy requirements, in an effort to reduce the occurrence or prevent future escapes.” §24-33.5-1217.7, C.R.S. At the request of the director of the Division of Fire Prevention and Control (DFPC), the review was completed by a team of four subject matter experts led by the Compliance and Professional Standards Office of the Colorado Department of Public Safety.

The Elkhorn Creek Unit #4 Prescribed Fire project took place on October 15 (Day 1) and October 16 (Day 2), 2019 on the Ben Delatour Scout Ranch, private property located in Larimer County, Colorado, as part of a forest restoration effort aimed to reduce the impact of high severity wildfire on Elkhorn Creek, an important tributary of the Poudre River. The Nature Conservancy planned and led the project, dividing the unit into two subunits, Unit 4a that was 385 acres, and Unit 4b, at 120 acres.

The Nature Conservancy staffed the project using a “collaborative burning” organization consisting of personnel from several different partner agencies and organizations. On Day 1, Unit 4a was burned successfully, implementation was executed within the Prescribed Fire Plan’s parameters, and the objectives were met. On Day 2, Unit 4b was ignited within the Prescribed Fire Plan’s parameters. Despite the smaller unit size, operations moved slower in Unit 4b due to the unit’s more complex terrain which required additional coordination between firing and holding teams. On Day 2, the weather was drier, warmer, and windier than the day before, and at approximately 2:00 PM, cloud cover moved off the area, resulting in an increase in fire behavior. At 3:00 PM, a spot fire was identified but quickly contained just over the eastern boundary of the unit. However, only minutes later, two more spot fires were located to the south of the first. Located in dry, dead grass on a steep slope aligned with strong westerly winds, these two spots quickly grew together and began spreading rapidly away from the unit towards the Glacier View community to the east. Leadership personnel, quickly determining that on-site resources would not be able to contain the fire, immediately ordered ground and aerial resources and then declared the wildfire at 3:59 PM. In total, the fire burned 682 acres, with 118 acres outside of the planned boundaries of the project and 82 acres off the Scout Ranch property. One outbuilding was destroyed by the fire.

What We Found

The Review Team found that many interrelated factors together created the conditions leading to the escape and declaration of a wildfire. Though no factors were identified as primary to causation in and of themselves, the following list summarizes the factors that the Review Team identified as most important for lessons learned for the prescribed fire community in order to reduce occurrence of or prevent future escapes.

- Several common cognitive biases and heuristics likely influenced decision-making, leading prescribed fire personnel to undervalue the actual risk of burning in Unit 4b on October 16, 2019.

- The prescribed fire project was implemented in accordance with the prescribed fire plan, however, weaknesses in the plan came into play and compounded on one another, leading to implementation of the project under weather and fuel moisture conditions that exceeded reasonable limits for prescribed fire in the project area. Observations related to the plan include complex challenges related to the fire behavior fuel models utilized, weather parameter values in the prescription too broad to limit implementation windows, use of a single wind parameter that did not match the type of wind measurements taken during implementation of the project, and inconsistencies among specific elements in the plan.

- Inadequate analysis of weather information during implementation of the project prevented fire personnel from accurately understanding current conditions. Observations related to the on-site weather analysis include apparent lack of clarity on the importance of differences between types of wind measurements as well as methods for conversions between them, and inaccurate comparisons of current conditions against parameter values in the prescribed fire plan and in the spot weather forecasts produced for the project.

- Overhead (leadership) fire personnel were qualified and experienced in their positions. However, below the overhead level, several participants interviewed noted a lack of experience amongst participants because the project was a “collaborative burn” (a prescribed fire implemented using personnel from multiple agencies partnering together to leverage resources and enhance learning and training opportunities). Unfamiliarity with one another’s training and experience, as well as many individuals with less experience, added a layer of complexity and some delays in operations during implementation of the project.

- DFPC did not contribute assistance in the planning or implementation of this prescribed fire because it is bound by state statutes that prioritize wildfire suppression and sacrifice proactive measures to reduce wildfire risk to communities. DFPC has no policy enforcement authority regarding prescribed fire conducted on privately-owned land and has no liability protection when engaged in prescribed fire because of a broad statutory waiver of governmental immunity. As a result, DFPC has very limited organizational capacity to assist with planning or implementing prescribed fire. DFPC’s statutory authority and framework only effectively address one of the three goals of the National Cohesive Wildland Fire Management Strategy, “Safe and Effective Wildfire Response.” This leaves the two other goals, “Resilient Landscapes,” and “Fire Adapted Communities” largely unmet by DFPC.

- Finally, several factors present on the Elkhorn Creek Unit 4 Prescribed Fire are not unique to this event, and have been previously documented in surveys of other prescribed fires that escaped and were declared wildfire. These common factors and best practices are presented below as a list of “lessons re-learned” for prescribed fire practitioners:

- Utilize portable remote automated weather stations to gather site-specific weather data.
- Blackline depth is not sufficient to contain potential spotting from fuels within the unit.
- Fuels and weather generated surprising fire behavior, even though it was outlined in the prescribed fire plan.
- Fuel models selected in prescription development do not accurately represent potential fire behavior.
- Unexpected winds (strength, duration, direction) occur.
- Burning adjacent to lands where no agreements exist with the adjacent landowner(s).
- Notifications to adjacent landowners prior to ignition is viewed as inadequate after the prescribed fire is declared a wildfire.
- A systematic tendency to underrate overall prescribed fire complexity.
- 43% of declared wildfires occur in six hours or less from the time of ignition.
- Lighting at the upper end of the prescription, where prescription parameters are often exceeded during the peak of the day.
- Prescribed fire plans lack enough depth and detail for the complexity of the project.
- There is always a desire to make plans broad to increase their utility, but all plan elements must still be cohesive with one another
- Finding a balance between prescribed fire and containment objectives is often difficult. Ensuring both can be met simultaneously must occur to reduce risk to either objective.

Commendations and Recommendations

First, based on things that went right during the project and from which other prescribed fire practitioners can learn, the Review Team identified five commendations.

1. Burning adjacent to WUI is inherently more difficult, but significantly more impactful than burning far away from assets that require protection from wildfire. The goals of the Coalition for the Poudre River Watershed, Elkhorn Creek Forest Health Initiative, and Elkhorn Creek #4 Prescribed Fire are in concert with those of the National Cohesive Wildland Fire Management Strategy, which are: 1) Resilient Landscapes, 2) Fire Adapted Communities, and 3) Safe and Effective Wildfire Response.

2. The Nature Conservancy, Colorado, fills a vital gap between private landowners and State and Federal agencies who are not as well equipped to navigate the complexities of implementing broadcast prescribed fire on private lands.

3. The difficulty of suppressing the spot fires that eventually led to the wildfire declaration was rapidly recognized by all involved.

4. The decision to declare a wildfire was made very quickly, and a smooth transition into a suppression organization occurred.

5. The prescribed fire organization rapidly shifted into a suppression organization, with predefined roles and responsibilities, limiting a loss of situational awareness during a very dynamic situation.

Second, based on the interrelated factors summarized in the findings above, the Review Team identified five recommendations, two applicable to all prescribed fire practitioners, two applicable to The Nature Conservancy, and one applicable to DFPC.

Recommendations for All Prescribed Fire Practitioners

1. A strong understanding of fire weather is critical to mitigating risk and responding to changing conditions. Review fire weather concepts presented in the National Wildfire Coordinating Group (NWCG) Intermediate Wildland Fire Weather Behavior (S-290) course and fire weather data acquisition and analysis concepts presented in the NWCG Intermediate National Fire Danger Rating System (S-491) course before each fire season utilizing an Incident Meteorologist (IMET), a Long Term Fire Analyst (LTAN), Fire Behavior Analyst (FBAN), or other knowledgeable individual, and incorporate these concepts into development of prescribed fire plans.
    - Review and remain diligent regarding the differences between 20-ft sustained 10 minute average winds, gusts, eye level, and midflame wind speeds.
    - Ensure on-site wind measurements are consistent with the type of wind parameters used in the prescribed fire plan, or ensure that accurate conversion techniques are accurately and consistently applied.
2. Apply “lessons re-learned” from the factors and best practices identified as being common between this prescribed fire and previous prescribed fires that were later declared wildfires.

Recommendations for The Nature Conservancy

3. Evaluate and refine the collaborative burning approach, including considerations for additional cooperative or partnership agreements to increase the experience level below that of overhead or trainee positions on high consequence prescribed fires.
4. Consider the full adoption of the DFPC Colorado Prescribed Fire Planning and Implementation Policy Guide as well as the Prescribed Fire Complexity Rating System Guide (NWCG PMS-424-1).
    - Adoption of these guides would increase consistency and support cooperation between The Nature Conservancy and DFPC and other Colorado partners.

Recommendations for the Division of Fire Prevention and Control

5. Evaluate all DFPC statutory and policy frameworks and craft solutions to align with all three co-equal goals of the National Cohesive Wildland Fire Management Strategy.
    - Changes to DFPC’s organizational focus and statutory authority may be necessary to reduce wildfire risk to communities and create resilient landscapes. In the face of an increasingly complex wildland fire environment, the ability to implement proactive measures must be part of a holistic strategy to reduce risk.

2. Review Process

Colorado statute defines “escaped prescribed fire” to mean when a prescribed fire “exceeds the control capability of on-site resources” and further mandates that the Colorado Division of Fire Prevention and Control (DFPC) conduct or cause to be conducted a “formal review” following the escape of a prescribed fire. See 24-33.5-1217.7, C.R.S. (“Escaped Prescribed Fires”). As established by the statute, the purpose of the formal review is “to identify the factors that contributed to the escape, including compliance with policy requirements, in an effort to reduce the occurrence or prevent future escapes.” 33.5-1217.7(2), C.R.S.

The Elkhorn Creek Unit #4 Prescribed Fire is the first prescribed fire to escape since enactment of the statute. Immediately following its escape, the Director of DFPC initiated the formal review process in accordance with the statute. In order to ensure objectivity in the review process, the Director requested that the Compliance and Professional Standards Office (CPSO) within the Executive Director’s Office of the Department of Public Safety conduct the review.

The review process consisted of four phases:

Phase	Description	Timeframe
Phase I	Define Review Process	October and November 2019
Phase II	Data Collection	November 2019 through January 2020
Phase III	Verify and Synthesize	January and February 2020
Phase IV	Disseminate Findings	February and March 2020

In Phase I, the review process was defined and the review team members were confirmed. Based on research and review of other review processes, the Facilitated Learning Analysis (FLA) tool was selected to serve as the model for this review. FLA was first developed by the United States Forest Service beginning over 15 years ago. It is a tool designed for evaluating accidents and other unintended outcomes and is used by a wide variety of organizations to foster organizational learning as the response to unexpected outcomes. With the FLA tool as a starting point, the process for this review was refined and adapted throughout the course of the review to meet the objective set by the statute.

The Review Team was assembled starting with a CPSO Compliance Officer who worked to identify and invite suitable subject matter experts to serve on the team. The subject matter experts were identified based on their expertise related to the subject matter and, in order to ensure objectivity, only individuals with no direct connection to or prior experience with the prescribed fire at issue were selected.

Review Team Member	Expertise & Role
Bobbie Mooney, Compliance Officer, CPSO	Review Team Lead; Review Process Facilitator; Law & Policy SME
James Fischer, Forester, Trinchera Ranch	Colorado Forestry SME; Private Sector Prescribed Fire SME
Brad Pietruszka, Fuels Program Manager, San Juan National Forest, U.S. Forest Service	Fuels and Fire Behavior SME; Operations SME
Tim Mathewson, Fire Meteorologist - Incident Meteorologist, Bureau of Land Management	Fire Meteorology SME; Climatology SME

In Phase II, the Review Team collected data. Data collection included documentation from TNC such as the Elkhorn Creek Unit #4 Prescribed Fire Plan (**Appendix A**), the prescribed fire plan for the earlier Elkhorn Creek Unit #1 prescribed fire, maps, organizational charts, photos, forecasts used, notes taken, the FEMO (Fire Effects Monitor) summary report, smoke forms, and internal policies. Additionally, the Review Team collected information such as additional weather data, additional maps, imagery from the DFPC Multi Mission Aircraft, and the WildCAD Incident Cards. The review also conducted interviews with over a dozen individuals with information relevant to understanding the events, and collected notes, photos, and other documentation from those interviewees.

In Phase III, the Review Team verified and synthesized the information collected. Central to that process was a two-day dialogue session during which the Review Team analyzed the information they had collected and sought to understand the conditions that made the participants' actions seem reasonable, natural, or expected in the context of the situation leading up to the escape. This process was adapted from the "lessons learned analysis" approach presented in the U.S. Forest Service's 2013 Facilitated Learning Analysis Implementation Guide. Following the dialogue session, the Review Team worked to collect additional information needed to fill in remaining gaps in their understanding. As the last and most time-intensive component of Phase III, the team worked collaboratively to draft the written report and appendices.

Finally, in Phase IV, the final report was completed and released as a public document. Although the statute does not specify the end product or target audience for the review, DFPC determined that the review would produce a report that will be shared publicly for the benefit of all.

3. Setting and Background

The Elkhorn Creek Unit #4 Prescribed Fire ("ECU4 Rx Fire") project took place on October 15 and October 16, 2019 on the Ben Delatour Scout Ranch in Larimer County, Colorado. The following is a description of the general setting and background of the project.

3.1. Fall 2019 Fire Season and Average Precipitation

The fall of 2019 was not an overly active wildfire season in Colorado, but included the Decker Fire which burned 8,959 acres in south central Colorado. The Decker Fire started on September 8th and remained active until significant precipitation occurred around the fourth week of October. There were at least three other fires that occurred during the same time period. All of the Rocky Mountain Region Incident Management Teams were committed to these fires. The southern and western portions of Colorado were in an expanding drought cycle. This drought was having an impact on the rest of the state due to a continued high pressure system sitting over the western portion of the state. This high pressure system was having a drying effect on the rest of the State with limited precipitation and poor relative humidity recovery rates.

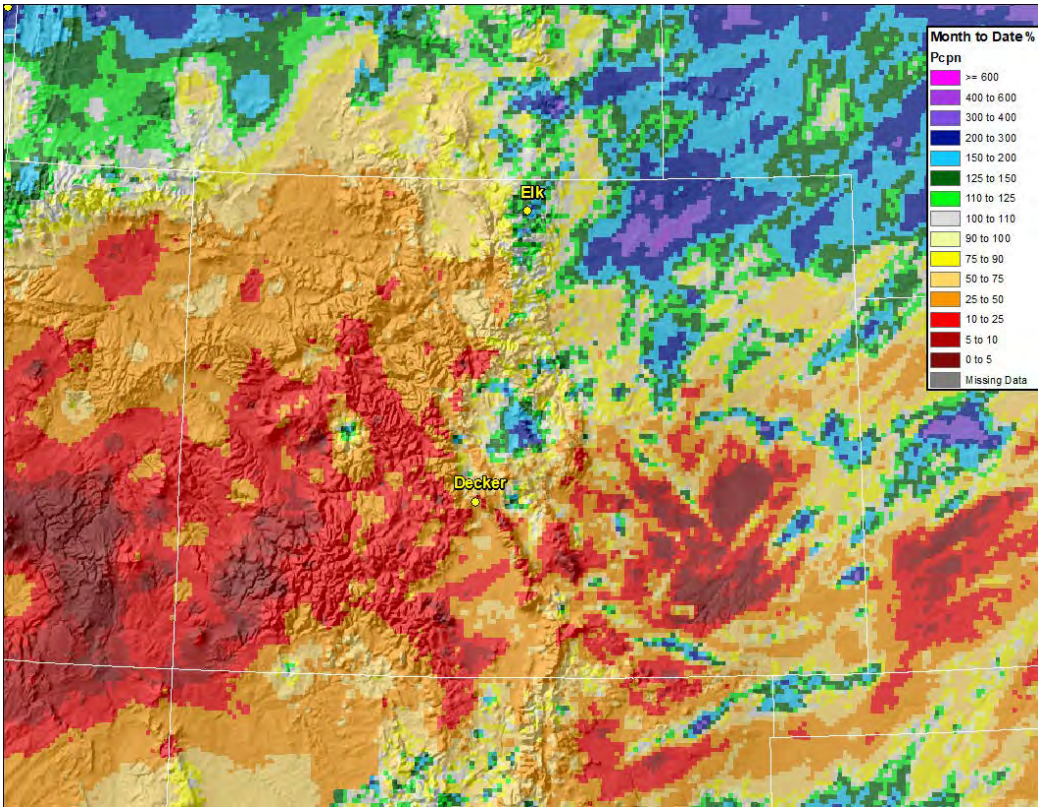


Figure 3.1: September 2019 percent of average precipitation in Colorado.

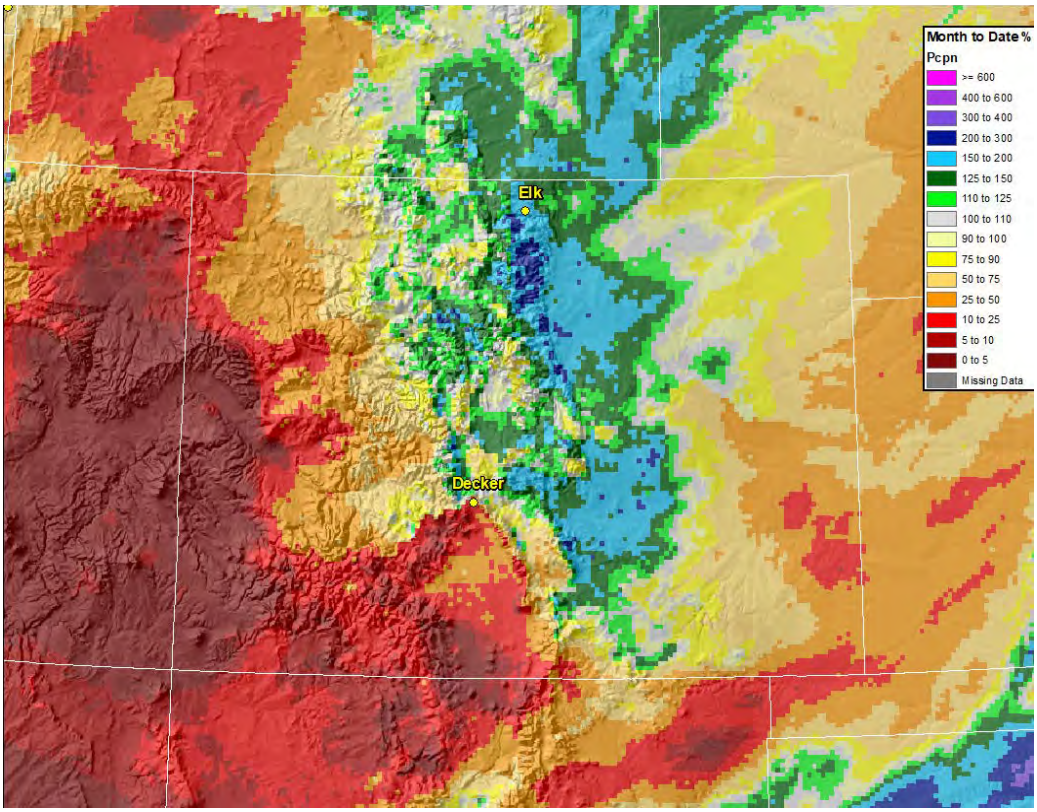


Figure 3.2: October 2019 percent of average precipitation in Colorado.

3.2. Physical Setting of the Project

The ECU4 Rx Fire took place in Larimer County approximately 40 miles to the northwest of the Fort Collins - Loveland metropolitan area (see General Location Map below).The Fort Collins - Loveland metropolitan area is roughly 50 miles north of Denver, Colorado and 47 miles south of Cheyenne, WY. This region has seen significant population growth over the past few decades, causing an expansion of development in the foothills. This is not uncommon along the front range of Colorado. The foothills and mountains located to the west of the Fort Collins - Loveland metropolitan area are critical for supplying water, recreational activities of all types, ecologically valuable habitats, highly-prized visual scenery, and home sites.

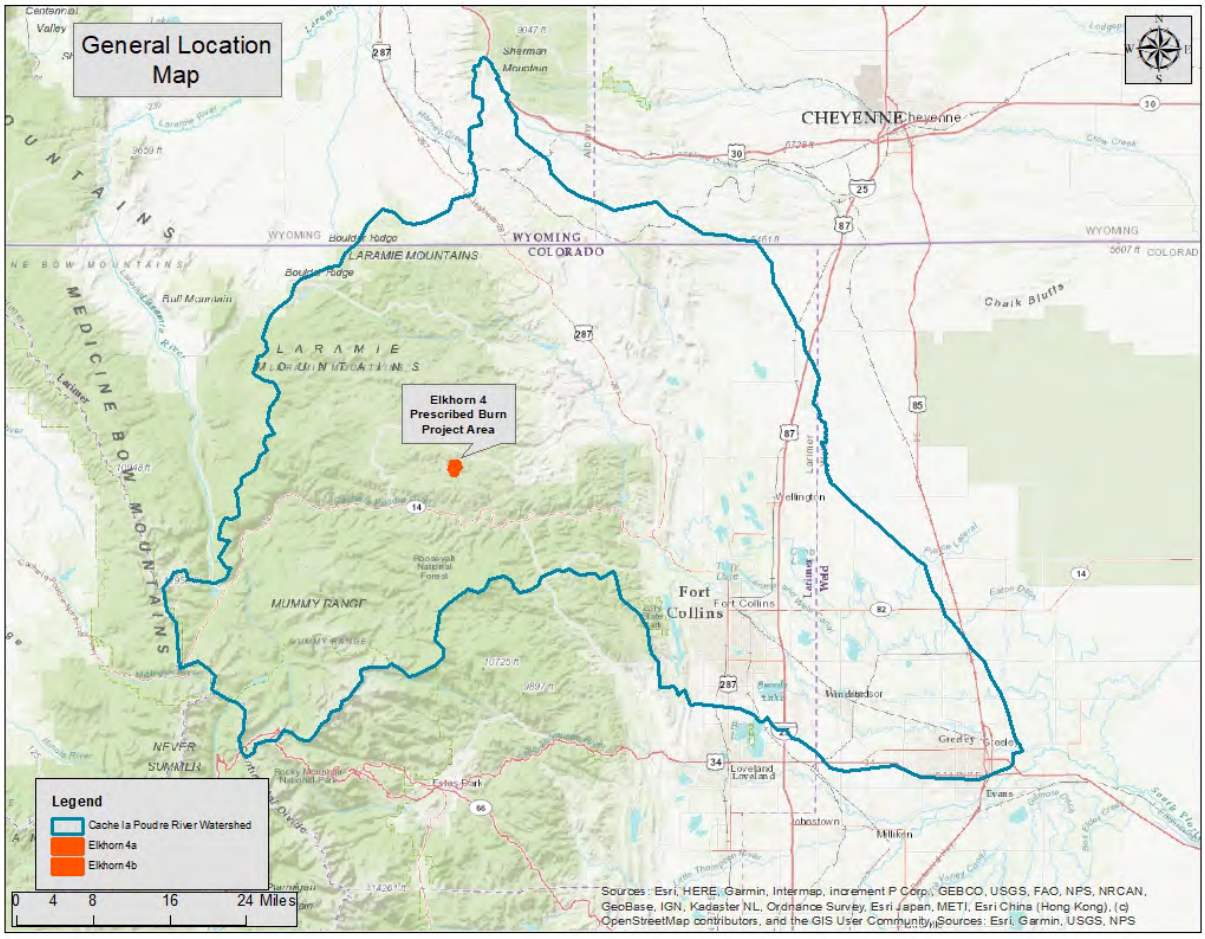


Figure 3.3: Map of the general location of the prescribe fire project.

The vegetation of this area consists of mixed conifer forest and grasslands. The predominant tree species in the area are Ponderosa pine and Douglas fir. Aspen, lodgepole pine, and spruce species are found in lesser amounts throughout this region. The Ponderosa pine ecosystem of this area is dependent on frequent low severity fires. Historic fire regimes of the area (Kaufmann et al. 2006) indicate that at any given elevation, xeric (dry) sites were more likely to support low density stands and low severity fires than were mesic (moist) sites.

The Poudre River watershed is extremely important to the Fort Collins - Loveland metropolitan area. This watershed encompasses roughly 1,056 square miles from the headwaters to the confluence with the South Platte River. The watershed supports the Front Range cities of Fort Collins, Greeley, Timnath, and Windsor. Wildfire has had a negative impact on the watershed and will continue to with future wildfires.

This area is no different from the rest of the western United States with regard to increased forest stocking levels and changing composition, which has increased fuel loading. This change has been ongoing for more than 100 years. These changes include the following but are not limited to fragmentation, urbanization, insect and disease outbreaks, fire suppression, changing weather

patterns along with new, and uncharted climatological events. All of these issues lead to catastrophic wildfires that significantly threaten life and property.

3.3. Elkhorn Creek Forest Health Initiative

The High Park and Hewlett Gulch Fires of 2012 burned roughly 90,000 acres in the Poudre River Watershed. After these devastating wildfires, the High Park Restoration Coalition was formed to "improve and maintain the ecological health of the Poudre River watershed through community collaboration." The Coalition was made up of local water utilities, business owners, local non-profits, and natural resource agencies with the intent of planning and prioritizing post-fire restoration needs. In 2013, the Coalition formalized into the Coalition for the Poudre River Watershed (CPRW), becoming a 501(c)3 non-profit organization based in Fort Collins, CO. Today, CPRW includes stakeholders from the US Forest Service, Colorado State University, Larimer County, the City of Fort Collins, the City of Greeley, the Colorado State Forest Service, the Town of Windsor, Weld County, and The Nature Conservancy.

In 2015, CPRW partnered with Larimer County Conservation Corps, Wildlands Restoration Volunteers, the Ben Delatour Scout Ranch, and The Nature Conservancy (TNC) to collectively form the Elkhorn Creek Forest Health Initiative (ECFHI) to help maintain and enhance the resiliency of the Cache la Poudre River though management activities aimed to reduce the impact of high severity wildfire on Elkhorn Creek, an important tributary of the Poudre River. ECFHI designed and implemented a multi-faceted forest health project to reduce wildfire risk, protect water quality, improve forest resilience, and increase local forestry skills. Under the plan, ECFHI has been able to treat approximately several hundred acres of high priority forest on the Ben Delatour Scout Ranch to reduce wildfire risk and create a more resilient landscape. ECFHI identified this area for focus because of unhealthy forest densities and high fuel loading there and because the project would complement existing US Forest Service and other treatments in the area. According to ECFHI, the forest conditions in this area are the result of fire exclusion over the past 100+ years and their goal is to achieve a more open forested condition through the use of mechanical and hand thinning and prescribed fire.

3.4. The Nature Conservancy

Founded in 1951, The Nature Conservancy is a global environmental nonprofit with diverse programs focused on water and land conservation in 79 countries and territories across six continents. They strongly believe in science-based solutions and collaborative partnerships to protect, enhance, and conserve critical areas around the globe. TNC has been a part of Colorado's stewardship and conservation movement for over two decades. In the past decade or so, TNC has been working with the U.S. Forest Service, Rocky Mountain Region to identify, prioritize, and implement cross-boundary partnerships in critical watersheds in the Front Range of Colorado, including the Poudre River Watershed. These partnerships focus on accelerated forest restoration and reducing the risk of wildfires to critically important watersheds and wildland urban interface communities. These activities require planning, public outreach, landscape scale analysis, communication with local and state fire authorities, and forest treatments to reduce fuel

loadings. This responsibility falls under TNC's Forest and Fire program in Colorado. They develop and implement an integrated strategy to land management planning that covers, forest, fire, water, recreation, and climate change.

The Nature Conservancy started utilizing/implementing prescribed fire in 1962 and since that time has grown their program worldwide. They have developed the program to grow skilled and diverse fire managers, help communities that live in a fire-adapted ecosystem to be safer, build relationships, and work collaboratively. In 2008, TNC created the Prescribed Fire Training Exchange (TREX) to provide much needed training to people that work with prescribed fire. The intent of TREX is to promote cooperative burning by leveraging skills, resources, and staff to get more training and treatment accomplished. This program is nationwide and is continuing to grow. Since 2012, there have been more than 20 TREX programs across the United States, with one on the San Juan National Forest in September of 2019.

3.5. The Scout Ranch

The 3,200-acre Ben Delatour Scout Ranch ("the Scout Ranch"), owned by the Boy Scouts of America and located southeast of Red Feather Lakes, CO, was chosen for the focus of implementation of the ECFHI. ECFHI chose the ranch because of the forestry work already underway and because the property adjoins U.S. Forest Service property implementing similar forestry practices and prescribed fire. Thus producing the benefits of a more continuous and uninterrupted landscape scale project in the Poudre River Watershed. The Scout Ranch did not have the staff needed to conduct a project of this scale so TNC took on the role, supplying expertise needed to write and carry out prescribed fire projects. The Scout Ranch had wanted to use prescribed fire as a management tool for years but was constrained due to cost, inexperience, and lack of human resources. Once these hurdles were overcome, the Scout Ranch and TNC moved ahead with planning a prescribed fire on the property.

In September of 2017, TNC conducted a 150 acre broadcast prescribed fire on the Scout Ranch. That project, the Elkhorn Creek Unit #1, was the first of its kind on private land in the Poudre River Watershed. TNC used their collaborative burning experience to implement the prescribed fire, utilizing 40 people from various agencies and organizations with varying backgrounds and experience levels to conduct the project. After the burn, TNC and Colorado Forest Restoration Institute at Colorado State University studied the effects of the prescribed fire on consuming surface fuels and scorch height. The results showed a significant reduction in surface fuels and an increased crown base height. Based on these results, TNC and the Scout Ranch staff planned on continuing to use prescribed fire as a tool for forest health improvement on the Scout Ranch. Planning and preparation work started for the second prescribed burn on the Scout Ranch to be completed in 2019.

The Scout Ranch is bordered by the Roosevelt National Forest on the northwest and south sides. The Jack Nicol Cub Scout Camp is on the western border of the Scout Ranch. Private property borders the Scout Ranch on the east, which is primarily individual homes. The community of Glacier View is just a few miles directly east of the Scout Ranch.

A comprehensive forest management plan was developed for the property and was updated in 2017. This plan has seven goals to which the Elkhorn Creek Unit #4 Prescribed Fire Plan's goals and objectives tier.

3.6. Elkhorn Creek Unit #4 Prescribed Fire Plan

The Elkhorn Creek Unit #4 Prescribed Fire Plan ("ECU4 Rx Fire Plan") was developed by TNC to serve multiple goals: to provide for firefighting and public safety, to reduce fuels, to reintroduce fire to the ecosystem, and to provide training opportunities. A total of 505 acres of the Scout Ranch were targeted in the Plan for treatment, divided into two units: Unit 4a containing 385 acres and Unit 4b containing 120 acres. (See Figure 3.4 below.) The Plan was developed consistently with the directions and standards of TNC and their prescribed fire plan template. The following goals and objectives were identified for the ECU4 Rx Fire project:

Incident Objectives/Goals from the Prescribed Fire Plan and Incident Action Plan

- Provide for firefighter and public safety.
- Reduce accumulated thatch, shrubs, ponderosa and Douglas-fir seedlings and saplings, and reduce dead fuels to minimize the potential for high-severity effects following wildfires.
- Reintroduce fire as a natural process in the ponderosa pine ecosystem.
- Provide training opportunities where appropriate based on conditions and staffing.

Prescribed Fire Objectives from Prescribed Fire Plan and Incident Action Plan

- Reduce conifer regeneration (<6" DBH) by at least 20% within 1 year of the burn.
- Reduce 1-, 10-, and 100-hour fuels by 30% immediately post burn.
- Limit mortality of trees greater than 10" DBH to 20% or less.
- Increase native herbaceous vegetative cover by 20% within 2 years of the burn.

TNC is not required by Colorado state law to follow the Division of Fire Prevention and Control (DFPC) or the National Wildland Fire Coordinating Group (NWCG) prescribed fire plan template when burning on private property in the state of Colorado. DFPC's prescribed fire template, which is based on NWCG standards, is required only when contracting with DFPC or any other state agencies that have direct involvement in prescribed fire. However, DFPC strongly encourages all practitioners of prescribed fire in Colorado to utilize NWCG standards. TNC's prescribed fire personnel meet the qualification standards set forth by NWCG to be certified in the planning and implementation of prescribed fire. Broadcast burns conducted in Larimer County must have a written prescribed fire plan that follows federal or state guidelines and TNC met this requirement in preparing the ECU4 Rx Fire Plan. Though not required to do so, TNC did request DFPC Unit Chief for Prescribed Fire and Fuels review the Plan to make sure it contained the required elements of the DFPC prescribed fire plan template. This was also done as a way to inform DFPC that TNC was planning to conduct a prescribed fire on the Scout Ranch. TNC is not the only practitioner of prescribed fire in the state of Colorado that has to navigate the varying array of state and local laws that regulate prescribed fire to make sure they meet all legal requirements.

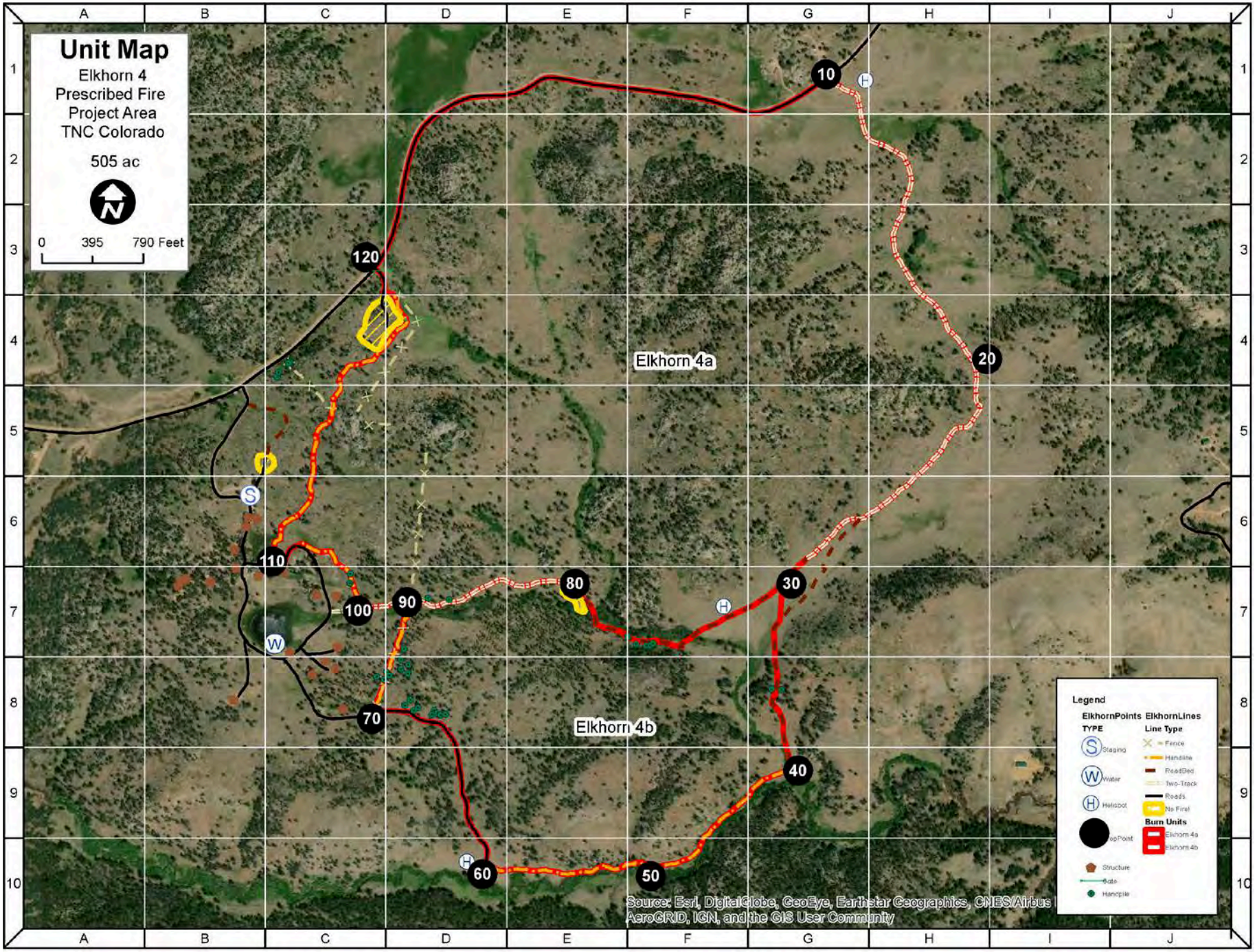


Figure 3.4: Map of the Elkhorn Creek Unit #4 Prescribed Fire Unit.

4. Description of the Event

This section provides the factual story of the events of the ECU4 Rx Fire based on interviews conducted with involved personnel and verified against supporting documentation.

4.1. Planning and Preparation

Planning for ECU4 Rx Fire began over a year before the implementation. The prescribed fire plan preparer made the first site visit in September of 2018 and worked to develop the plan over the course of that fall and winter. The prescribed fire plan preparer had a decade of experience writing these types of plans, primarily in settings with similar landscape and WUI characteristics. However, this was the preparer's first project in Colorado and with TNC, and therefore it was necessary to get to know the local players and partners, as well as learn the TNC and DFPC prescribed fire plan templates. During the plan preparation process, the preparer frequently consulted with partners, local experts, and TNC colleagues. A TNC-specific Complexity Analysis was completed for the project as well as the TNC-specific Consequence Analysis, identifying the project as a High Consequence prescribed fire, primarily because of the proximity to structures to the east. During the plan preparation process, the preparer was also working on plans for three or four other prescribed fire projects. The ECU4 Rx Fire Plan was completed in the early spring of 2019, and the TNC Colorado staff walked through it thoroughly in June, but they waited to collect signatures on the plan until open positions at the Scout Ranch were filled. The signatures on the plan were ultimately collected on September 4, 2019 and October 1, 2019.

In August of 2019, planning for the project ramped up including getting prep and equipment ready for the project, and reaching out to partner agencies for personnel to staff the operation. It was determined that TNC's Colorado Fire Manager would serve as the Burn Boss (RXB2) on the project and the plan's preparer would serve as the Burn Boss Trainee (RXB2(T)). September was a busy month for the TNC Colorado fire management staff and during that month, their staff was reduced from four to three members when the staff member who completed the technical review of the ECU4 Rx Fire Plan moved on from the TNC Colorado chapter. Still, the Burn Boss Trainee took time to ask for lessons learned from individuals involved in burning the Elkhorn Creek Units #1 in 2017. Told that planning had not been as robust as it could have been on that project, the Burn Boss Trainee's intent was to do better for Unit #4. Additionally, after a thought-provoking discussion at a Colorado Prescribed Fire Council meeting on September 19, 2019, TNC staff put additional effort into what they described as contingency planning. As part of that extra planning, a separate "contingency map" was prepared and eventually distributed to all participants.

TNC made efforts to involve the local community at the same time that planning was occurring, and hosted open houses to showcase the project. These events were sparsely attended. Later, a concerted effort to increase public outreach was made by the Burn Boss Trainee after a

presentation at the September 2019 Colorado Prescribed Fire Council meeting, and 1,500 letters were sent to homeowners informing them of the goals and timing of the prescribed fire. However, it turns out that very few people opened those letters, as learned later at a heavily attended community meeting regarding the Elk Fire.

Physical preparation of the site of the prescribed fire project involved working with existing features, cow paths, and roads around the unit, and some construction of hand and dozer lines. Areas were identified for exclusion from fire, and several dozer lines were put in to protect these areas.

The week before the burn, participating personnel completed a tour of the unit. Of the overhead personnel, only the Zulu Holding Boss was unable to attend, and therefore the Burn Boss Trainee assigned him to the upwind side of the unit. TNC identified the following Tuesday, Wednesday, Thursday as target days to complete the burn.

On Thursday, October 10 into Friday October 11, 2019, the area of the prescribed fire received 2 to 3 inches of snow and some partners asked TNC if they were going to call off the burn as a result. TNC personnel visited the unit on Sunday, October 13 and observed that snow remained only on the north aspects and the unit appeared to be drying out. On Monday October 14, TNC returned to the site to go back over some of their prep work and complete final arrangements. That evening, TNC held an operational team meeting with the individuals that would serve in overhead roles during the project.

4.2. Day 1 - Tuesday, October 15, 2019 (Unit 4a)

Ignition operations began on Tuesday October 15, 2019 (“Day 1”) in the northern subpart of Elkhorn Creek Unit #4, known as “Unit 4a,” consisting of approximately 385 acres. (See Figure 3.4 above.) About 50 individuals participated in the operation representing over a dozen different agencies and organizations. Under the supervision of the Burn Boss and Burn Boss Trainee, the organization was divided into two divisions each consisting of a firing team and holding team. The “Alpha” division was assigned to the work along the north and then western boundaries of Unit 4a, and the “Zulu” division was assigned to the work along the east and then southern boundaries of the unit.

That morning, the incident command post (ICP) briefing was held at 0915 hrs. The incident action plan (IAP) and weather forecasts were reviewed with all fire personnel. After the main briefing, at about 0945 hrs, the Zulu and Alpha divisions each held breakout briefings to review end state, purpose, and tasks, and to ask and answer questions to ensure an understanding of leader’s intent for each operational period. Many participants had not yet seen the burn unit and therefore the Burn Boss and Burn Boss Trainee had both divisions set out at 1000 hrs to scout the unit on foot for approximately an hour. After scouting was complete, participants reconvened and in accordance with TNC policy, the Burn Boss and Burn Boss Trainee asked all participants if they were comfortable with the plan and whether anyone would like to turn down the assignment. No participants turned down the assignment or expressed concerns regarding the

plan. The Burn Boss and Burn Boss Trainee then worked through the “Go/No Go” checklist, including initiating the test fire.

The test fire was ignited at approximately 1204 hrs in the northeast corner of the unit near Drop Point 10 (“DP-10”). (See Figure 3.4 above for location of drop points referred to throughout this report.) The Burn Boss and Burn Boss Trainee documented that the test fire was successful; fire and smoke behavior were noted as within prescription; and weather and fuel conditions were noted as within prescription and consistent with the forecast.

At approximately 1220, the Burn Boss Trainee made the Go/No-Go decision as a “go” and then the Alpha and Zulu divisions began ignitions within their assigned areas. Alpha worked south along the eastern unit boundary, blacklining from DP-10 to DP-20 to DP-30, and Zulu worked westward along the northern unit boundary, blacklining from DP-10 to DP-120 to DP-110. Fire behavior was moderate, carrying well in grass and shrubs and causing some individual torching in juniper and fir trees. Progress was slow but steady, as the diverse group of people went through the process of getting to know each other and learning each other's knowledge and experience levels. After blacklining was completed, Alpha firing continued south with its own holding contingent, while Zulu continued to the west. Zulu’s firing patterns had to contend with additional terrain and the county road that was being used as a northern holding feature, slowing their progress more than Alpha’s.

Shifting winds were noticeable throughout the day, but overall fire behavior was meeting objectives and carried across the unit on its own without the need for interior firing. Fire behavior throughout the day was primarily surface fire, with continuous fuels carrying fire well in the grass and shrub components. Some single tree torching occurred both interior and near the lines, resulting in a few small but easily contained spot fires. At 1430 hrs, a 2’ x 2’ spot fire was located to the north of County Road 68C between DP-120 and DP-10 and quickly extinguished by a Type 6 engine and UTV assigned to Zulu holding.

As Zulu continued to the west, holding resources had to improve control lines ahead of them, slowing progress as holding and firing coordinated their efforts to make sure fire remained within the unit. While not expected based on the wind forecast, winds were blowing over the western line of the unit, requiring more time to ignite than if it were on the upwind side of the unit as forecast. Alpha firing and holding continued steadily with no issues, since winds were pulling fire into the unit and carrying it cross. Alpha had to pace themselves so they did not get fire established in front of Zulu. The firing teams of the two divisions tied in together at DP-110 and ceased firing operations for the day at 1730. At 1735, a spot fire of 10’ x 15’ was located at DP120 but quickly extinguished.

After operations were done for the day, a short AAR discussion was held. The overall consensus was that the day’s operations went well and the Unit 4a burn was a success. The Fire Effects Monitor (FEMO) noted that resource objectives were met regarding minimizing overstory mortality, reducing woody surface fuels, and stimulating herbaceous vegetation response.

That evening, with Unit 4a completed on Day 1, the Burn Boss and Burn Boss Trainee discussed plans for the next day regarding the southern portion of Elkhorn Creek Unit #4, known as “Unit 4b” and consisting of approximately 120 acres. They reviewed the October 15 PM spot forecast for the area. The spot forecast discussion addressed light winds Tuesday evening, limited humidity recovery Wednesday morning, strengthening winds Wednesday and Thursday, and then confusingly states, “By Thursday, with gusts expected around 30 mph, the combination of low relative humidity and gusty erratic winds will create critical fire weather conditions for both days with a Fire Weather Watch in effect for Thursday.” Taking note of the language “both days,” the Burn Boss and Burn Boss Trainee decided to take a look at the spot forecast again in the morning and reassess.

4.3. Day 2 - Wednesday, October 16, 2019 (Unit 4b)

On Wednesday, October 16, 2019 (“Day 2”), the Burn Boss and Burn Boss Trainee reviewed the October 16 AM spot forecast and noted that the discussion language had changed. In this new spot forecast, it stated that a Fire Weather Watch would be in effect only for Thursday (October 17). They discussed whether to proceed with operations that day but ultimately decided to move forward based on all the information before them. Unit 4b, though containing more complex terrain, was smaller than Unit 4a and there were more resources on hand the second day. On Day 1, they had successfully burned well over twice as many acres with less people and under what seemed to be very similar conditions. Though the Burn Boss and Burn Boss Trainee felt that conditions on Day 2 were near the “high end” of the prescription, with the new spot forecast looking better and no other indications otherwise, they concluded that they were within the parameters of their prescribed fire plan and safe to move forward.

On Day 2, once again about 50 individuals participated, representing over a dozen different agencies and organizations. Not all individuals on Day 2 had participated in Day 1, and many participants had not yet seen Unit 4b. On this day, the organization was divided into Alpha and Zulu divisions once again, with the same overhead assigned to the firing and holding boss roles as the day before. Zulu was assigned to work from east to west along the northern boundary of the unit and Alpha was assigned to work south along the eastern boundary of the unit, and then take the southern flank.

Roll call took place at 900 hrs and then the Alpha and Zulu divisions were released to scout the unit for approximately an hour, as they had the day before. The Burn Boss and Burn Boss Trainee held a tactical briefing with the firing and holding overhead at approximately 0945 hrs. They discussed forecasted winds and weather and all agreed that they could safely conduct operations within the prescription and parameters of the forecast. As a part of that briefing, they discussed pacing and established approximate timestamps for progress to align with the acreage and daylight parameters outlined in the smoke permit.

The operational period briefing was held at DP-30 from approximately 1000 to 1030 hrs. Following the large group briefing, holding and firing teams broke out into their respective

divisions for a more detailed tactical briefings. The Burn Boss and Burn Boss Trainee once again asked all participants for concerns with the plan and whether anyone wanted to turn down the assignment, but no concerns were raised. They then worked through the Go/No Go checklist starting at about 1100 hrs and initiated the test fire just southwest of DP-30 at 1121 hrs. Weather observations at that time noted temperature near the predicted high, relative humidity (RH) near the predicted low, high cloud cover, and winds slightly stronger than the previous day but mainly terrain-dominated and more predictable. The Burn Boss Trainee approved of the observed fire behavior and fire effects and continued forward with operations.

At 1151, Zulu firing began blacklining from DP-30 to DP-40, approximately 0.25 miles. Zulu holding resources were assigned to line some remaining piles from previous mechanical work between DP-70 and DP-90. Therefore, Alpha holding was assigned to work with Zulu firing. To begin, Zulu firing started at DP-30, burning out a triangle-shaped area to the south and west towards DP-80. (See original blacklining on map in Figure 4.1 below.) With that completed, they began to build blackline moving south along the eastern boundary of Unit 4b towards DP-40. Zulu firing worked carefully and slowly, burning out between the two-track road that designated the eastern boundary and a willow-lined creek, stopping just short of DP-40. Blacklining took time, and, as fire backed down towards the willows in the streambed, they swatted it out so that the fire would not reverse slope and run back uphill to the west. The blackline was ultimately completed later than planned at approximately 1345 hrs.

During this time, Alpha firing was in position and waiting to begin firing on a knob northwest of DP-40. At 1215 hrs, Alpha firing began interior ignitions, establishing fire on a ridgeline just north of DP-40. Alpha firing continued with ignitions in a chevron pattern off ridge tops, working north and west. Fire backed very slowly from the ridgetops in all directions with low flame lengths and occasional torching in brush and juniper under cloudy skies. Alpha firing continued with interior ignitions north of DP-40, moving westward efficiently without issue.

At 1300 hrs, Zulu holding finished their assignment prepping the piles near DP-70 and headed back east for a briefing at 1400 hrs at DP-30. By this point, Zulu firing had completed blacklining and was ready to move into interior ignitions. From that point forward, Zulu holding was assigned to support Zulu firing with an additional mission to point protect a large slash pile near DP-80 that was designated for exclusion from the prescribed fire.

At this point, the two firing teams were working in parallel from east to west conducting unanchored interior ignitions (firing not adjacent to control features or previously burned areas). Zulu initiated firing on the ridge north of where Alpha had started, and Alpha continued firing along ridges to the south of them. As Zulu's fire began to back off the ridge, another firing group from Zulu began firing below the ridgetop fire to bring it to the northern boundary of Unit 4b. This fire was just west of the test fire near DP-30, and allowed to run back into the previously burned area. The two teams had good radio communication and frequently could see each other across the approximately 200 to 250 yard distance between the two teams. Zulu was moving more slowly and requested that Alpha hold up so they would not get too far ahead. Around this time (between 1330 and 1500 hrs), Alpha holding put in a very small amount (<40 yards) of

additional blackline to create a “catcher’s mitt” to the west of DP-40 in anticipation of turning to the west soon. (See catcher’s mitt blacklining on map in Figure 4.1 below.)

Figure 4.1: Map of Original and Additional “Catcher’s Mitt” Blacklining.

After taking weather observations at 1430 hrs, the FEMO joined the Alpha firing team on the top of a ridge to gauge interior weather conditions and fire behavior. Winds were measured as averaging 4 mph in the drainage on the southern boundary of the unit, but gusts of 23 mph at the top of the ridge were observed. The FEMO noted that the high winds and exposed fine dead fuel moisture of 3% were at the high-end of the prescription and communicated that to the Burn Boss Trainee by radio. The Burn Boss Trainee acknowledged the increase in fire behavior and began a patrol of the east holding line. Alpha holding was focused on patrolling the line between DP-30 and DP-40 with an engine positioned at the highpoint between the two DPs.

By now, Alpha firing was wrapping up their current task and about to discuss next steps while Zulu firing was continuing ignitions in grass and understory working towards DP-80. That’s when the first spot fire was called over the radio.

The Burn Boss located and then announced the first spot fire over the radio at approximately 1500 hrs. It was a smoldering punky log, just over the eastern boundary to the east of DP-30, and it was easily contained with available resources within less than 20 minutes. At this point, all firing teams had paused and

“What strikes me about that moment is that that ember must have come from a long distance!” By that time the eastern boundary of the unit near DP-30 was blacklined with hundreds of feet of cold black grass. “I wish I had asked myself, where did that spot come from?”

-Alpha Holding Boss

were listening in on the radio. Just minutes later though, two more spot fires would be detected and called in over the radio.

After the first spot was detected, the Alpha Holding Boss set out to patrol south from DP-30, driving a UTV south towards DP-40 along the rough road that was the eastern boundary of Unit 4b. Upon cresting the high point between DP-30 and DP-40, the Alpha Holding Boss laid eyes on two small spot fires in the “the one place that we couldn’t get a spot” - in the steep grassy drainage to the east of the road. At approximately 1526 hrs, the Holding Boss called in over the radio the two spots, each approximately 10’ x 20’, located close together in the grass in the drainage at least 50 feet east of the line. (See Figure 4.2 below.) Other personnel familiar the Holding Boss and that individual’s extensive fire experience, immediately detected in the Holding Boss’s voice that the situation was serious. The two spots quickly grew together and started spreading rapidly up the drainage towards the northeast in continuous cheat grass.

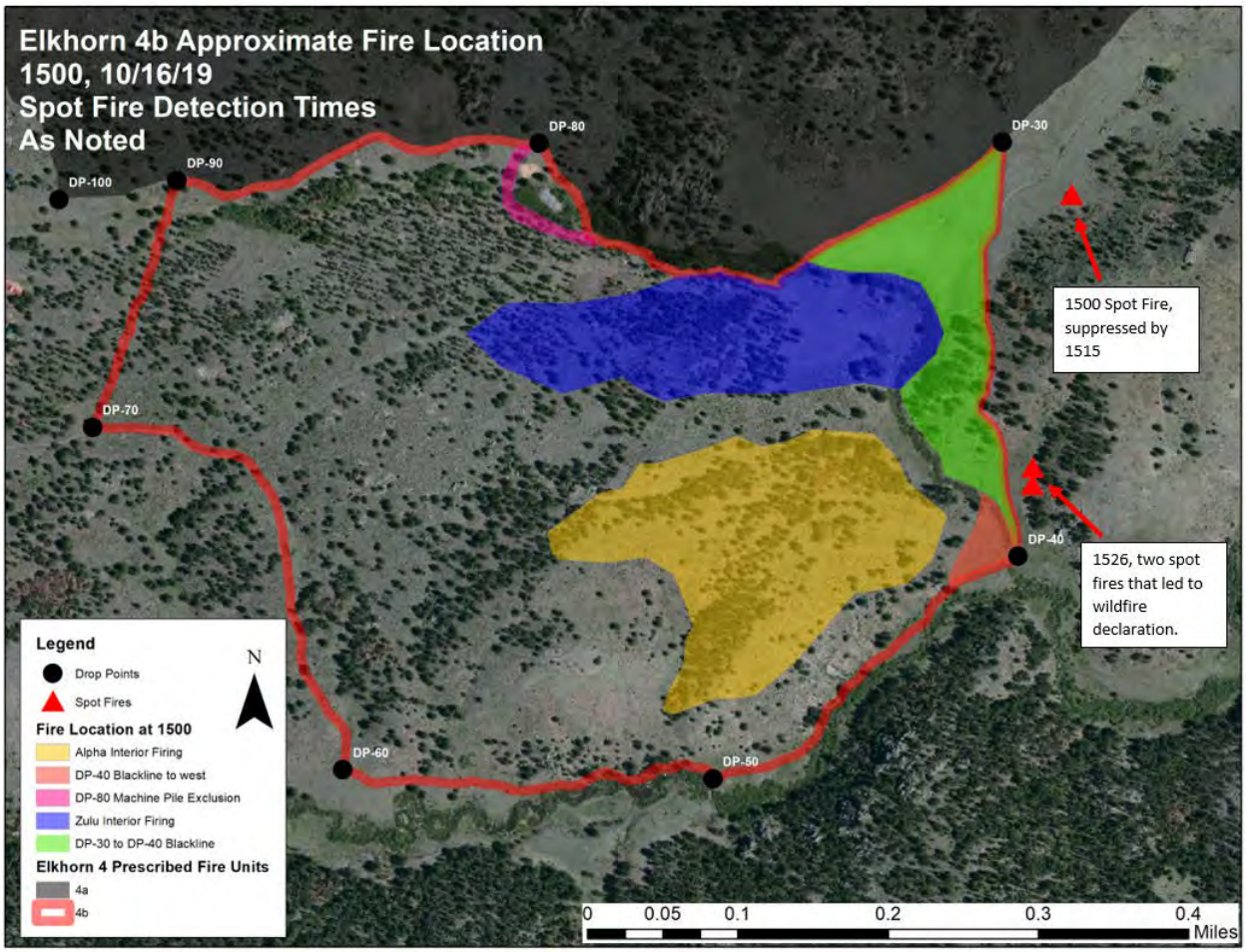


Figure 4.2: Map of Approximate firing locations and location of spot fires.

The Alpha Holding Boss directed Alpha holding resources to respond to the spot fire immediately, and called for resources from Zulu holding as well. A Type 6 engine from Alpha Holding attempted to engage the spot fires, but ran out of hardline before they could reach the spots. As additional resources arrived, it was difficult to engage with direct attack due to the rate

of spread and fire intensity. Resources repositioned to scout the right flank of the spot fire, keeping as tight as possible on the fire's edge where they were able to engage.

In response to the radio traffic, the Zulu Firing Boss trainee headed towards DP-30 on foot while the Zulu Firing Boss and their lighters remained in position to complete ignitions needed to button up around the slash pile at DP-80. The Alpha Firing Boss and three other individuals also headed towards the spot fires while the Alpha Firing Boss Trainee and one other individual remained in position south of Zulu's ridgeline firing. The Burn Boss and Burn Boss Trainee contacted the nearby Red Feather North Prescribed Fire on USFS lands and requested two engines to respond, and two Type 6 engines were en route within minutes. A few minutes later, orders for additional resources came to Fort Collins Dispatch from the ECU4 Rx Fire, including a water tender, two more type six engines, and two Type 2IA hand crews.

Upon reaching the area, the Burn Boss immediately took off on foot to scout the left flank of the spot fire, until reaching a high ridge top from where it was apparent that the fire was within ½ mile from the nearest structure on adjacent private land and 100 ft from the Scout Ranch property boundary. Based on the rate of spread observed, the Burn Boss concluded that they would not be able to suppress the spot before it left the Scout Ranch property boundary. Because one established trigger point for declaring a wildfire was fire crossing the property boundary, the Burn Boss immediately declared a wildfire at 1559 hrs. From there, the organization quickly and smoothly transitioned into suppression operations under the command of personnel from the Larimer County Sheriff's Office. Orders for multiple aircraft including single engine and heavy air tankers, lead planes, helicopters, and aerial supervision were placed, along with additional ground resources. Mandatory evacuation orders were issued for roughly 100 residences by 1800 hrs on October 16, 2019.

Elkhorn Creek Prescribed Fire Unit 4b Approximate Timeline: October 16th, 2019	
900 hrs	ICP Briefing
905 hrs	Scouting Start
1025 hrs	Scouting End
1030 hrs	Ops Briefing
1100 hrs	Go No/Go
1121 hrs	Test Fire
1151 hrs	DP30-40 Blackline Start
1345 hrs	DP30-40 Blackline End
1215 hrs	Alpha Interior Ignition Start
1320 hrs	Zulu Interior Ignition Start (DP30-80)
1500 hrs	DP-40 to DP-50 Blackline

1400 hrs	Cloud Cover breaks
1500 hrs	DP30 Spot Fire Detection
1526 hrs	North of DP40 2 Spot Fire Detection
1545 hrs	Realize Containment is Difficult
1559 hrs	Wildfire Declaration

Figure 4.3: Approximate Timeline - October 16, 2019

By 1825 hrs on October 16th, fire behavior was significantly moderating. Resources worked late into the night and made a good deal of progress in containing the wildfire. The wildfire was 80% contained by Thursday, completely contained by 0800 hrs on Friday, and declared controlled on Sunday. In total, the Elk Fire wildfire burned 682 acres, with 118 acres outside of the planned boundaries of the prescribed fire and 82 acres off the Scout Ranch property. One outbuilding was destroyed by the fire.

5. Objective Factors Analysis and Lesson Learned

This section provides description and analysis of objective factors and conditions relevant to the escape as identified by the Review Team through the review process.

5.1. Seasonal Severity

Several climate and weather variables can be used to measure seasonal severity. Long-term trends of Temperature, Relative Humidity, Wind, Precipitation (and combination thereof), and an assortment of indices were analyzed to provide an accurate depiction of conditions leading up to the ECU4 Rx Fire.

Antecedent conditions leading up to the ECU4 Rx Fire were characterized by below average precipitation, periods of above average temperatures, and frequent episodes of low humidity combined with wind. A meager monsoon season resulted in total precipitation amounts from August 1 thru October 14, 2019 of just over an inch (1.09”) for the area, including 2-3 inches of snow on October 10-11, 2019. Though these amounts are much higher than what occurred in other parts of the state of Colorado during the same period, this value is below the seasonal average for this area. Temperature and precipitation anomalies for July-September 2019, depicted in Figures 5.1 and 5.2, provide an accurate portrayal of warmth and dryness during the period, with yellow and brown shades indicative of warmer than average temperatures and below average precipitation.

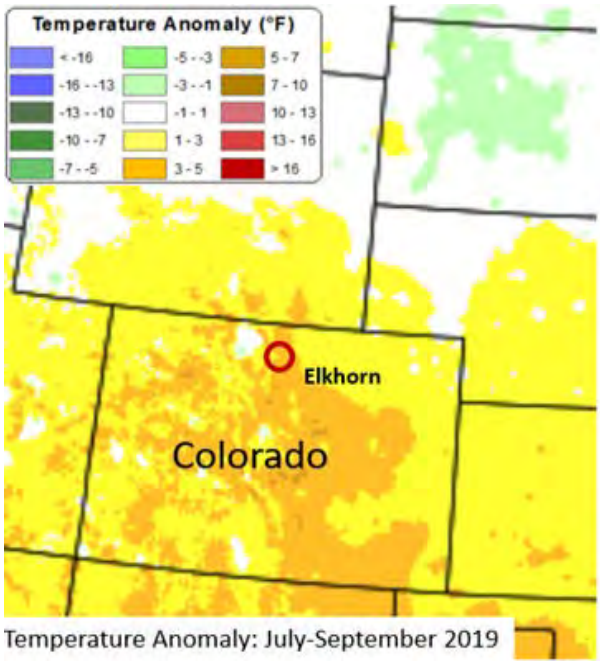


Figure 5.1: Mean Temperature Anomaly (PRISM Data-Oregon State University) for July-September 2019. Warm colors (orange and reds) indicate above average temperatures and cool coolers (greens and blues) indicate below average temperatures.

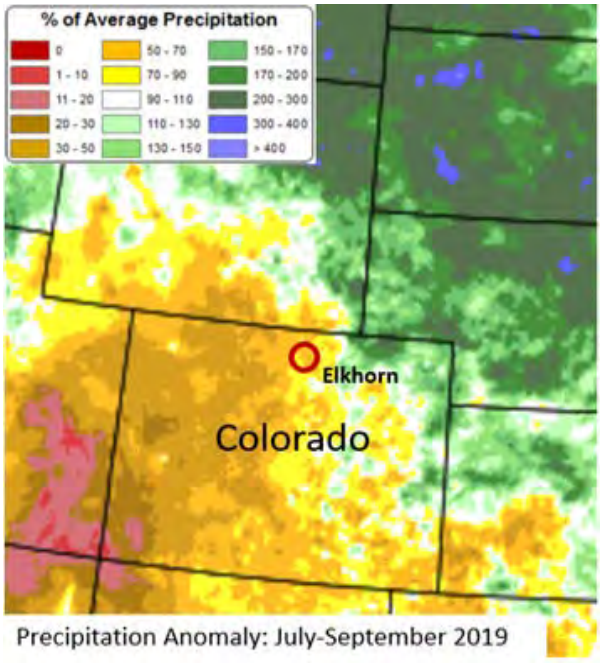


Figure 5.2: Percent of Ave. Precipitation (PRISM Data-Oregon State University) for July-September 2019. Yellow and red colors indicate below average precipitation with greens and blues indicative of above average precipitation.

Additionally, climate data from the Remote Automatic Weather Station (RAWS) in Red Feather, located 5.5 miles NW of the Elkhorn Creek Unit #4, provide insight on the frequency and strength of low humidity and wind episodes that occurred in the period immediately preceding the prescribed fire (September 1- October 14, 2019). See Figures 5.3 and 5.4 below. Red Feather RAWS has an extensive climate record dating back to 1985 (34 years), along with other supporting climate data extending back to 1970. Though 5.5 miles to the northwest and 400-500 ft higher in elevation, Red Feather RAWS is an excellent surrogate for the Elkhorn Creek Unit #4 in terms of climate record, observations, and prescribed fire planning.

Figure 5.3: Google Map showing proximity of the Red Feather Remote Automated Weather Station (RAWS) to Elkhorn Creek Unit #4.

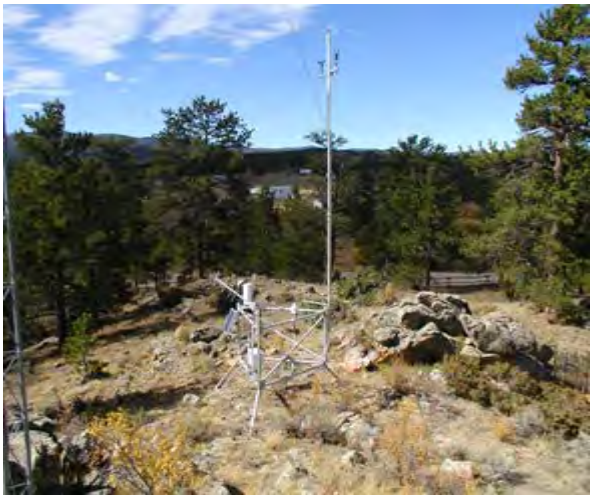


Figure 5.4: Photo of Red Feather Remote Automated Weather Station (RAWS).

Analysis of maximum temperature (MaxT), minimum relative humidity (MinRH), sustained wind speed, and max wind gusts during September 1 to October 14, 2019 (Figures 5.5-5.8) indicate frequent episodes of warm, dry, and windy conditions. Importantly, the data also indicates abrupt warm, dry, and windy periods over Elkhorn Creek Unit #4 following precipitation events. Abrupt warm, dry, and windy conditions following precipitation events can significantly reduce the benefits of rain or snow received due to more rapid evaporation (changes from liquid to vapor) and/or sublimation (changes from ice/snow to vapor) that prevents dead fuels and soil from taking on moisture.

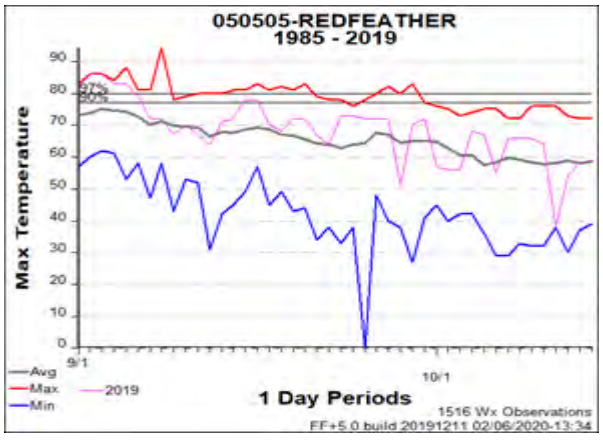


Figure 5.5. Maximum Temperature (pink line) for the Red Feather RAWS from September 1-October 14, 2019. The red line represents the highest MaxT, grey line is the average, and blue line lowest MaxT for the time period and dataset dating back to 1985.

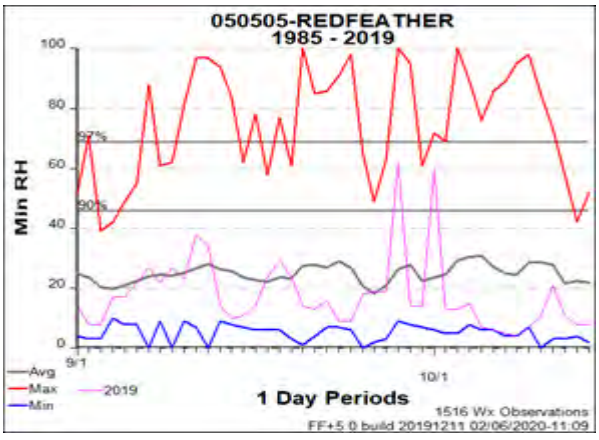


Figure 5.6. Minimum Relative Humidity (RH) (pink line) for the Red Feather RAWS from September 1-October 14, 2019. The red line represents the highest Minimum RH value, grey line is the average, and blue line lowest Minimum RH value for the time period.

Figure 5.8, daily wind gust speeds, indicates 23 of the 44 days from September 1 to October 14 experienced wind speeds above the 90th percentile for that location. Sustained wind speed (Figure 5.7) shows similar results. Many of these windy periods combined with near or record low relative humidity (RH) (Figure 5.6), and in some cases, the MinRH dropped into the single digits with poor overnight recovery (recovery less than 30%). Furthermore, data shows 26 of the 44 days had MinRH at 20% or lower, and 19 of the 44 days had MinRH at 15% or lower. A MinRH value of 15% or lower is a critical level when issuance of Fire Weather Watches and Red Flag Warnings are considered by the National Weather Service (among other factors).

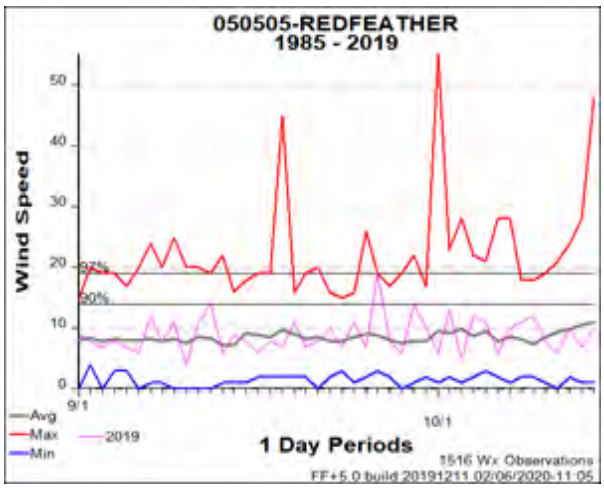


Figure 5.7: Sustained Wind Speed (mph) (pink line) for the Red Feather RAWS from September 1-October 14, 2019. The red line represents the Average Sustained Wind Speed value, grey line is the average, and blue line lowest Average Sustained Wind Speed value for the time period and dataset dating back to 1985.

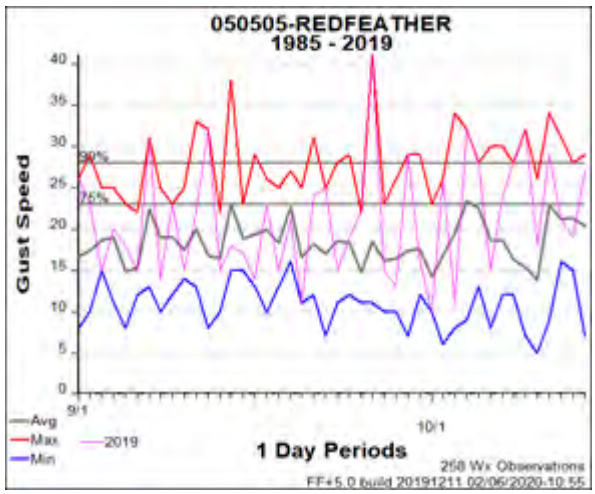


Figure 5.8: Max Wind Gust Speed (mph) (pink line) for the Red Feather RAWS from September 1-October 14, 2019. The red line represents the Max Wind Gust value, grey line is the average, and blue line lowest Max Wind Gust value for the time period and dataset dating back to 1985.

Though illustrated and briefly discussed in **Appendix C (Fire Weather Review Report)**, the U.S. Drought Monitor is not a good indicator or predictor of seasonal and fire environment severity in terms environmental factors (namely fuel and fire weather conditions) for a variety of reasons. Drought indices and changes in respective drought categories (D0- *Abnormally Dry* to D4- *Exceptional Drought*) typically require a 30-day wet or dry period to yield a corresponding category change and do a substandard job accounting for snowpack, among other reasons. A better indicator is the Evaporative Demand Drought Index (EDDI) which is calculated from temperature, humidity, wind speed, and solar radiation, and can be utilized for early warning and flash drought detection (among other climate or meteorological fields); conditions that may not be represented in the standard U.S. Drought Monitor. The corresponding Evaporative Demand Drought Index (EDDI) for a 4-week period ending on October 9, 2019 (Figure 5.9) identified periods in which the index ranged from the 90th to the 98th percentile in terms of the combination of temperature, humidity, wind speed, and solar radiation, further reinforcing conditions recorded at the Red Feather RAWS during September 1-October 14, 2019.

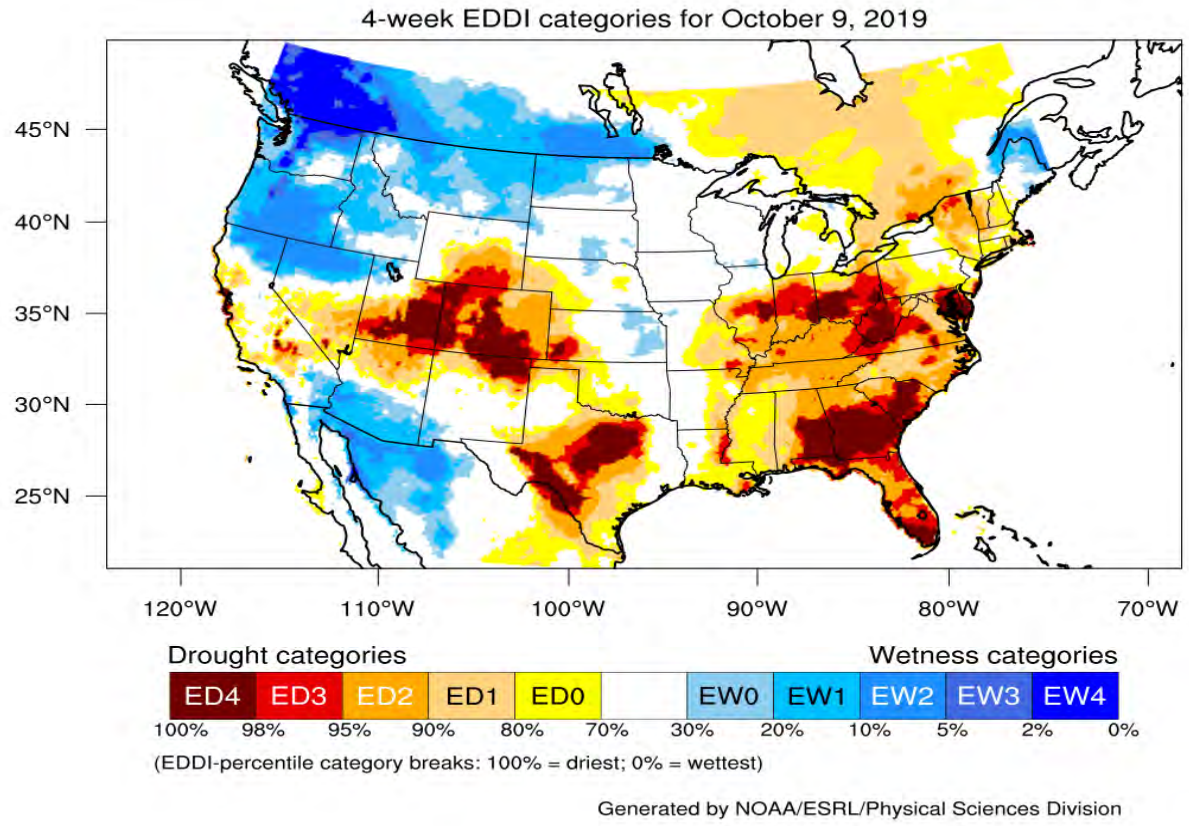


Figure 5.9: Evaporative Demand Drought Index (EDDI) for a 4-week period ending October 9, 2019.

5.2. Weather During Implementation

Before a meteorological analysis was conducted for October 15-16, 2019, the ECU4 Rx Fire Plan weather parameters were analyzed first to provide a perspective of climatology for the area compared to weather variables in the Plan. This was achieved by utilizing common tools including Fire Family Plus and a supporting data record from the Red Feather RAWS. Evaluation of the weather variables listed in **Element 7: Prescription** (Figure 5.10) and the seasonality listed in **Element 9: Pre-Burn Considerations and Scheduling** (Figure 5.11) of the Plan was performed.

Element 7: Prescription

Fuel Parameters:	**LOW**	**PREFERRED**	**HIGH**	**OUT***
1-Hour Fuel Moisture (%)	**13**	**6-8**	**4**	Sustained 20' winds >24 without blacklining or other mitigating factors** or high Fuel Parameters + more than one of the following weather parameters
10-Hour Fuel Moisture (%)	**15**	**8-10**	**6**	
100-Hour Fuel Moisture (%)	**17**	**12**	**8**	
Live Fuel Moisture (%) (Herb/Woody %)	**60/90**	**40/70**	**30/60**	
Weather Parameters:				
Air Temperature (F)	40 (2.51%)	70 (65%)	85 (99.74%)	--
Probability of Ignition	17	40-60	80	--
20 ft wind speed (mph)	**10 (72%)**	**18 (97%)**	**24 (99%)**	25 (99.27%)
Wind Direction(s)	*Refer to smoke permit. Southwesterly component would be preferred from a tactical perspective.			--

Figure 5.10: ECU4 Rx Fire Prescription for Fuels, Weather, Fire Behavior and Smoke with percentiles added and highlighted in Red.

Element 9: Pre-Burn Considerations and Scheduling

Scheduling			
Seasons of Burn	Fall, Winter Spring	Time of Day:	Any
Earliest Date	Check with Camp for Camper Conflicts Each Year	Blackline Phase Length:	1-2 Days
Latest Date	N/A	Burnout Phase Length:	2-3 Days

Figure 5.11: Element 9: Pre-Burn Considerations Including Season(s) of Burn.

Table 1 below depicts the weather parameters and breakpoints used in the ECU4 Rx Fire Plan, compared to the climate record retrieved from the Red Feather RAWS. In **Element 7: Prescription**, the Plan identified maximum air temperatures of 40°F as "Low", 70°F as "Preferred", and 85°F as "High." Climate records from the Red Feather RAWS show that the percentile values for those maximum temperatures (MaxT) range from the 2.51st percentile to the 99th percentile for the climate period assessed, a range that is exceptionally broad. Moreover, MaxT as low as 40°F and as high as 85°F are extremely rare events for this area, based on the time of year (seasonality). The Plan's 20-foot sustained wind speed breakpoints are 10 mph (Low), 18 mph (Preferred), 24 mph (High), and 25 mph or greater (Out of Prescription). Again, considering climate data record for the area, the percentile for 10 mph is the 72nd, 18 mph is 97th, 24 mph is 99th and 25 mph or greater is 99thpercentile. The sustained wind speed breakpoints in the Plan for *Preferred, High*, and *Out*, are of rare occurrence (less than 3%) for the area when

considering the climate record of sustained 10-minute average 20-ft wind speed at the Red Feather RAWS.

Table 1. Weather Parameters Included in the Burn Plan Compared to the Percentiles Calculated at Red Feather RAWS from September 1 through October 14 (1985-2019).

Weather Parameters	Low	Percentile	Preferred	Percentile	High	Percentile	Out*	Percentile
MaxT (°F)	40	2.51	70	65%	85	99%	N/A	N/A
20-ft Wind (Sustained mph)	10	72	18	97%	24	99%	25	99%

Wind is one of the most critical components of the fire environment, therefore it is important to understand and distinguish between a 20-ft wind speed and a midflame wind speed, both of which are used in fire behavior calculations. Wind speeds in the meteorological analysis below are both 20-ft wind (for fixed stations) and midflame wind (also known as eye-level wind) for on-site observations, and will be identified as such. Standardized 20-ft winds are typically measured by permanent or fixed local RAWS, like the station pictured in Figure 5.12 and located at Red Feather. These types of stations are usually sited and maintained by fire agencies, typically federal or state, and must meet NWCG standards and guidelines as outlined in *PMS-426-3 NWCG Standards for Fire Weather Stations*. Importantly, forecast 20-ft winds are provided in Spot Weather Forecasts generated by local National Weather Service (NWS) offices for use in prescribed fire operations and wildfire incidents.

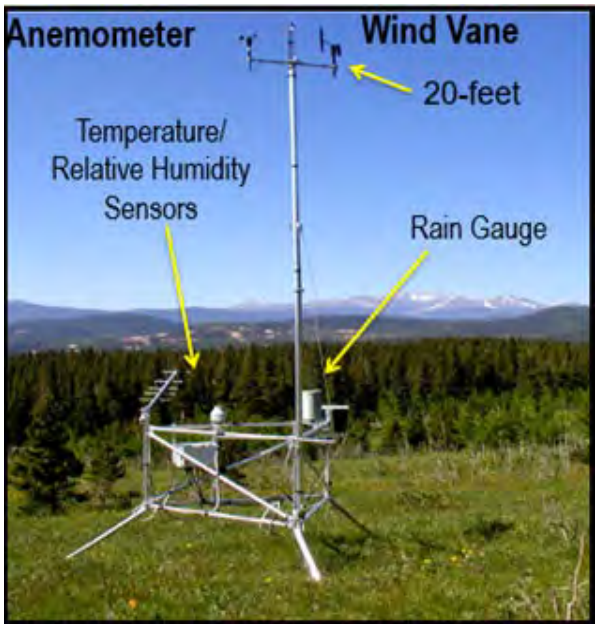


Figure 5.12: Electronic components of a Remote Automated Weather Station (RAWS). The anemometer and wind vane are located 20-ft above the ground.

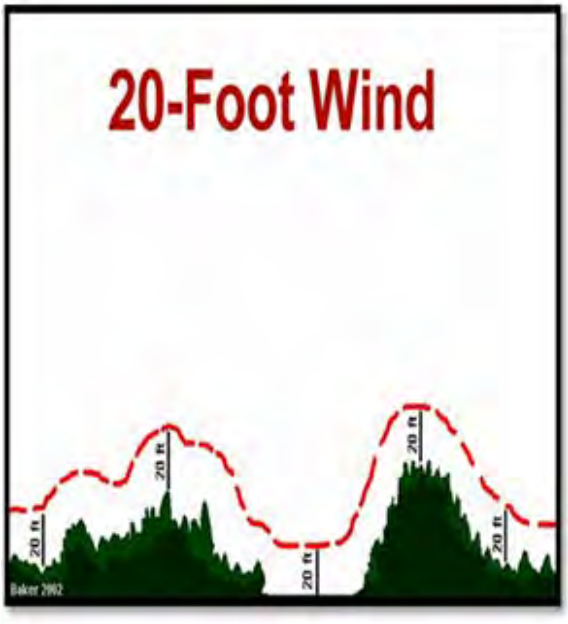


Figure 5.13: This diagram illustrates the measurement of the 20-ft wind. 20-ft wind (surface wind) is measured 20-ft above the average vegetation.

Whether from a RAWS or a NWS Spot Weather Forecast, a 20-ft wind speed (sustained or gust) can then be reduced using a *Wind Adjustment Factor* (WAF) (Figure 5.14), based on sheltering and fuel type, to calculate a *Midflame Wind Speed* (MWS) (Figure 5.15). Midflame wind is the wind that acts directly on the flaming fire front at the level of ½ the flame height and is required to determine fire behavior calculations such as rates of spread (ROS). The WAF is typically part of a prescribed fire plan. Eye-level wind, that is manually measured on-site in the field using hand-held wind meters, is a customary surrogate for the midflame wind. When comparing 20-ft wind vs. midflame wind (eye-level) speeds, the midflame wind speed will ***always*** be lower than the 20-ft wind speed due to vegetation and sheltering. Moreover, fuel type and sheltering result in varying degrees of friction and can lead to a ***significant*** decrease in wind speed at midflame level, 50% to 90% reduction of the 20-ft wind speed depending on fuel type and sheltering. Wind and other meteorological factors were closely examined for Day 1 and Day 2 operational periods below.

Degree of Sheltering	Fuel Model	Adjustment Factor
Unsheltered	4, 13	0.5
	8, 9	0.3
	All Others	0.4
Partially Sheltered	All Models	0.3
Fully Sheltered	All Models	
	Open Stand	0.2
	Dense Stand	0.1

Figure 5.14: Midflame Wind Adjustment Factor (WAF) table. This table contains the adjustment factor for the 20-ft wind speed reduction.

Figure 5.15: This image illustrates a midflame wind, which is calculated as half the flame height OR estimated by eye-level wind measurements.

Meteorological analysis for October 15th and 16th indicates a substantial change in temperatures and humidity, and increase in wind from Day 1 to Day 2. On Day 1, on-site FEMO observations indicate RH dropped to 11% by 1300 hrs, 10% lower than was forecast. However, a stationary frontal boundary shifted west and into the Elkhorn Creek Unit #4 between 1300 and 1350 hrs, supporting cool temperatures, much higher RH (35%-40%), and variable or shifting wind flow for the remainder of the operational period. In comparison, the Red Feather RAWS located 5.5 miles to the northwest was positioned just west of the frontal boundary and experienced dry and gusty conditions during the entire operational period (16% RH and gusts to 33 mph). A sample of on-site observations on Day 1 compared to the Red Feather RAWS and the Redstone RAWS for around the same time are included in Table 2.

Table 2. A Sample of October 15, 2019, On-Site Observations Compared to Red Feather RAWS and Redstone RAWS Around the Same Time.

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	1100	Red Feather	8233	49	15%	10G26mph	W
10/15/2019	1100	Redstone	6160	47	50%	10G15 mph	SSE
10/15/2019	**1045**	**On-Site Ob**		**46**	**43%**	**3G5 mph**	**NE**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	1200	Red Feather	8233	52	16%	8G23mph	W
10/15/2019	1200	Redstone	6160	50	46%	10G16 mph	SSE
10/15/2019	**1140**	**On-Site Ob**		**54**	**18%**	**7G13 mph**	**SSW**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	1300	Red Feather	8233	54	16%	10G26mph	W
10/15/2019	1300	Redstone	6160	52	41%	9G15 mph	SSE
10/15/2019	**1300**	**On-Site Ob**		**60**	**11%**	**5G10 mph**	**Var (W)**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	1400	Red Feather	8233	56	16%	11G26mph	W
10/15/2019	1400	Redstone	6160	53	38%	9G16 mph	SSE
10/15/2019	**1350**	**On-Site Ob**		**54**	**39%**	**4G7 mph**	**Var (SE)**

Note: On-site observation is measured at eye-level

The position and western extent of the stationary front is illustrated in Figure 5.16, which was produced using ArcGIS and weather observation (including onsite) in the area, as shown in Table 2. Additionally, other analysis tools were used, including the upper air sounding from Denver (KDNR) on the morning of October 15, 2019 (Figure 5.17). The Denver (KDNR) upper air sounding provided further evidence of a boundary along the eastern slopes of the Front Range, with easterly flow near the surface along with a low-level frontal inversion (cold air at the surface, capped by a warm layer).

Figure 5.16: Frontal Analysis for 1400 hrs, October 15, 2019. Corresponding surface observations indicate the boundary pushing back into (westward) the Elkhorn Unit #4, indicative of the increase in RH and wind shift.

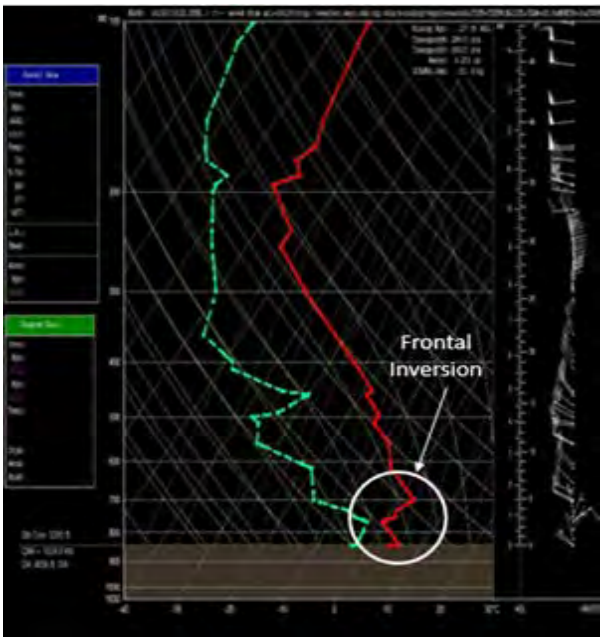


Figure 5.17. KDNR (Denver) for October 15, 2019 (12Z). The temperature (red line), dewpoint temperature (green line) and wind profile (wind barbs) are displayed.

Images taken on October 15 near the fire-line (Figure 5.18) reveal a wind shear (change in wind direction and/or speed with height) environment, with easterly flow near the surface and westerly flow above the surface. The shear environment is commensurate with low-level frontal boundaries that frequent the Front Range.

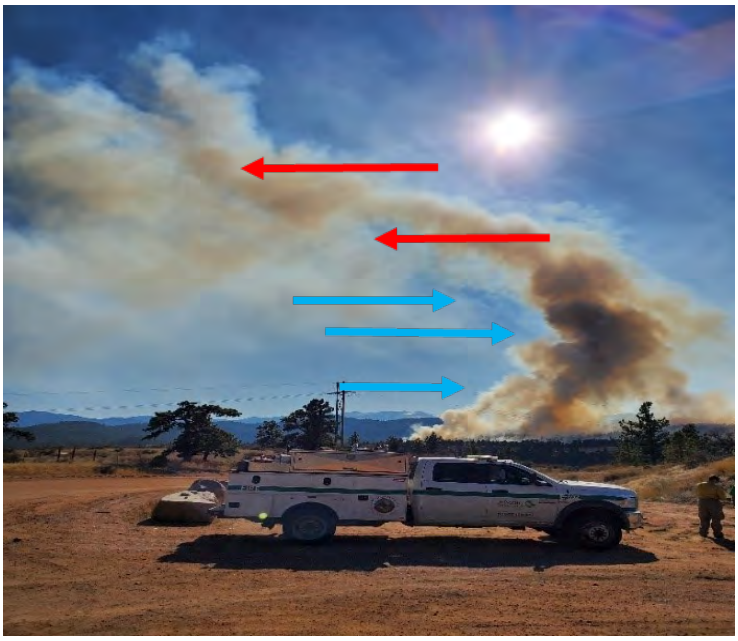


Figure 5.18: Smoke column behavior looking south. Smoke column behavior indicative of a wind shear profile associated with shallow frontal boundary in the area. Photo taken on October 15, 2019 at 1441 hrs.

On Day 2, dry and breezy conditions developed during the early morning hours, likely related to the upper air high pressure moving into the area and associated warm front passage through the Elkhorn Creek Unit #4, as the stationary front and upper trough weakened and exited east. The Red Feather RAWS recorded a sharp drop in RH values (from 59% to 24%) during the overnight hours, along with increased wind speed (gusts to 21 mph).

Importantly, the FEMO Summary Report supports this weather transition on the Elkhorn Creek Unit #4, stating *"consistently strong winds beginning around 0430 that calmed by 0930".*

Using identical methodology as the October 15th analysis, surface observations and ArcGIS provided a refined depiction of surface conditions and a timeline for October 16, 2019. Figure 5.19 is an illustration of the leading edge of warmer and drier air (warm front) migrating through the Elkhorn Creek Unit #4 area during the early morning hours (prior to 0600 hrs.). The Denver (KDNR) upper air sounding (Figure 5.20) shows a low-level nighttime/radiation inversion, at least over Denver. Considering observed surface conditions, elevation differences between Denver and Elkhorn Creek Unit #4, and characteristics of the early morning sounding, the unit likely started the operational period with no or weak inversion conditions, further expanding the burn window for the day (the period of the day when environmental factors support independent spread of fire).

Figure 5.19: A warm frontal boundary (depicted by the red line) had moved east of the Elkhorn Unit #4 during the early morning hours of October 16, 2019. FEMO observation at 0945 measured an RH of 20%.

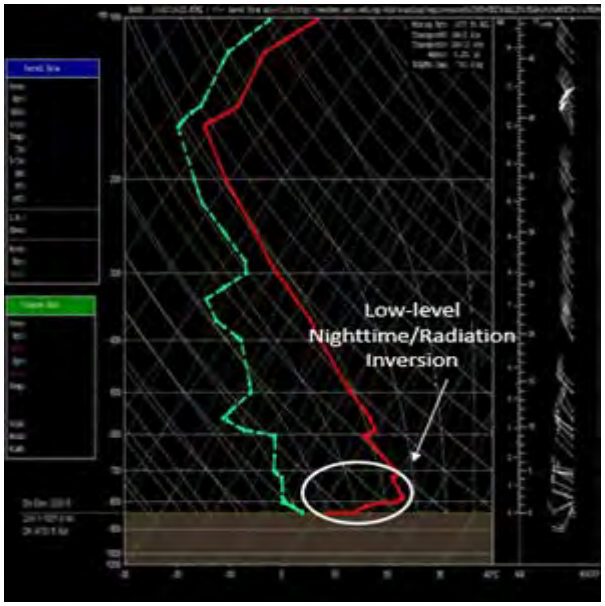


Figure 5.20: KDNR (Denver) for October 16, 2019 (12Z). The temperature (red line), dewpoint temperature (green line) and wind profile (wind barbs) are displayed..

Table 3. below compares 0945 hrs on-site observation for Day 2 against Red Feather and Redstone RAWS measured at 1000 hrs. All observations provided in the table exhibit warm and dry conditions starting the Day 2 operational period. The on-site observations taken at 0945 hrs yielded a dry-bulb temperature of 56 °F and RH of 20%, which was approximately 10 degrees warmer and 23% drier that the previous day for around the same time (The first on-site measurement was at 1045 hrs on the 15th vs. 0945 hrs on the 16th, therefore the differences could have been more). Though winds were light on the unit at the time, Red Feather RAWS was already experiencing 20-ft wind gusts to 15 mph.

Table 3. October 16, 2019 0945 On-Site Observation Compared to 1000 Red Feather RAWS and Redstone RAWS.

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1000	Red Feather	8233	51	20%	4G15mph	WSW
10/16/2019	1000	Redstone	6160	54	33%	3G6 mph	N
10/16/2019	**0945**	**On-Site Ob**		**56**	**20%**	**Light**	**W**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1100	Red Feather	8233	55	17%	8G18mph	W
10/16/2019	1100	Redstone	6160	61	27%	1G5 mph	NNW
10/16/2019	**1050**	**On-Site Ob**		**62**	**17%**	**2G8 mph**	**Terrain**

Note: On-site observation is measured at eye-level. RH 14% at test fire time of 1120.

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1200	Red Feather	8233	58	15%	11G25mph	WSW
10/16/2019	1200	Redstone	6160	65	19%	2G5 mph	S
10/16/2019	**1200**	**On-Site Ob**		**62**	**14%**	**2G6 mph**	**WSW**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1330	Red Feather	8233	61	14%	13G29mph	WSW
10/16/2019	1330	Redstone	6160	71	13%	5G7 mph	SSE
10/16/2019	**1330**	**On-Site Ob**		**65**	**14%**	**2G8 mph**	**W**

***Note: On-site observation is measured at eye-level,* Cloud cover decreased at 1350**

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1430	Red Feather	8233	65	12%	11G27mph	WSW
10/16/2019	1430	Redstone	6160	67	16%	6G9 mph	SE
10/16/2019	**1430**	**On-Site Ob**		**70**	**13%**	**4G10 mph**	**W**

***Note: On-site observation is measured at eye-level,* Gust at eye-level of 23 mph on ridgetop**

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1530	Red Feather	8233	65	11%	13G31mph	WSW
10/16/2019	1530	Redstone	6160	74	14%	6G12 mph	SE

Note: No on-site observation measured. Wildfire declared at 1545-1600

As the day progressed, warmer, drier, and windier conditions developed, with these environmental factors peaking during the afternoon hours. On-site observations from late morning until that last reading at 1430 showed decreasing clouds, dry-bulb (DB) temperatures increasing to 70, relative humidity decreasing to 13%, and eye-level wind gusting to 23 mph on the ridgetop (more exposed location). Around the same time, the Red Feather RAWS (located 5.5 miles to the northwest) measured 20-ft wind gusts over 30 mph.

The Denver (KDNR) upper air sounding (Figure 5.21) for the afternoon of October 16, 2019 (image dated October 17, 2019 00Z), provides further insight in the vertical structure of temperature, dewpoint temperature (atmospheric moisture), and wind, and the changes that ensued from the afternoon of Day 1- October 15th (dated October 16, 2019 00z) in cyan vs. Day 2- October 16th (dated October 17, 2019 00z) in Red. Specifically, the afternoon sounding on October 16th shows approximately 20°F increase in temperature and 3-5°F decrease in dewpoint temperature below 700mb (approximately 10,000-ft MSL) compared to airmass conditions on October 15th. Finally, low-level wind profile comparisons correspond well to changes conveyed in on-site observations with a variable or easterly component wind flow on Day 1, giving way to westerly flow on Day 2. Bottom line, airmass and wind changes were considerable during the 36-hour period from Day 1 operations to Day 2 operations.

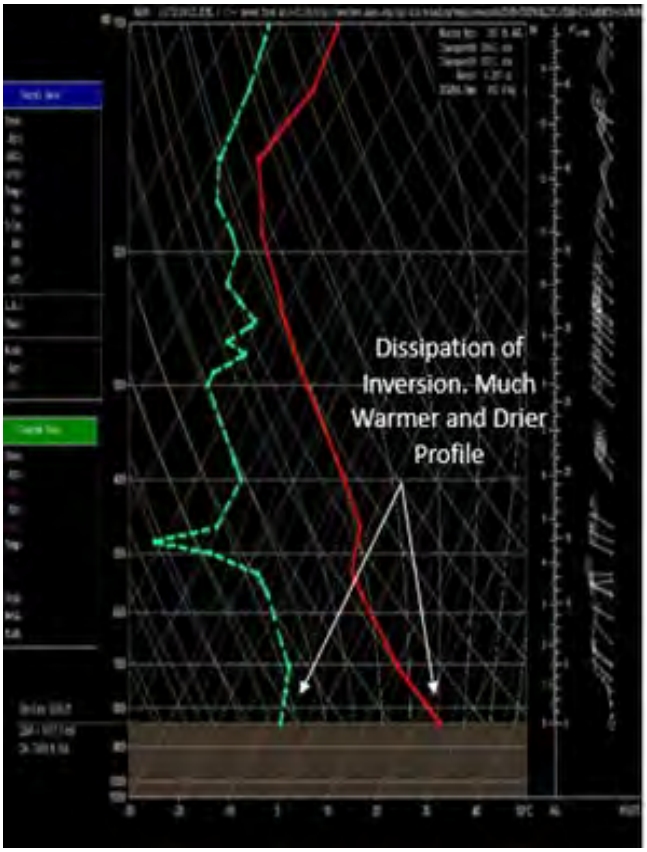


Figure 5.21: KDNR (Denver) for October 17, 2019 00Z. The temperature (red line), dewpoint temperature (green line) and wind profile (wind barbs) are displayed.

Smoke from a prescribed fire or wildfire, is an excellent visual indicator for estimating factors that are impacting the fire environment. These factors include atmospheric stability, and wind speed and direction. Images of the smoke column and deduced smoke behavior on the afternoon of October 16 are revealing of the wind profile present. Figure 5.22 is an image taken on October 16, around 1520 hrs. The smoke behavior seen in the photo is characteristic of a wind driven fire, with the smoke column being sheared by strong winds (smoke remaining near the ground surface).

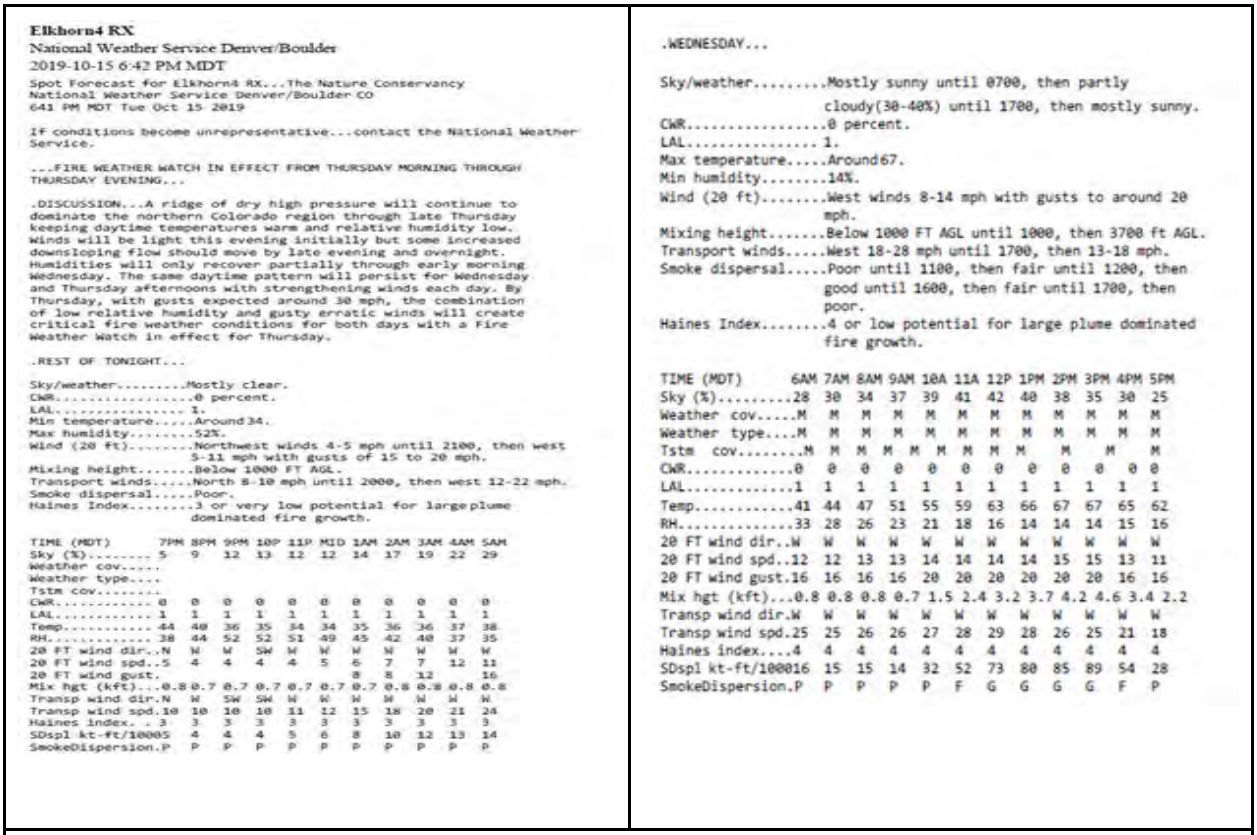
Figure 5.22: Photo of the Elkhorn Creek Unit #4 at 1520 on October 16, 2019. Smoke column is being sheared off by strong westerly flow.

Furthermore, supporting meteorological data, spot weather forecasts, the ECU4 Rx Fire Plan, fire behavior, and information gathered during the interview process required a more comprehensive evaluation of wind (observed and forecast), related to the Day 2 operational period.

The spot weather forecast for the Day 2 operational period was requested and received the evening prior (1841 hrs., October 15, 2019) and again on the morning of ignitions (0711 hrs. October 16, 2019) (Figures 5.23 and 5.24). Discussion between the Burn Boss and Burn Boss Trainee regarding the wind forecast versus values outlined in the ECU Rx Fire Plan occurred during the evening planning meeting on October 15 and morning of October 16. The interview process revealed that both the Burn Boss and Burn Boss Trainee evaluated the 20-ft wind forecast as being on the "high end" of the burn, as outlined in the Plan. However , the *20-ft sustained wind forecast* from the evening of October 15 and morning of October 16 (for Day 2) were "West winds 8-14 mph" and "West winds 9-15 mph", respectively. Both of these forecast 20-ft sustained wind speed ranges fall within the "Low" or "Preferred" categories outlined in the Plan, and not the "High" end as expressed in the interviews. Both spot weather forecasts also provided a *20-ft wind gust forecast* of "around 20 mph" but the ECU4 Rx Fire Plan did not establish any 20-ft wind gust breakpoints. From this it appears that the Burn Boss and Burn Boss Trainee (among other fireline personnel) did not decipher between 20-ft sustained wind and 20-ft wind gusts. They were incorrectly treated as one and the same.

Importantly, midflame wind speed was not a part of the ECU4 Rx Fire Plan either. Though it may not be required as part of the Plan, eye-level (midflame) wind is measured consistently on prescribed fires and wildfires. It is evident fireline personnel did not translate between eye-level (midflame) wind speed and 20-ft wind speed provided in the spot weather forecasts, with the vast majority of the interviewees considering the 23 mph eye-level (midflame) wind gust speed measured on the ridgetop around 1430 hrs as in line with the spot weather forecast 20-ft wind gust speed of “around 20 mph” (Figures 5.23 and 5.24). Unfortunately, this was not the case. In fact, as already discussed, 20-ft wind gusts at the Red Feather RAWS was over 30 mph. It is plausible that on-site 20-ft wind gusts also exceeded 30 mph, and possibly much higher if one considers the wind adjustment factors between 20-ft wind and midflame wind speed. The combination of on-site observations, wind adjustment factors, and 20-ft wind gust speed from fixed stations also raises questions regarding the accuracy of the forecast, at least in terms of gust speeds.

Finally, the shortcomings of the ECU4 Rx Fire Plan fire weather breakpoints that established the “Low”, “Preferred”, “High”, and “Out” categories, as already discussed, are equally tangible findings. A very generalized approach when determining weather climatology to formulate fire weather breakpoints to meet objectives, diminishes the effectiveness of a prescribed fire plan.



Elkhorn4 RX
National Weather Service Denver/Boulder
2019-10-15 6:42 PM MDT

Spot Forecast for Elkhorn4 RX...The Nature Conservancy
National Weather Service Denver/Boulder CO
641 PM MDT Tue Oct 15 2019

If conditions become unrepresentative...contact the National Weather Service.

...FIRE WEATHER WATCH IN EFFECT FROM THURSDAY MORNING THROUGH THURSDAY EVENING...

.DISCUSSION...A ridge of dry high pressure will continue to dominate the northern Colorado region through late Thursday keeping daytime temperatures warm and relative humidity low. Winds will be light this evening initially but some increased downsloping flow should move by late evening and overnight. Humidities will only recover partially through early morning Wednesday. The same daytime pattern will persist for Wednesday and Thursday afternoons with strengthening winds each day. By Thursday, with gusts expected around 30 mph, the combination of low relative humidity and gusty erratic winds will create critical fire weather conditions for both days with a Fire Weather Watch in effect for Thursday.

.REST OF TONIGHT...

Sky/weather.....Mostly clear.
CWR.....0 percent.
LAL.....1.
Min temperature.....Around 34.
Max humidity.....52%.
Wind (20 ft).....Northwest winds 4-5 mph until 2100, then west 5-11 mph with gusts of 15 to 20 mph.
Mixing height.....Below 1000 FT AGL.
Transport winds.....North 8-10 mph until 2000, then west 12-22 mph.
Smoke dispersal.....Poor.
Haines Index.....3 or very low potential for large plume dominated fire growth.

TIME (MDT)	7PM	8PM	9PM	10P	11P	MID	1AM	2AM	3AM	4AM	5AM
Sky (%).....	5	9	12	13	12	12	14	17	19	22	29
Weather cov.....											
Weather type....											
Tstm cov.....											
CWR.....	0	0	0	0	0	0	0	0	0	0	0
LAL.....	1	1	1	1	1	1	1	1	1	1	1
Temp.....	44	40	36	35	34	34	35	36	36	37	38
RH.....	38	44	52	52	51	49	45	42	40	37	35
20 FT wind dir..	N	W	W	SW	W	W	W	W	W	W	W
20 FT wind spd..	5	4	4	4	4	5	6	7	7	12	11
20 FT wind gust.							8	8	12		16
Mix hgt (kft)...	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8
Transp wind dir.	N	W	SW	SW	W	W	W	W	W	W	W
Transp wind spd.	10	10	10	10	11	12	15	18	20	21	24
Haines index..	3	3	3	3	3	3	3	3	3	3	3
SDspl kt-ft/1000	5	4	4	4	5	6	8	10	12	13	14
SmokeDispersion.	P	P	P	P	P	P	P	P	P	P	P

.WEDNESDAY...

Sky/weather.....Mostly sunny until 0700, then partly cloudy(30-40%) until 1700, then mostly sunny.
CWR.....0 percent.
LAL.....1.
Max temperature.....Around 67.
Min humidity.....14%.
Wind (20 ft).....West winds 8-14 mph with gusts to around 20 mph.
Mixing height.....Below 1000 FT AGL until 1000, then 3700 ft AGL.
Transport winds.....West 18-28 mph until 1700, then 13-18 mph.
Smoke dispersal.....Poor until 1100, then fair until 1200, then good until 1600, then fair until 1700, then poor.
Haines Index.....4 or low potential for large plume dominated fire growth.

TIME (MDT)	6AM	7AM	8AM	9AM	10A	11A	12P	1PM	2PM	3PM	4PM	5PM
Sky (%).....	28	30	34	37	39	41	42	40	38	35	30	25
Weather cov.....	M	M	M	M	M	M	M	M	M	M	M	M
Weather type....	M	M	M	M	M	M	M	M	M	M	M	M
Tstm cov.....	M	M	M	M	M	M	M	M	M	M	M	M
CWR.....	0	0	0	0	0	0	0	0	0	0	0	0
LAL.....	1	1	1	1	1	1	1	1	1	1	1	1
Temp.....	41	44	47	51	55	59	63	66	67	67	65	62
RH.....	33	28	26	23	21	18	16	14	14	14	15	16
20 FT wind dir..	W	W	W	W	W	W	W	W	W	W	W	W
20 FT wind spd..	12	12	13	13	14	14	14	14	15	15	13	11
20 FT wind gust.	16	16	16	16	20	20	20	20	20	20	16	16
Mix hgt (kft)...	0.8	0.8	0.8	0.7	1.5	2.4	3.2	3.7	4.2	4.6	3.4	2.2
Transp wind dir.	W	W	W	W	W	W	W	W	W	W	W	W
Transp wind spd.	25	25	26	26	27	28	29	28	26	25	21	18
Haines index....	4	4	4	4	4	4	4	4	4	4	4	4
SDspl kt-ft/1000	16	15	15	14	32	52	73	80	85	89	54	28
SmokeDispersion.	P	P	P	P	P	F	G	G	G	G	F	P

Figure 5.23. The spot forecast (October 15, 2019 @ 1841 hrs) for the ECU4 Rx Fire provided by the National Weather Service Office in Boulder, Colorado.

Elkhorn4 RX

National Weather Service Denver/Boulder

2019-10-16 7:11 AM MDT

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Spot Forecast for Elkhorn4 RX...The Nature Conservancy
National Weather Service Denver/Boulder CO
711 AM MDT Wed Oct 16 2019

If conditions become unrepresentative...contact the National Weather
Service.

...FIRE WEATHER WATCH IN EFFECT FROM THURSDAY MORNING THROUGH
THURSDAY EVENING...

.DISCUSSION....A dry northwesterly flow today will bring breezy
conditions with very low humidity. Temperatures will be warmer
today, despite the high clouds that will be present. Smoke
dispersion will become good by 11 AM to Noon.

Fire danger is expected to increase on Thursday as southwest flow
aloft increases. At this time, it appears the stronger winds won't
arrive until mid to late afternoon. However, humidities will be
very low so a Fire Weather Watch is in effect for Thursday. Friday
will likely feature windy conditions but cooler temperatures and
higher humidity.


.REST OF TODAY...

Sky/weather.........Mostly cloudy(60-65%) until 1100, then partly
                    cloudy(40-50%).
CWR.................0 percent.
LAL.................1.
Max temperature.....Around 67.
Min humidity........12%.
Wind (20 ft)........West winds 9-15 mph with gusts to around 20
                    mph.
Mixing height.......3800 ft AGL.
Transport winds.....West 22-32 mph until 1700, then 16-21 mph.
Smoke dispersal.....Poor until 1100, then fair until 1200, then
                    good until 1400, then very good until 1600,
                    then good until 1700, then poor.
Haines Index........4 or low potential for large plume dominated
                    fire growth.
```

Figure 5.24. The spot forecast (October 16, 2019 @ 0711 hrs) for the ECU4 Rx Fire provided the National Weather Service Office in Boulder, Colorado.

Fire Weather Conclusions:

A weak and sporadic monsoon circulation resulted in inadequate moisture across Colorado during the late summer of 2019. The drier than average conditions, combined with frequent episodes of

wind and low humidity that frequented the area from early September into mid-October exacerbated the drying of fuels, and further minimized the benefits of rain and snow that fell on the Elkhorn Creek Unit #4 during the late summer and early fall period. In addition to climatology from the Red Feather RAWS, the Evaporative Demand Drought Index (EDDI) provided another perspective of how warm, dry and windy conditions were leading up to implementation of the project.

Importantly, to simply state that warm, dry, and windy conditions were key weather factors that led to the ECU4 Rx Fire escape, over simplifies and dilutes lessons learned. Evaluation of weather elements begin with a burn plan that represents a prescribed fire unit based on the best data and/or science available. Other meteorological parameters that could of been included in the ECU4 Rx Fire Plan's "Low", "Preferred", "High", "Out" categories, or at least evaluated as part of implementing the Plan, include 20-ft wind gust speeds, midflame sustained wind speed, midflame wind gust speed, and MinRH. *However, this additional meteorological data is insufficient as part of a prescribed fire plan unless it's a result of a thorough assessment of climate and weather data using known standards, practices, and fire weather stations that are specific to fire behavior calculations.* Assuming these meteorological standards are met when developing the plan, it's imperative that fire weather elements are consistent with measurement practices that will be utilized during operations. For example, if known 20-ft sustained wind speed are established as part of the plan, then the 20-ft sustained wind speed should be measured on-site, or fireline personnel should be able to convert eye-level sustained wind speed to the 20-ft wind speed by applying the WAF. Either way, consistent measurement practices allows for a reliable comparison and monitoring of weather outlined in the Plan versus what is occurring on the ground.

Finally, a more thorough evaluation of localized weather conditions by the NWS and fireline overhead may improve forecasts for the area in the future. The forecast for the Day 1 operational period does provide variability in wind speed and direction (which occurred), however there is no mention of impacts from the frontal boundary and increase in RH in the afternoon, and there was no communication or collaboration with the NWS initiated by the Burn Boss or Burn Boss Trainee. Additionally, the spot weather forecast for the Day 2 operational period underestimated 20-ft wind gust speeds by at least 10 mph. The Burn Boss and Burn Boss Trainee identified the gust speed in the spot weather forecast as being on the "high end" of the prescription on the evening before and the morning of Day 2. Evaluation of local observations and consultation with the NWS may have provided valuable insight for the "Go/No Go" decision.

5.3. Fuel Conditions

A light snowfall occurred on October 10th and 11th, and both the Burn Boss and Burn Boss Trainee identified that this put them at ease regarding fuel dryness in the area. Indeed, on October 15th there were still snow patches present on North aspects during operations in Unit 4a. However, the overall amount of moisture provided by this snow was only 0.10- 0.12 inches (from to 2-3 inches of snow), yet it limited the ability of TNC to collect fuel moistures before implementation.

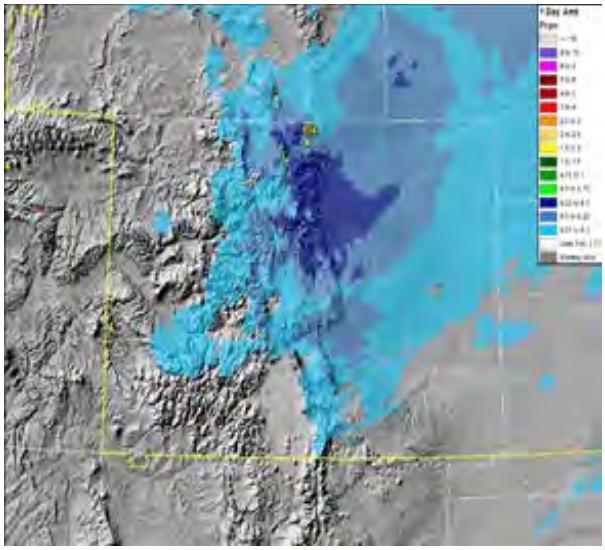


Figure 5.25: Precipitation Analysis for 10/10-11/2019-5-6 Day Prior to Burn

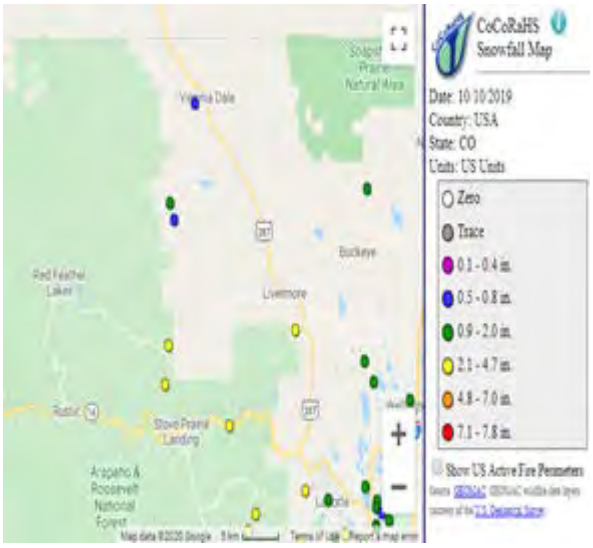


Figure 5.26: CoCoRaHS Snowfall Map for 10/10/2019-5-6 Day Prior to Burn

Fuel moisture sampling is not advisable within the first 24 hours after a precipitation event because fuel moisture levels are typically significantly elevated during that time and not representative of fuel conditions later on. With snow on the ground until October 12th, the earliest possible date fuel moistures could have been sampled was October 13th with results available the next day, but other logistical needs trumped the collection of fuel moisture samples and they were not taken.

Numerous interviewees mentioned that fuel moistures taken by the Arapaho-Roosevelt National Forest at the Red Feather fuel moisture monitoring site were used as a proxy. Relevant information available at the time of October 15th is shown below from Red Feather fuel moisture sampling site on the National Fuel Moisture Database.

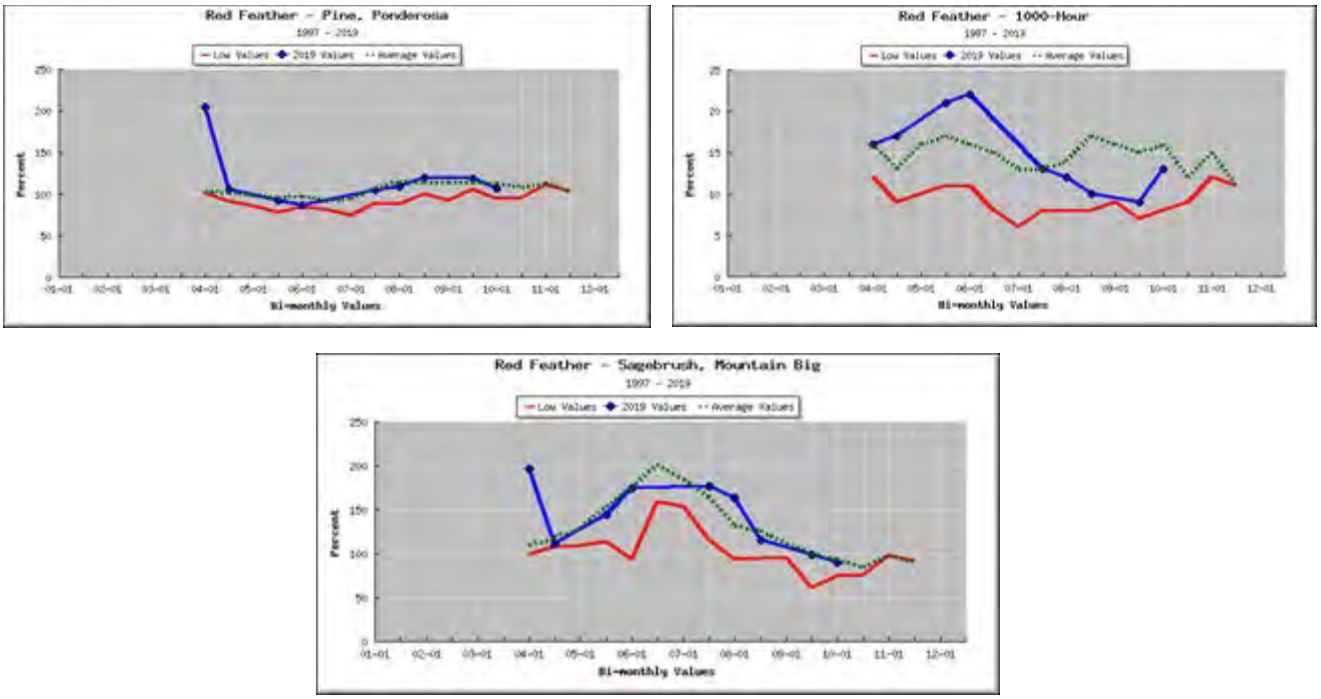


Figure 5.27: Fuel moisture levels recorded by the Arapaho-Roosevelt National Forest at the Red Feather fuel moisture monitoring site.

For October 1, the Red Feather fuel moisture monitoring site reported the observed dead fuel moisture of 1000-hour timelag fuels at 13%, while ponderosa pine live foliar moisture was 107%, and Mountain Big Sagebrush live foliar moisture was 90%, all near average values for the time of year.

While Red Feather fuel moistures were near seasonal averages, none of the species or sizes sampled were directly incorporated in the fire behavior prescription element of the Prescribed Fire Plan. Further, visual evidence shows that live herbaceous fuels (grasses) were fully cured, as were live woody fuels (shrubs). These two fuels, in addition to fine dead fuels (1-hour timelag) were the most critical fuel moistures to fire behavior on the ECU4 Rx Fire project.

Minimum temperatures in the area dropped below freezing on September 22, and from October 2 to October 7, with hard freezes below 15°F occurring on October 10 and 11. These successive freezing events completely cured herbaceous fuels in the area (resulting in 30% live herbaceous moisture content), which is evident from photographs of the prescribed fire. See Figure 5.28 below. While 30% implies that there is some moisture left in the live herbaceous fuels, for the purposes of fire behavior calculations, it means the fuel is to be treated as dead fuel. Indeed, in many surface fire behavior fuel models (including GR2 and TU1, the surface fuel models selected in the ECU4 Rx Fire Plan) the entire live herbaceous load is transferred to a dead herbaceous fuel loading category (called a dynamic fuel model) and the moisture from a dead one-hour timelag fuel is used in calculations.

Given the mid-October implementation of the project, seasonal senescence had occurred on many woody shrub species, resulting in leaf fall and dormancy, also evident from photographs (Figure 5.28). Therefore, live woody fuel moistures can be represented as 60% during the implementation of the ECU4 Rx Fire.

Figure 5.28: October 15, 2019 on-site photo showing cured grasses.

Fuel moisture forecasts from the NWCG's Weather Information Management System (WIMS) also provide insight into fuel conditions during the project. The Fort Collins Interagency Dispatch Center provides daily WIMS indices for numerous Remote Automated Weather Stations (RAWS) on their website during fire season, including on October 15th and 16th, 2019. While these values are not measured, they are interpolated from National Fire Danger Rating System models.

WIMS forecast fuel moistures for October 15 and 16, 2019 are shown in Table 4 below. WIMS Forecast data is shown rather than observed values because that is what would have been available to fire personnel at the time of implementation.

Table 4. WIMS Forecast Fuel Moisture Values at Red Feather RAWS, fuel model 7G2P2.

Date	1-hour dead fuel moisture	10-hour dead fuel moisture	100-hour dead fuel moisture	Live herbaceous moisture	Live woody moisture
10/15	3.91	4.26	6.98	30.7	92.2
10/16	3.36	5.1	6.88	3.4*	89
*WIMS processing allows live herbaceous moistures to drop below 30%, while fire behavior processors treat 30% and lower live herbaceous moisture as a fully cured dead fuel.					

While WIMS values are available throughout the year on the Fort Collins Interagency Dispatch Center's website, a more common method to determine 1-hour fuel moisture in the field is to reference site-specific weather forecasts or on-site observations to the NWCG "lookup tables" to determine fine dead fuel moisture level and probability of ignition. The FEMOs on-site during the ECU4 Rx Fire were responsible for looking up and reporting the hourly fine dead fuel moisture and probability of ignition. Their observations are shown below in Table 5.

Table 5. Weather observations, fuel moisture levels, PIG, and notes recorded by FEMOs.

Date	**Time**	**Dry Bulb**	**RH (%)**	**Winds (MPH)**	**% Cloud Cover**	**Fine Dead Fuel (unshaded/shaded %)**	**Prob. Of Ignition (unshaded/ shaded %)**	**Notes**
10/15	1045	46	43	3(5), NE	1	9/12	30/20	
10/15	1140	54	18	7(13), SSW	1	5/7	60/40	
10/15	1300	60	11	5(10), var W	1	3/6	80/50	
10/15	1350	54	39	4(7), var SE	1	7/10	40/30	
10/15	1500	54	38	3(8), ENE	1	7/10	40/30	
10/15	1600	50	40	3(6), E	1	8/11	40/20	
10/15	1700	48	43	2(6), SSE	0	9/11	30/20	
10/16	0945	56	20	Light, W	80	6/8	50/40	
10/16	1050	62	17	2(8), terrain-driven	70	5/7	60/40	RH of 14% recorded at 1120 at test fire location
10/16	1200	62	14	2(6), WSW	80	3/6	80/50	
10/16	1330	65	14	2(8), W	70	3/6	80/50	Cloud cover reduced at 1350
10/16	1430	70	13	4(10), W	40	3/6	80/50	Gusts of 23 MPH recorded on ridgetop

A final source of information about fuel conditions comes from the spot weather forecasts provided by the National Weather Service's Boulder Weather Forecast Office for the ECU4 Rx Fire. Using the maximum temperature and minimum relative humidity from the spot forecasts and the field lookup tables, fine dead fuel moisture are determined as 5% on October 15th, and 3% on October 16th.

Key Fuels Takeaways:

- Live fuel moistures were within prescription on October 15th and 16th.
- Given the cured state of grasses, and their role as the primary carrier of fire, fine dead fuel moisture is critically important to determining fire intensity and rates of spread as well as suppression capabilities.
- Fuel moistures at Red Feather fuel sampling site were representative of on-site conditions, but the types sampled are not of categories that are incorporated into surface fire behavior models.
- WIMS forecast dead fuel moistures were lower than values identified by the prescription on October 15th and 16th.
- Spot weather forecasts indicated a fine dead fuel moisture of 5% on October 15th and 3% on October 16th.
- Surface Fire Behavior Fuel Model GR2 (used in the ECU4 RX Fire Plan) is completely composed of 1 hour and live herbaceous fuels. When curing of herbaceous fuels occurs, the fuel model treats all live fuel loading the same as if it were dead, exponentially increasing fire intensity and rate of spread.
- All live herbaceous fuels and woody fuels were dormant, both from seasonal patterns as well as from multiple freezing events in the weeks prior to ignition.

5.4. Fire Behavior

On October 16th at 1121 hrs, a test fire was initiated southwest of DP-30, producing flame lengths from 1-3 ft with rates of spread of 14 chains per hour (approximately 2 mph) in grass. Given the seasonality of the ECU4 Rx Fire, a later test fire time is unsurprising due to the significantly smaller amount of daylight in October than in summer. Once main ignitions began, flame lengths of 3-6 ft were observed in brush with single tree torching of junipers. Cloud cover was substantially higher than the previous day until mid-afternoon. Throughout the day, fire behavior slowly increased until around 1345 hrs, when cloud cover significantly decreased. The increase in sun exposure led to an uptick in fire behavior across the unit. Fire intensity increased, with flame lengths from 6-8 ft in brush, with rates of spread above 20 chains per hour (0.25 mph) observed in grass. Backing fire intensity and rate of spread increased downhill from the Alpha firing team's ignitions, and fire would back down in grasses and then flank to the east with strong west winds. Torching was observed in mature ponderosa pine around 1430 hrs.

Figure 5.29: October 16, 2019 on-site photo showing test fire.

Figure 5.30: October 16, 2019 on-site photo showing fire behavior.

Figure 5.31: October 16, 2019 on-site photo showing Zulu firing personnel.

As fire intensity began to increase, additional fire was put down by a number of firing groups in order to bring the fire to control features. The firing between the ridgeline and the north boundary was initiated in order to more rapidly finish ignitions in Unit 4b, but wasn't anchored to either a previously burned area or a control feature. This firing operation likely led to the initial spot near DP-30, either from a wind driven surface fire or from torching of a small tree closer to the test fire site.

The Alpha division's initial ridgetop firing was similarly unanchored, and fire was allowed to move on its own downslope to the south, then be influenced by open winds and pushed east, then move back upslope into a previously burned area. As it continued this general pattern, it eventually worked its way into an area of beetle-killed ponderosa pine that had fallen down. As fire slowly worked into this area, the Zulu Firing Boss Trainee observed an increase in overall fire intensity, but was eventually blocked by smoke and terrain as they continued their ignitions.

Blowdown near Alpha firings ridgetop on an east aspect. This area of blowdown is 1 acre in size and less than 600' from control features on the east perimeter. Imagery from Google Earth.

Figure 5.32: Google Earth imagery showing blowdown pocket within Unit 4b.

The two spot fires that led to the eventual wildfire declaration were likely generated from this area of blowdown. BEHAVE Plus and FARSITE show this is the most likely spotting source. See **Appendix D (Fuels and Fire Behavior Review Report)** for additional information.

Key Fire Behavior Takeaways:

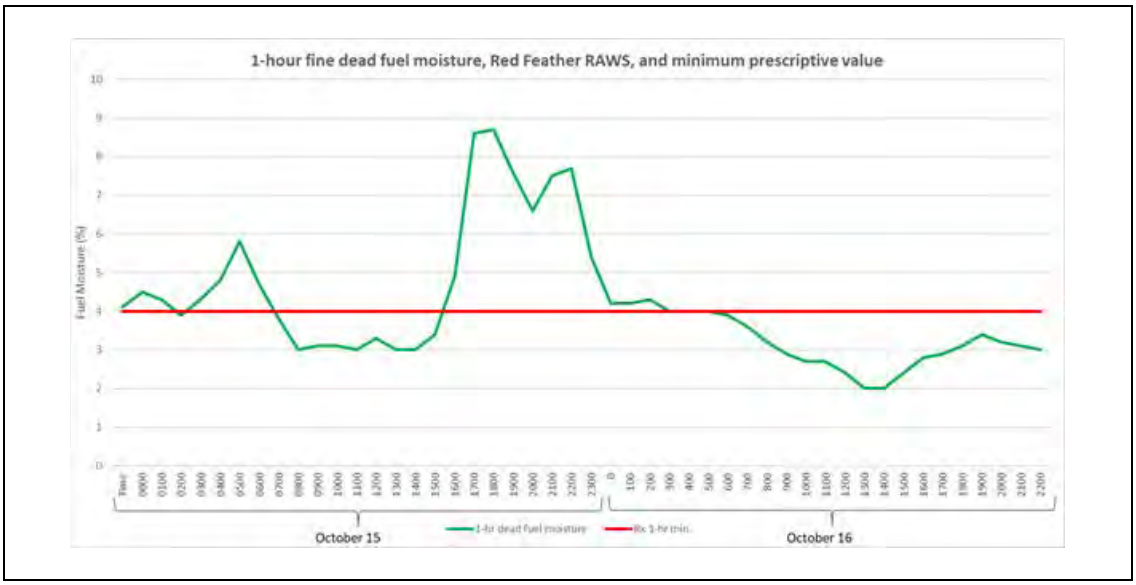
- Observed fire behavior within the unit boundaries was within prescriptive ranges on both October 15th and October 16th, including single tree torching, wind driven surface fire, and intense surface fire.
- Early cloud cover moved off the unit by the peak of the burn period.
- Interior ignitions were not anchored to previously burned areas or control features, allowing fire to spread freely with available fuels, wind, and terrain.
- Blacklining from DP-30 to DP-40 was checked at the band of willows along a north/south tributary of Elkhorn Creek, which allowed for the main fire to impact the dormant willows later in the burn period.
- Fuels were not available to burn until mid-morning, resulting in delays in securing lines adjacent to southwest aspects until near the peak of the burn period.
- Blackline depth ranged from 600 feet to 50 feet but was not enough to reduce spotting from interior ignitions.
- The spot fires that led to the wildfire declaration were most likely generated from an area of blowdown 600 ft west of the eastern control line at the same elevation as the spot fire.

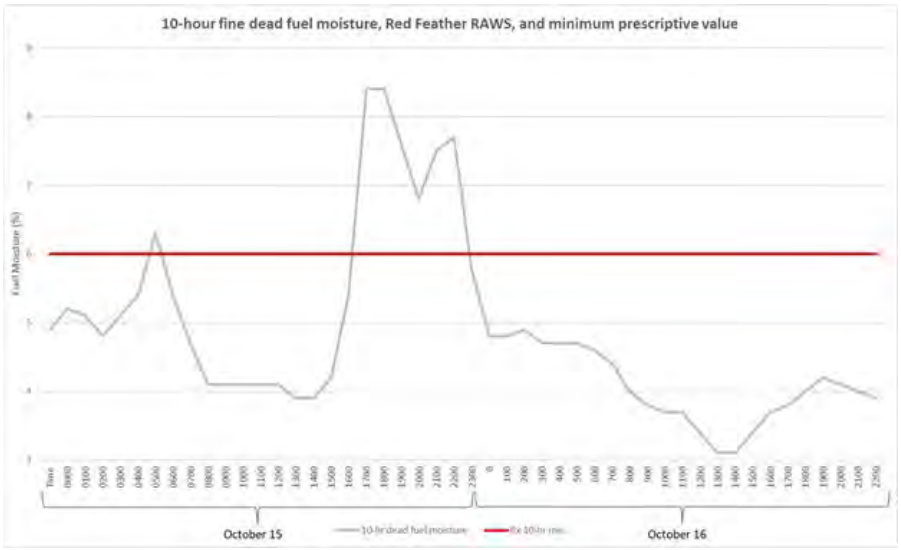
5.5. National Fire Danger Rating System

The National Fire Danger Rating System (NFDRS), in use since 1978, provides a consistent system to process weather information from Remote Automated Weather Stations (RAWS) into predictive metrics related to fire danger for the United States. The closest and most representative RAWS site is the Red Feather RAWS (050505), located at 8,216 ft elevation and approximately 5.5 miles northwest of Elkhorn Creek Unit #4.

Currently NFDRS is in the process of updating from the 1978 version ("NFDRS 1978") to the 2016 version ("NFDRS 2016), with improvements to live and dead fuel moisture calculations, but at the time of the ECU4 Rx Fire, only NFDRS 1978 outputs would have been available to personnel associated with the project. For this reason, NFDRS 1978 outputs were used for purposes of this review.

NFDRS hourly fuel moisture data for fuel model G were analyzed through FireFamily Plus to produce the charts below of calculated hourly fuel moistures of the 1, 10, and 100-hour timelag categories (Figure 5.33).





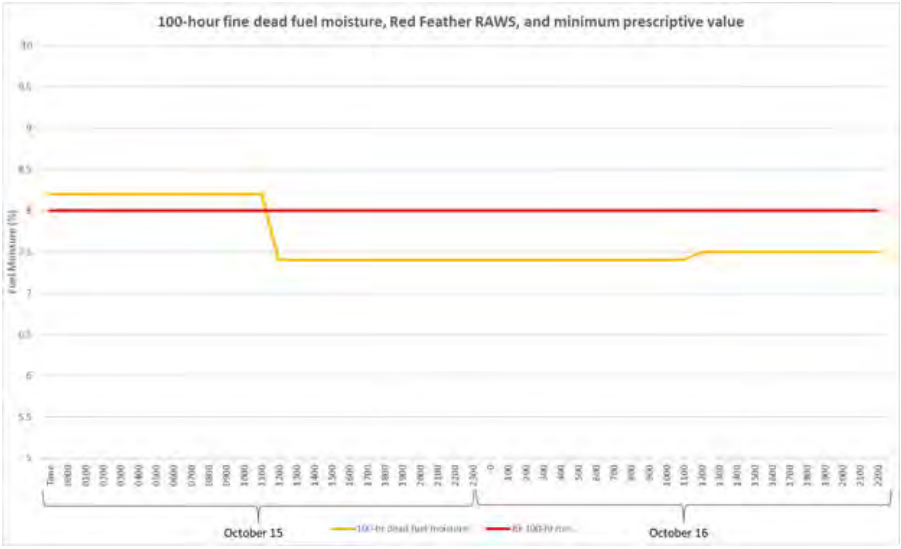


Figure 5.33: Calculated hourly fuel moistures of the 1, 10, and 100-hour timelag categories, produced using FireFamily Plus.

Locally relevant indices from NFDRS are analyzed and communicated to the field in a format called Fire Danger Pocket Cards. The Fort Collins Interagency Dispatch Center provides Fire Danger Pocket Cards for the Red Feather Lakes area using data from Red Feather RAWS from 2004-2018. This information shows Energy Release Component (ERC), a cumulative index of seasonal live and dead fuel dryness, as the index to reference for the area. The Pocket Card is shown below, with notations added (Figure 5.34).

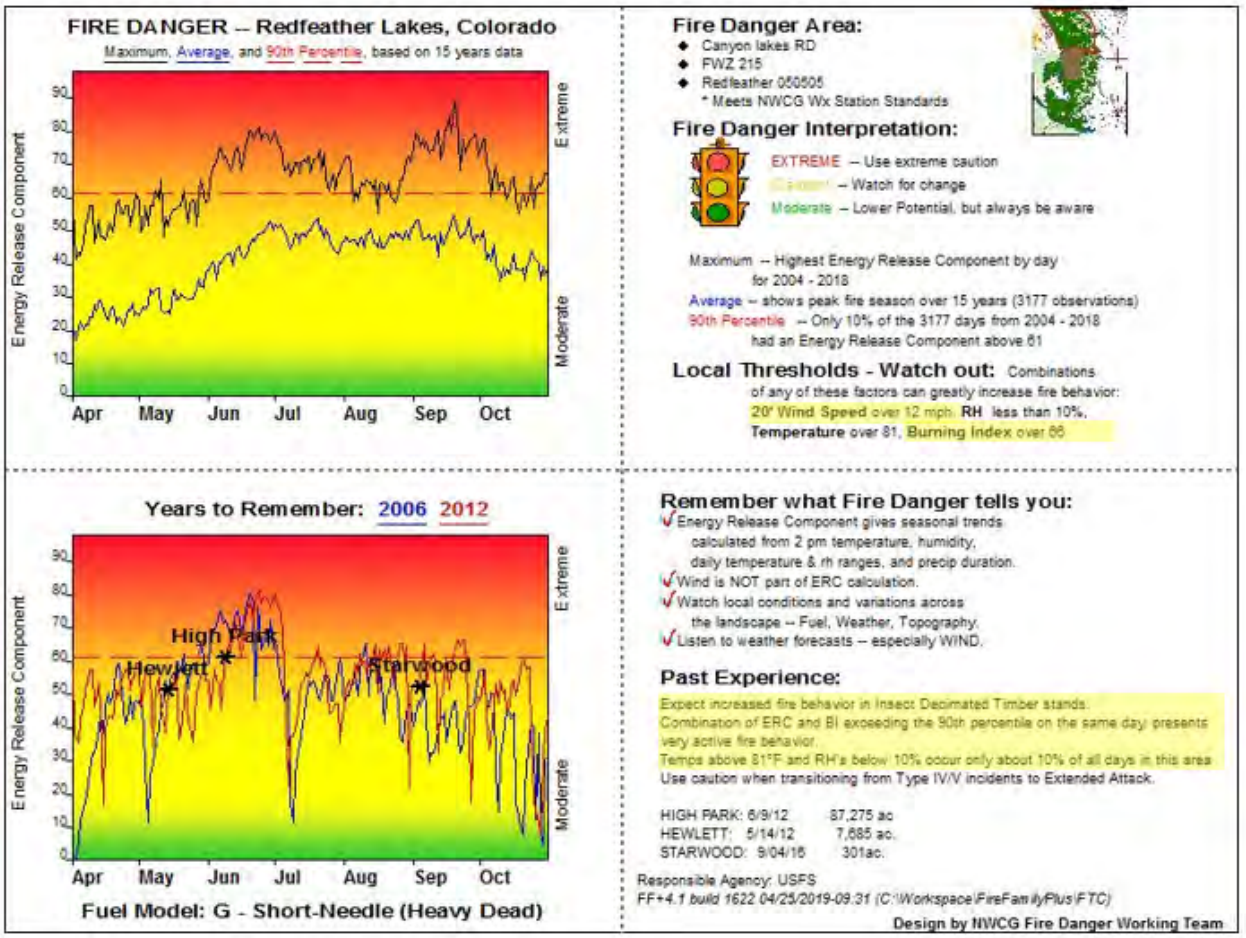


Figure 5.34: Fire Danger Pocket Card for the Red Feather Lakes area, with notations.

The Red Feather pocket card indicates that 20-ft wind speeds over 12mph and Burning Index (BI) above 66 are both local "Watch Out" thresholds. Burning Index is another NFDRS output that combines ERC with Spread Component, essentially adding the influence of wind speed to ERC. The pocket card also points out that, "…ERC and BI exceeding the 90th percentile on the same day presents very active fire behavior." For reference, the 90th percentile ERC value is 59, and the 90th percentile BI value is 66 at Red Feather RAWS from 2000-2019.

WIMS forecast and observed ERC and BI values were posted on Fort Collins Dispatch website on October 15th and 16th and are summarized in Table 6 below. Forecast values are simply predicted weather information for the day in question processed through NFDRS, and observed values are NFDRS processed values on observed weather data at the RAWS in question.

Table 6. WIMS Forecast and Observed ERC and BI.

Date	ERC Forecast	BI Forecast	ERC Observed	BI Observed
October 15, 2019	62.2	64.7	63.4	66.8
October 16, 2019	63.7	77.4	65.3	77.9

The WIMS forecast values were very similar to the observed values on both the 15th and 16th of October. On October 16th, both forecast and observed ERC and BI were above the 90th percentile, indicative of a local "Watch Out" situation.

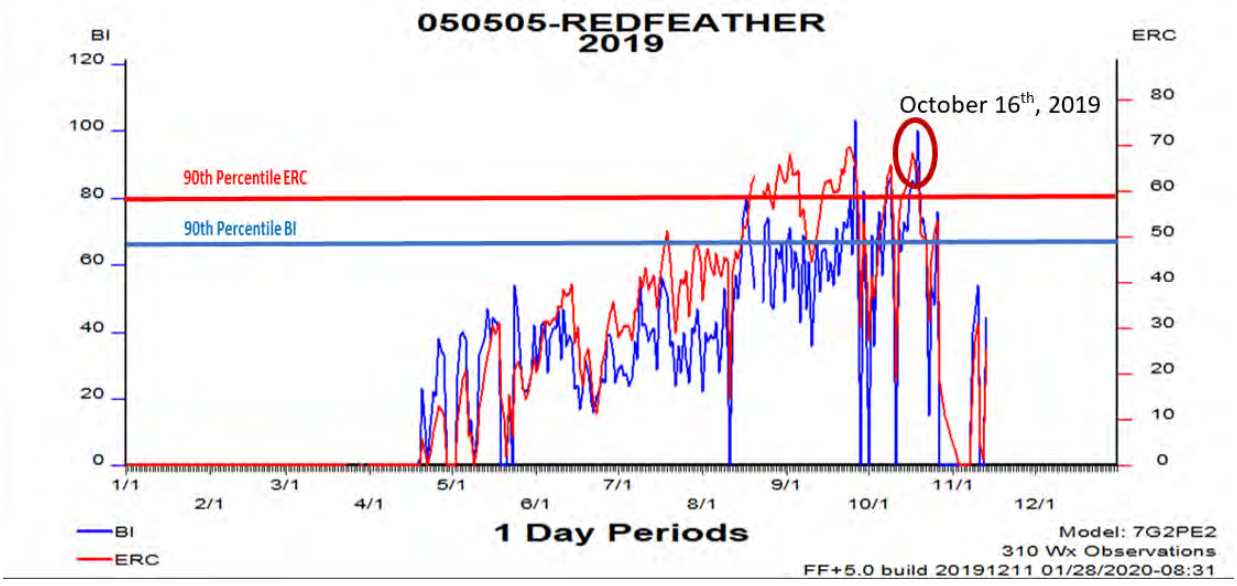


Figure 5.35: Daily ERC and BI values from Red Feather RAWS for 2019.

Shown above in Figure 5.35 is a chart of both daily ERC and BI values from Red Feather RAWS for 2019, with the 90th percentile ERC and BI levels shown as a steady line in the corresponding color. October 16th is circled in red.

Cross-referencing ERC and BI percentiles is commonly done to identify critical fire business thresholds, and this methodology can incorporate prescribed fires as well as wildfires. In Table 7 below, the ECU4 Rx Fire is compared to northern Front Range notable wildfires since 2000 in terms of ERC and BI percentiles. Percentiles are grouped into the 70th, 80th, 90th, and 97th bins, with the exception of the specific percentile values shown for October 16, 2019.

Table 7. Comparison of ERC and BI percentiles during notable fires.

Fire Name	Date	Acres Spread	ERC Percentile	BI Percentile
Bobcat	6/12/2000	10,599	97	97
Weaver Ranch	10/31/2001	1,600	80	97
Rennels	8/22/2010	327	80	80
Four Mile	9/6/2010	6,194	90	97
Reservoir Road	9/13/2010	652	97	90
Hewlett	5/15/2012	982	80	90
Hewlett	5/16/2012	4,112	80	90
High Park	6/9/2012	7,467	90	97
High Park	6/10/2012	29,492	90	97
Fern Lake	12/1/2012	1,590	90	90
Starwood	9/4/2016	301	70	80
Elk*	***10/16/2019***	***118***	***95***	***97***

**The Elkhorn Creek Unit #4 Prescribed Fire was renamed the Elk Fire after a wildfire declaration was made on October 16th. Only fire spread outside of the prescribed fire unit is shown above.*

The ECU4 Rx Fire was ignited under 95th percentile ERC's and 97th percentile BI's, well above the local Watch Out thresholds identified on the Red Feather pocket card, and under similar conditions as two of the largest fire spread days in recent history, June 9th and 10th, 2012, when the High Park Fire spread a combined 36,959 acres.

Key NFDRS Takeaways:

- Dead fuel moistures at the 1, 10, and 100-hour timelag categories were lower than values identified by the prescription between 0700-1500 hrs on October 15th, and between 0500-2300 hrs on October 16th.
    - At 1500 on October 16th, fine dead fuel moistures on site were recorded at 3%, and Red Feather RAWS estimated them at 2.4%.
    - *However, as discussed later, this does not mean that the prescribed fire was ignited outside of the prescription.*
- Pocket Cards, forecast ERC and BI, and observed ERC and BI were available on Fort Collins Interagency Dispatch's website on October 15th and 16th.
- The Red Feather Pocket Card indicates that 20-ft wind speeds above 12 mph, BI above 66, and ERC and BI above the 90th percentile are watch out situations.
- All of these criteria were met on October 16th and identified in forecast NFDRS indices and on the spot weather forecasts for October 16th.

- ERC was above the 95th percentile and BI was above the 97th percentile on October 16th, indicative of a critical fire environment in the northern Front Range.
- The area receives only 11 hours of daylight on October 16th. This shortened the burn period and reduced observed wildfire spread on October 16th.

5.6. Compliance with the Prescribed Fire Plan

The ECU4 Rx Fire was implemented consistent with the Prescribed Fire Plan. There were no actions taken that were not within the limits established by the Plan. However, as discussed in detail below, shortcomings and inconsistencies in the Plan occurred and compounded on one another all at once in a very short period of time during implementation on the second day of the project. This led to a condition where spot containment was unobtainable, which, as discussed below, the plan identified as possible but did not adequately address.

All participants interviewed stated that they placed lots of faith and trust in the burn plan and the plan preparer is highly regarded in their ability.

5.7. Prescribed Fire Plan Consistency with Policy

As a private non-governmental agency, TNC has several unique processes it must contend with in addition to state and federal guidelines. All broadcast prescribed fires should have a complexity analysis completed to subjectively gauge the relative complexity of the prescribed fire unit or units in question against the preparer's past experience and judgement. TNC utilizes a version of a complexity analysis that contains many similar elements to a state or federal analysis, but with different rankings and weightings for each element. (See **Appendix A**.) The TNC Complexity Analysis was last updated in 2007, and the plan preparer and other TNC employees have stated they use the NWCG Prescribed Fire Complexity Rating System Guide (PMS-424, July 2017) to inform their TNC complexity analyses. In addition to the complexity analysis, TNC also produces a "consequence analysis", which is similar in many respects to the complexity analysis, but focused solely on the potential consequences of the prescribed fire. As described by interviewees, the consequence analysis is informed by the complexity analysis, but is intended for a different audience (such as TNC executives, attorneys, and insurance managers) and required by TNCs liability insurance. In the case of the ECU4 Rx Fire, the consequence analysis identified that the burn had "the potential for high consequences from smoke or an escape fire," which was briefed to the TNC Colorado Executive Director on October 9, 2019 by the Burn Boss.

Any time that multiple processes are utilized to analyze the same thing, inconsistencies can begin to appear, and the complexity rating and consequence analysis of the ECU4 Rx Fire are no different. In the NWCG Complexity Rating Guide, pre-plan risks and post-plan risks are

judged against one another and inform the agency administrator of the values, hazard, and potential consequences of a prescribed fire. The TNC complexity analysis informs only post-plan values and hazards information, while the consequence analysis informs only post-plan potential consequences created by the intersection of the hazard and values. Instead of having all information necessary to make a risk-informed decision in one place, TNC prescribed fire plan preparers must instead go back and forth between two documents with two separate target audiences. Additionally, they lack the benefits of a pre-plan risk analysis which can inform specific mitigation measures in the prescribed fire plan, and serves as a baseline of risk management for prescribed fire planning.

Despite this unique consideration of TNC's prescribed fire planning process, the ECU4 Rx Fire Plan was largely consistent with TNC, DFPC, and NWCG policies, aside from different ordering and numbering of the individual elements. A summary breakdown by element is shown in Table 8 below, with areas of inconsistencies noted and their subjective importance in the outcome of the prescribed fire explained.

Table 8. Analysis of ECU4 Rx Fire Plan Elements.

Elkhorn Creek Unit #4 Prescribed Fire Plan Element	Plan Meets TNC Requirement?	Plan Meets DFPC Requirement*?	Plan Meets NWCG Requirement?	Potential Factors Contributing to Outcome	Relative Importance to Outcome of Potential Factor
1 - Signature Page	Yes	Partially	No	TNC allows Prescribed Fire Burn Boss Trainees at the complexity level of the plan to be the final preparer, NWCG & DFPC require final plan preparers be qualified at the level of the plans complexity, but nothing mandates private landowners follow DFPC policy.	**Low:** While the prescribed fire plan preparer was highly regarded in prescribed fire planning, an additional level of review required by DFPC or NWCG policy may have been beneficial, but was not required.
2 - Go/No Go Checklist	Yes	Yes - Prescribed Fire Go/No Go Checklist	Yes, Element 2B Go/No-Go Checklist		
2A - Prescribed Burn Screening Form and Consequence Analysis	Yes	Yes - Agency Administrator Ignition Authorization, Burn Boss Delegation	Yes, Element 2A AA Ignition Authorization	TNC splits complexity and consequence analyses, both of which focus only on post-plan risk. NWCG and DFPC utilize a combined pre and post plan complexity analysis incorporating consequences.	**Moderate:** Evaluating pre and post-plan risk including potential consequences in one place may streamline and further inform the risk management process, but was not required by TNC policy.
3 - Complexity Rating Summary	Yes	Partially	Partially		
4 - Description of Prescribed Fire Area	Yes	Yes	Yes		
5 - Objectives	Yes	Yes	Yes	Prescribed Fire Objectives indicate fire behavior necessary to achieve them. In this case, only a low to moderate intensity fire was necessary to achieve objectives.	**Moderate:** ECU4 Rx Fire Plan objectives can be met with low to moderate intensity surface fire at relatively mild environmental and fuel moisture parameters.
6 - Funding	Yes	Yes	Yes		

Elkhorn Creek Unit #4 Prescribed Fire Plan Element	Plan Meets TNC Requirement?	Plan Meets DFPC Requirement*?	Plan Meets NWCG Requirement?	Potential Factors Contributing to Outcome	Relative Importance to Outcome of Potential Factor
7 - Prescription	Partially	Partially	Partially	The ECU4 Rx Fire Plan Prescription met some but not all of TNC, DFPC, and NWCG guidance.	**High:** The environmental prescription could only be exceeded with 20-ft wind speeds at or above 25 mph. Predicted rates of spread are in excess of on-site and contingency containment abilities within the plan, and spotting distances exceed recommended blackline depth in Element 11. TNC guidance says plans should specify "Excluded combinations of parameters," and use fire behavior outputs to inform contingency planning, which this element did not address.
8 - Scheduling	Yes	Yes in Element 9 - Scheduling	Yes in Element 9 - Scheduling		
9A - Pre-Burn Considerations	Yes	Yes	Yes		
9A - Notifications & Public Relations	Yes	Yes, DFPC Elements 10 & 22	Yes		
9B - Partner & Other Notifications	Yes	Yes, DFPC Elements 10 & 22	Yes		
10 - Briefing	Yes	Yes by ECU4 Plan Element 2	Yes by ECU4 Plan Element 2		

Elkhorn Creek Unit #4 Prescribed Fire Plan Element	Plan Meets TNC Requirement?	Plan Meets DFPC Requirement*?	Plan Meets NWCG Requirement?	Potential Factors Contributing to Outcome	Relative Importance to Outcome of Potential Factor
11 - Organization and Equipment	Yes	Partially, DFPC Element 12	Partially	ECU4 Plan states that Fire Manager approval can lower minimum resources needed. Also stated is that fire behavior modeling shows that, “spot/slop containment will be unobtainable with resources on scene under Moderate and High conditions in fuel model GR2. Blacklines will be developed at a minimum of 100 feet utilizing backing fire before main ignitions begin.”	**High:** Adjustments to minimum organization require a plan amendment prior to implementation. While resources on scene exceeded minimum production rates, the plan notes that containment issues will exist at moderate and high end conditions, but recommends 100’ of blackline to mitigate this despite Element 7’s predicted spotting distances. On scene staffing met prescribed fire plan requirements, but was not sufficient to contain fire spread outside of the unit as predicted in Element 7.
12 - Communication	Yes	Yes, DFPC Element 13	Yes		
13 - Safety & Medical	Yes	Yes, DFPC Element 14	Partially	Public safety considerations are not included in the plan, but are not specifically required in TNC policy.	**Moderate:** Including public safety measures in prescribed fire plans, such as smoke on roadways, and evacuation contact information, can better inform contingency planning.
14 - Test Fire	Yes	Yes by ECU4 Plan Element 15	Yes		
15 - Ignition Plan	Yes	Partially, DFPC Element 16	Partially	ECU4 Plan states that blackline operations could be completed prior to main ignitions, leading to a smaller minimum required organization for unit ignition.	**NA:** While separate organizations are permissible, they must be reflected in the complexity analysis and organization and equipment elements, as well as requiring a separate prescription. However, blacklining was concurrent with main unit ignitions on Elkhorn Creek Unit 4b.

Elkhorn Creek Unit #4 Prescribed Fire Plan Element	Plan Meets TNC Requirement?	Plan Meets DFPC Requirement*?	Plan Meets NWCG Requirement?	Potential Factors Contributing to Outcome	Relative Importance to Outcome of Potential Factor
16 - Holding Plan	Yes	Partially, DFPC Element 17 & 18	Partially, NWCG Element 17	The ECU4 Plan does not identify patrol requirements for the prescribed fire.	**NA:** While not relevant to the outcome in this case, identifying patrol plan requirements should be incorporated into future planning efforts to reduce the risk of unintended outcomes.
17 - Contingency Plan	Yes	No, DFPC Element 19	No	The ECU4 Plan identifies Management Action Points and Actions Needed to address them, but does not identify by specific resources or production type what would be required to bring the project back into prescription.	**High:** Contingency planning is done to address low probability/high consequence events and the actions needed to mitigate them. While the ECU4 Plan identifies these events, it does not adequately describe the number and type of resources or production rates or actions needed to address them and bring the project back into prescription.
18 - Wildfire Declaration	Yes	Yes, DFPC Element 20	Yes	The ECU4 Plan refers to the "Jurisdictional Authority" but does not state who that authority is. This language is similar to TNC policy.	**Low:** This limitation was recognized on scene and mitigated by the ECU4 burn boss and trainee prior to any ignition.
19 - Smoke Management	Yes	Yes, DFPC Element 21	Yes		
20 - Monitoring	Yes	Yes, DFPC Element 23	Yes		
21 - Post-burn Activities	Yes	Yes, DFPC Element 24	Yes		
*The ECU4 Prescribed Fire Plan technically met all DFPC requirements because private landowners are not required to follow DFPC guidance. This table just attempts to show how much alignment exists between the ECU4 Plan and DFPC guidance for prescribed fire plans.					

As presented in Table 8 above, there are two ECU4 Rx Fire Plan elements that had a low degree of influence, three elements that had a moderate degree of influence, and three elements that had a high degree of influence on the eventual outcome. Most importantly, Elements 7 (Prescription), 11 (Organization and Equipment), and 17 (Contingency Plan) were not consistent with one another. The minimum organization in the Plan was not capable of containing fire spread outside of unit boundaries at moderate and high prescriptive parameters, and the number and type of contingency resources required to achieve fire containment was not identified. Many elements met the policy guidance of all agencies. The specific environmental and fuel moisture values used in the prescription were correctly modeled with adequate fire behavior fuel models to show that moderate to high intensity fire behavior would occur. However, the modeled fire behavior in the plan would likely exceed the objectives in Element 5 of the prescribed fire plan, as well as the ability of the recommended organization to contain it.

> "Describe only those parameters needed to identify the acceptable prescription window to meet prescribed fire objectives. In addition to the prescribed fire objectives, the prescription should take into consideration constraints such as smoke management issues and perimeter control concerns," PMS-484, page 24

Key Policy Consistency Takeaways:

- TNC uses a complexity analysis and consequence analysis that only analyze post-plan risk without a pre-plan baseline with which to compare that risk. These are separate documents with separate intended audiences, splitting the risk decision across two documents with two purposes.
- The ECU4 Prescribed Fire Plan was largely consistent with TNC, DFPC, and NWCG Policies. However, three elements of the ECU4 Rx Fire Plan had a high degree of influence on the outcome, specifically Element 7: Prescription, Element 11: Organization and Equipment, and Element 17: Contingency Plan.
    - These three elements did not fully incorporate the combined influence of environmental and fire behavior prescriptive parameters with necessary staffing and contingency actions.
- Element 11 recognizes that rates of spread would not be able to be contained by resources on scene and recommends 100 foot minimum blacklines to address this issue. However, spotting distances in Element 7 are much greater than 100 feet under all conditions.

5.8. Prescription Parameters

The prescription from the ECU Rx Fire Plan is shown below in red text.

Fuel Parameters:	LOW	PREFERRED	HIGH	OUT*
1-Hour Fuel Moisture (%)	**13**	**6-8**	**4**	Sustained 20' winds >24 without blacklining or other mitigating factors** or high Fuel Parameters + more than one of the following weather parameters
10-Hour Fuel Moisture (%)	**15**	**8-10**	**6**	
100-Hour Fuel Moisture (%)	**17**	**12**	**8**	
Live Fuel Moisture (%) (Herb/Woody%)	**60/90**	**40/70**	**30/60**	
Weather Parameters:				
Air Temperature (F)	40	70	85	--
Probability of Ignition	17	40-60	80	--
20 ft wind speed (mph)	**10**	**18**	**24**	25
Wind Direction(s)	*Refer to smoke permit. Southwesterly component would be preferred from a tactical perspective.			--

BOLD numbers indicate values used in Behave runs when a range of variables existed but all were not modeled.
**Other parameters could include: environmental or fuels conditions that moderate fire behavior, black lines are in place, natural barriers/sparse fuels that would limit fire spread.

Fire Behavior			
Fuel Model – GR2, TU1	**Acceptable Fire Behavior Range**		
	LOW	**PREFERRED**	**HIGH**
Rate of spread (ch/hr)	15.8/.8	78.5/6.3	153.9/11.3
Headfire flame length (feet)	2.5/.2	6.5/2.6	9.0/3.6
Backfire (*sic)* flame length (feet)	.7/.2	1.3/.5	1.5/.6
Scorch height (feet)	5/0	29/4	58/7
Spotting distance (mi)	.2	.4	.5
Probability of ignition (%)	17	40	76

Narrative

A low to moderate intensity burn will be needed to meet the resource objectives of reducing conifer seedlings and saplings (<6”) by 20% and removing 30% of 1-hour, 10-hour, and 100-hour fuels from the burn unit. The desired fire intensity will also support the Forest Management Objective of creating and supporting the maintenance of forest stand structures that will be consistent with low and mixed-severity fires.

In the areas with mixed conifers, heavier pockets of fuel loading exist and an increase in fire behavior and single-tree torching can be expected. Fire intensities in these areas will likely lead to isolated pockets of mortality due to higher flame lengths and increased residence time in larger diameter fuels.

The ECU4 Rx Fire Plan used the GR2 – Low Load, Dry Climate Grass (Dynamic) and the TU1 – Low Load Dry Climate Timber-Grass-Shrub (Dynamic) surface fire behavior fuel models to calculate surface fire behavior characteristics. In general, these selections were adequate to assess surface fire behavior characteristics, with GR2 generally over predicting spread rates and fire intensities and TU1 under predicting these characteristics. But since the objectives of the prescribed fire were to both reduce conifer regeneration and maintain the majority of the larger diameter overstory, we have to assess TU1’s ability to predict small diameter mortality in order to gauge its utility as a fuel model. By running BEHAVE Plus with the same inputs as the “High” prescription parameters, but instead finding only values that would achieve this singular objective (small diameter mortality), it becomes apparent that TU1 as a surface fuel model selection is not capable of reducing over 20% of small diameter trees under any realistic wind scenario. Since TU1 is one of the least reactive (slowly spreading and very low intensity) surface fuel models that users can select, this is not surprising.

In prescription development, utilizing objectives that identify minimum and maximum limits on a fire effect, such as mortality of different size classes of vegetation, is done to identify fuel moisture and environmental conditions in which objectives can be met while control of the fire is maintained. A maximum limit objective is one that should not be exceeded. In the case of ECU4, the objective, “Limit mortality of trees greater than 10” DBH to 20% or less” is a maximum limit objective. The objective, “Reduce conifer regeneration (<6” DBH) by at least 20% within 1 year of the burn” is a minimum limit objective. Within the BEHAVE Plus software utilized to model fire behavior parameters, both of these scenarios need to be run to identify what conditions can be present to both *reach* over 20% mortality in conifer regeneration and *limit* mortality of overstory trees below 20%. There is a desirable fire intensity level that will meet both objectives simultaneously that is both above a very low intensity fire and below a very high intensity fire. Unfortunately, TU1 is a difficult surface fuel model to assess these objectives with, as it will only show low intensity surface fire behavior characteristics under all fuel moisture and wind scenarios.

Since a dynamic fuel model was selected, it is apparent that the plan preparer felt that live fuel moistures, both woody and herbaceous, were important influences on fire behavior. Based on observed fire behavior and the knowledge that both live and dead moistures were important to predicting fire behavior, fuel models that may have helped identify potential mortality constraints are GS1 – Low Load, Dry Climate Grass-Shrub (Dynamic) or GS2 – Moderate Load, Dry Climate Grass-Shrub. Both of these surface fuel models are significantly more reactive than TU1, and would have shown that 20-ft above 18 miles per hour in GS1 and above 4 miles per hour in GS2 would have exceeded the limiting objective of the ECU4 Rx Fire Plan while at the same time reducing the rate of spread of the adjacent grass fuels.

While dead fuel moistures and probability of ignition (82% at 1430 hrs on October 16th) were outside of the "High" limits identified in the ECU4 Rx Fire Plan, ignition on October 15th and October 16th cannot be considered igniting out of prescription based on the text of the Plan. This is simply because the prescription states that only "Sustained 20 ft winds >24 without blacklining or other mitigating factors**" are out of prescription, and on both October 15th and 16th sustained 20-ft wind speed did not exceed 24 mph and blacklining was performed that met the mitigation language of the Plan.

This is not to say that the limits identified within the prescription were reasonable or desirable in the local context of the fire environment, or appropriate to achieve the prescribed fire objectives. Table 9 below shows the ECU4 Rx Fire Plan's Environmental Prescription values compared to how frequently those values occur as observed at Red Feather RAWS between September 1 and October 31 between 2000 and 2019. These dates were used based on Element 9 in the Plan that stated that implementation could take place in the Fall, Winter, or Spring, along with the low to dormant live fuel moistures in Element 7 reflective of seasonal curing.

Table 9. ECU4 Rx Fire Plan Values Compared to Red Feather RAWS Observations

Parameter	Low	Preferred	High	Occurrence Above High End Value (%)
1-hour fuel moisture %	13	6-8	4	35% of all days have 1-hour fuel moisture below 4%
10-hour fuel moisture %	15	8-10	6	43% of all days have 10-hour fuel moisture below 6%
100-hour fuel moisture %	17	12	8	15% of all days have 100-hour fuel moisture below 8%
Air Temperature	40	70	85	<.001%of all days have maximum temperatures above 85
20 foot sustained wind speed	10	18	24	0.4% of all days have 20-foot sustained winds above 24 mph

The ECU4 Rx Fire Plan specifies that only a 20-ft wind above 24 miles per hour would exceed prescriptive parameters. As observed at Red Feather RAWS, this occurs less than 0.4% of the

time. Twenty foot sustained 10 minute average winds below 13 miles per hour occur 85.5% of the time, which may be an appropriate value to incorporate into future planning efforts.

While 1, 10, and 100-hour fuel moistures were below prescriptive values on both days, the prescription allows for this. What the prescription did not take into account was the compounding influence that progressively higher wind speeds have on progressively drier fuels, regardless of fuel model selections. The influence of wind speed on fire behavior is linear. The influence of fuel moisture on fire behavior is quadratic. When combining drier fuels with higher winds, the effect becomes exponential, with very little additional wind or just slightly drier fuels having a dramatic effect on fire behavior. A schematic of this exponential effect is below.

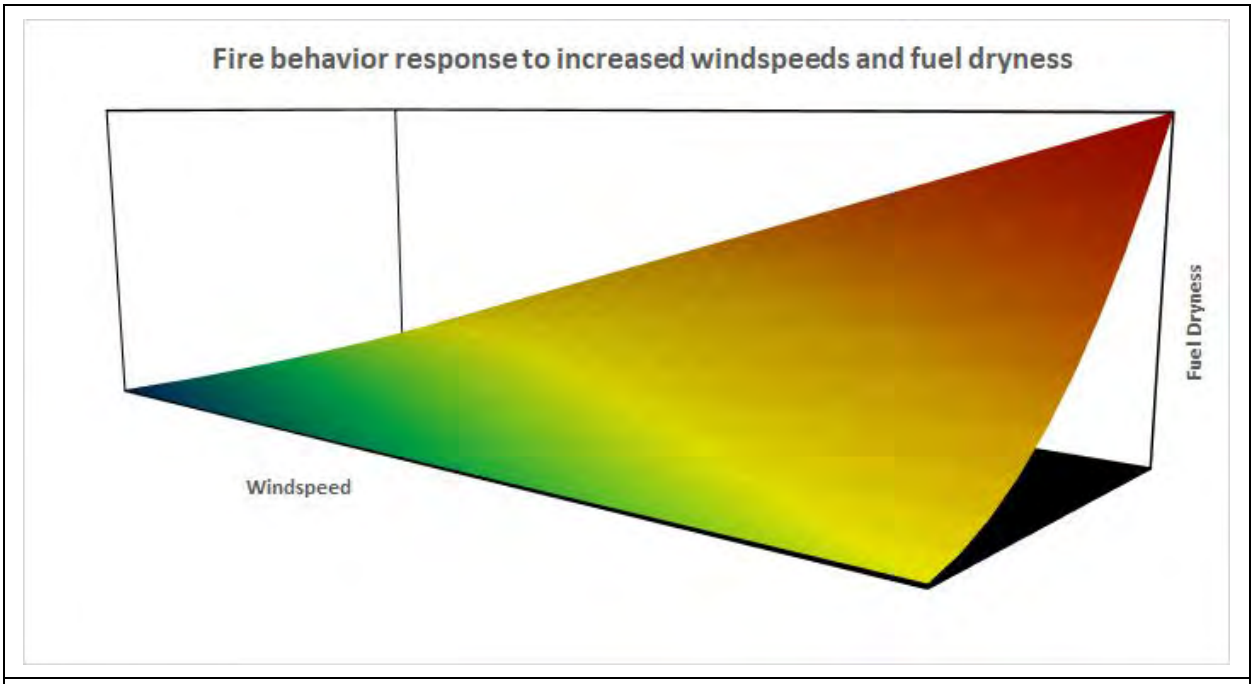


Figure 5.36: Fire Behavior Response to Increased Wind Speeds and Fuel Dryness

While TNC has their own policy regarding prescription development, the NWCG PMS-484 states that, “In many cases, burning under the extremes of all prescriptive parameters would not meet or may possibly exceed the desired prescribed fire behavior characteristics and are therefore out of prescription.” The ECU4 Rx Fire Plan only had one variable (sustained 20-ft wind speed) that would cause the prescription to be exceeded. However, careful consideration of the interaction of all prescriptive variables must occur to avoid over achieving objectives or creating containment concerns.

Key ECU4 Prescription Takeaways

- Fuel moisture parameters in the prescription were appropriate to meet objectives.

- Selection of TU1 for a surface fuel model would have under predicted fire behavior characteristics, and influenced the selection of higher wind speeds than necessary to meet prescribed fire objectives.
- The prescription allowed for dead fuel moistures to be lower than high end values so long as 20-ft wind speeds are less than 25 mph sustained. 20-ft wind speed was the only prescriptive parameter that had to be adhered to for the prescribed fire to be considered out of prescription.
- 20-ft sustained wind speed in excess of 25 mph occur 0.44% of the time at Red Feather RAWS.
- The highest sustained 20-ft wind speed at Red Feather RAWS on October 16th was 13 mph.
- The spot weather forecast called for sustained 20-ft winds to be 9-15 mph with gusts to around 20 mph.

5.9. Contingency Planning

With specific regards to contingency planning, it is important to discuss the intent of this portion of prescribed fire planning. Most if not all personnel interviewed in the process of this review felt that contingency planning was extremely robust and effective, including the IC assignment, identification of best potential control features outside of unit boundaries, and organization assignments if fire spread outside of the planned unit boundaries. While this planning directly contributed to the rapid containment of the Elk Fire, it is best described as extended attack actions and opportunities to aid in wildfire suppression as part of the Wildfire Declaration Element.

In a prescribed fire planning context, contingency planning is done to identify high consequence/low probability events and address what specific type of resource or specific line production rate would be necessary to return the prescribed fire to its planned state. The preferred rate of spread identified in Element 7of the ECU4 Rx Fire Plan is 78.5 chains per hour in grass, roughly equivalent to 1 mile per hour. In order to contain a fire spreading at one mile per hour, resources have to be available to construct line at a rate of at least 2.25 miles per hour. The ECU4 Rx Fire Plan required production rates of 64 chains per hour (0.8 miles per hour). On October 16th, 2019, there were more resources on site than the Plan called for, but their combined production rate was not capable of containing fire outside of the unit boundary. In Element 11, the Plan correctly identified that would be the case, but did not address that risk by requiring resources capable of containing fire spread outside of unit boundaries.

Key Contingency Planning Takeaways:

- The Plan correctly identified fire behavior characteristics that would exceed the containment ability of resources on site, but this was not adequately addressed in the Contingency Plan element of the Plan.

- The Contingency Plan element did not specifically identify resource types, amounts, or production rates needed to return the project to prescriptive parameters.

5.10. Qualifications, Experience, and Involvement of Key Personnel

All overhead personnel were qualified and highly experienced in the positions they were performing on the ECU4 Rx Fire. TNC is a partner agency to NWCG and prescribes additional experience for its prescribed fire burn bosses as compared to NWCG requirements. However, personnel in non-overhead roles had a broad range of qualifications and experience, much of which cannot be quantified by the Review Team. On the ECU4 Rx Fire, there were personnel representing two NGO's, 10 local government agencies, two state government (non-DFPC) agencies, and one federal agency, in addition to numerous observers, one media outlet representative, and a representative for the Scout Ranch.

TNC frequently uses this unique staffing model involving personnel from many different partner agencies and organizations to implement prescribed fires. As early as mid-September, TNC Colorado staff members began looking for potential dates to conduct the prescribed fire, and began notifying partners of a planned ignition date sometime in early to mid-October. Because of the staffing model that TNC has to operate with, a long lead-time is needed to ensure that enough of these resources can commit for the prescribed fire to proceed.

"Collaborative burning" is the term used by TNC to describe this method of prescribed fire implementation. This method has the significant benefit of increasing the capability and experience of local resources who are not exposed to broadcast prescribed fire as frequently as others in the fire management community, but comes with some drawbacks.

"Many folks will only show up to burn if they can get training opportunities, and we can't always turn people away because we need the bodies" - Burn Boss

To create enough depth in a broadcast prescribed fire organization using a collaborative burning approach takes more time to stand up than in the standard land management agency workflow. In a state or federal governmental land management agency, resources are more abundant in general, and can be ordered and paid for through existing dispatch mechanisms and interagency agreements. Funding is legislated for prescribed fire implementation, and fire managers have many more tools available for implementation. Conversely, collaborative burning is necessarily constricted by funding, and to pay all personnel associated with this model would require significantly more agreements needed than state or federal land management agencies must deal with, with more funding needed to even begin this process than what is available.

With this funding restriction known to all partners, there is still a desire to implement prescribed fires, but there becomes a stronger focus on the training that partner agency employees and volunteers will receive as part of the deal to provide resources for TNC prescribed fires. With

training opportunities as the carrot, a collaborative burning model can and usually does have trainee positions working under every qualified individual, and has indeed become a large focus of TNC Colorado's prescribed fire objectives.

From the prescribed fire plan, Element 5: Objectives, Management Summary and Goals:

4. Provide training opportunities where appropriate based on conditions and staffing

While utilizing numerous trainees is admirable, it also reduces the number of qualified middle leaders like Firefighter Type 1's (FFT1) that are implementing alongside less experienced individuals. These middle leaders have the experience and judgement needed to instruct inexperienced people regarding the basics of prescribed fire operations and safety, and can be counted on to provide personal leadership to up to seven people. But, there were fewer FFT1's available to the ECU4 Rx Fire organization simply because they were largely being used in single resource boss trainee roles, or serving as other qualified overhead positions. Numerous fire-line personnel interviewed noted that they wished there were more FFT1's to provide specific hands-on training to less experienced individuals, a role that was instead filled by either qualified overhead or trainee overhead. The necessary focus of these overhead personnel on basic tactical and safety training for inexperienced personnel led to inevitable delays in timing, a point brought up by numerous interviewees. The delays in implementation resulted in free spreading fire that spotted over a critical holding point at the peak burning period of October 16th.

"One VFD made the comment nobody had been on any kind of wildfire in the past 3 years. Part of the feeling I got was that it was a prescribed fire, but also a training exercise. Not that you can't do that, but you still need to have the operations part solid."
- Zulu Holding Boss

Interestingly, when asked about what was unique or different that stood out on the ECU4 Rx Fire, the interviewees answers can be sorted by agency affiliation. TNC employees interviewed recognized some of the limitations of collaborative burning, but placed an overall higher value on increasing partner and cooperator experience while shaping the social dynamic of prescribed fire. Conversely, non-TNC employees recognized some benefits of collaborative burning, but also identified the very low experience level of non-overhead personnel and the perceived focus on trainee opportunities over operational aspects of the prescribed fire. This one issue represents the majority of different opinions among the participants interviewed.

Key Personnel Takeaways:

- All overhead personnel were qualified and experienced in their roles.

- Below the overhead level, several participants interviewed noted a lack of experience of on-site resources.
- The collaborative burning model is dependent on partner agencies lending resources to TNC in exchange for training opportunities, leading to a loss of middle leaders who can provide hands on training for less experienced individuals.

6. Subjective Factors Analysis and Lessons Learned

How many decisions have you made in your life and career that in hindsight seem questionable? How many times did you make an ill-informed decision, but did not suffer a bad outcome? The idea that people are consistently rational and narrowly self-interested, and always select the optimal solution to meet their subjective ends is a myth -- the "*homo economicus"* fallacy. In reality, all complex decision making involves many more factors than strictly rational, data-informed objective calculations.

Throughout all our decision making, cognitive biases and heuristics are at play. A cognitive bias is a systemic error in thinking, in the sense that a judgment deviates from what would be considered desirable from the perspective of accepted norms or correct in terms of formal logic. A heuristic is best described as a rule of thumb, a simple strategy or mental process that humans use to quickly form judgements, make decisions, and find solutions to complex problems. If you were told that all fish live in water, and all trout are fish, would you conclude that all giraffes live in trees or that all trout live in water? When given two simple statements, humans can deduce the common element between them and make a rapid judgement. However, when complex decisions need to be made before all information is completely available, people are heavily influenced by their interpretation of past events, their internal beliefs, and external cues before them.

On the ECU4 Rx Fire, as on many if not all prescribed fires nationwide, difficult decisions with a significant degree of uncertainty were made that inevitably led to the observed outcome. While it is not possible to know exactly what thought process led to decisions, we can look at a few through the lens of some common biases and heuristics. By evaluating decision-making on this incident, the broader community of prescribed fire practitioners can begin to add more context to their risk management strategies, focused on the leaps in logic that we all make. Furthermore, consideration of cognitive biases impacting the Review Team during the review process puts the review findings in relevant context as well.

6.1. Hindsight Bias

If you have ever had your decisions called into question after the fact, it probably did not feel very good, or even right. People have the unfortunate tendency after the fact to perceive events as more predictable than they actually were before the event took place. This is known as hindsight bias, and is the most difficult bias to overcome when trying to learn from past events

with information available in the present that was not at the time the decision was made. It is especially difficult to address this bias from the perspective of a review team trying to learn from an unintended outcome.

““It is an acknowledged fact that we perceive errors in the work of others more readily than in our own.” -Leonardo Da Vinci

There is no doubt that hindsight bias is present in the Review Team. It is our human nature to do so. But we want to be transparent in addressing that the bias exists, so that prescribed fire practitioners can learn from the recommendations in this report, and that we do not appear overly confident that we can predict the future. We can't do that, but what we can say is that there will certainly be other prescribed fires that are declared wildfires, and that lessons learned from this review process have been documented time and time again in other declared wildfire reviews (Dether, 2005).

As active prescribed fire practitioners on the Review Team, it is very possible that we will have our decisions called into question at some point in the future, and recognize the difficult and honest discussions that the individuals we spoke with were willing to have. It is our hope that this level of integrity and honesty can be learned from to make all organizations more resilient and highly reliable.

6.2. Outcome Bias

Another struggle of the Review Team was to overcome was outcome bias, where the quality of decisions made is questioned after the outcome of the decision is known. As much as we have tried to place ourselves in the participants' shoes, we fundamentally cannot; we were not there, and we did not experience the full context of decision making as it was occurring. What we have tried to do to address this bias is to honestly discuss all decision making throughout this report, both by participants and by the Review Team. As a review team, we acknowledge that if the situation was reversed, we would want the same level of understanding applied to our decision making processes.

6.3. Counterfactual Thinking

Counterfactual thinking is another bias that shows up after an unintended outcome occurs. Have you ever thought, “If I had only done Y instead of X, this whole situation would be different”? Then you have used counterfactual thinking. The fact is, even if you had done Y instead of X there is no way of knowing whether the outcome would be any different, and what's showing is the human tendency to minimize regret when making decisions or evaluating those decisions afterwards. Was there any way to know at the time that decision X would lead to the outcome? In the case of the ECU4 Rx Fire, was there any evidence that participants ignored information they had available, or made bad-faith decisions upon the evidence they had? Not when viewed through the lens of how we know people make decisions.

Just because information was available does not mean that it would be used, or even accessible to participants. And even if it were used or known about, it does not mean that a different decision would have been made. Going further, even if a different decision was made, we have the tendency to focus on the ways it could have been better than the eventual outcome, not worse. It is sort of a bias within a bias.

All lines of reasoning along these principles are evidence of counterfactual thinking, and we have tried to eliminate that bias to the best of our ability. While there were shortcomings within the prescribed fire plan, they were not made from a place of ill-intent or intentional disregard of the risks. Rather, a number of objective and subjective factors coalesced into the observed outcome. It is the goal of this report to focus on the only outcome that did occur on October 16, 2019, not to present alternate realities and judge the merits of those after the fact.

6.4. Confirmation Bias

Confirmation bias takes effect when information is searched for and interpreted in a way that confirms our perceptions of reality, reinforcing our beliefs at the expense of disregarding potentially pertinent information that does not match those beliefs.

> "The continuing search for confirming evidence postpones the realization that something unexpected is developing. If you are slow to realize that things are not the way you expected them to be, the problem worsens and becomes harder to solve. When it finally becomes clear that your expectation is wrong, there may be few options left to resolve the problem." *Managing the Unexpected*, Weick and Sutcliffe, 2001,

The ECU4 Rx Fire was not TNC's first time implementing a broadcast prescribed fire on the Scout Ranch. Back in 2017, they successfully burned adjacent units with no control issues. Yet in interviews for this review, it became apparent that many participants viewed the fire effects from these prescribed fires as too low, and indeed rain began immediately after ignitions ceased in 2017.

Regarding Unit 4a, burned on Day 1, participants described the first order fire effects as, "beautiful," "incredible," and other very positive terms by interviewees. The positive terms used to describe fire effects from Unit 4a likely reinforced the belief that the environmental parameters at the time were necessary to achieve the desired effects, and the fact that Unit 4a was burned successfully, likely reinforced for the participants the idea that they were able to implement prescribed fire under conditions near the upper end of their prescription. With all of this information in the minds of participants on October 16th, the weather forecast and unit specifics were perceived as being similar to the previous day. The combined effect of seeing desirable fire effects the previous day under perceived similar conditions likely led to the insertion of confirmation bias in decision making.

The objective reality on October 16th was that winds were forecast to be stronger, terrain in Unit 4b was more difficult, and ignition and holding patterns would be more complex, even though the unit was smaller. Participants noted in interviews that the fact that the unit was smaller was important in decision-making, but placed less emphasis on other added complexities of Unit 4b. It is likely that confirmation bias contributed to participants viewing this information as less relevant because it did not match their beliefs and perceptions of the situation.

6.5. Self-Serving Bias

When unintended outcomes happen, is someone to blame, or is it the inevitable outcome of the situation? How much responsibility we accept for an outcome is directly related to whether that outcome is viewed as successful or not. The self-serving bias affects decision making in this way, and also describes the tendency for ambiguous information to be viewed in beneficial terms by the evaluator.

Prescribed fire is the most effective land management tool to reduce wildfire risk in much of the western United States. The argument can also be made that it is the safest tool available. Nationwide, there are several thousand prescribed fires implemented each year, with only a handful leaving their project boundaries and being declared wildfires. To the participants interviewed in this case, many professed that the spot fires that led to the eventual wildfire declaration were simply in the wrong place at the right time. Ambiguous information, like the weather forecasts, fuel moisture conditions, observed early morning winds on October 16th, and their faith in the prescribed fire plan was interpreted in a way that was supportive of implementation on October 16th in Unit 4b. If put in the same situation as the burn boss, with the knowledge that you successfully burned Unit 4a the day prior, and with a high degree of confidence in the prescribed fire plan, can anyone make the case that they wouldn't interpret the available information the same way?

6.6. Affect Heuristic

The affect heuristic, while similar to the confirmation bias, is different in that it refers to the emotional response from a stimulus that subconsciously influences the decision maker. Depending on how the decision maker feels about an action, either positively or negatively, an external influence can shape the decision maker's emotions and thus their decision. In terms of evaluating risks, if an external stimulus causes the decision maker to have a positive feeling, their eventual decision is more likely to judge the risks as low and the benefits as high. If the external stimulus causes the decision maker to have a negative feeling, their eventual decision is more likely to judge the risks as high and the benefits as low.

External stimuli are at the core of the affect heuristic, and on October 16th, the operational period briefing was held at Drop Point 30, directly adjacent to Unit 4a. The mere location of the briefing, the smell of cold black, and the striking visual of a recently successfully burned area, may have been enough to subconsciously influence decision making.

6.7. State of Colorado Policy Overview and Influences

The ECU4 Rx Fire was unique in Colorado, being that it was on privately owned lands and implemented by a non-governmental organization. In the state of Colorado, the Division of Fire Prevention and Control (DFPC) is the state agency responsible for wildfire and prescribed fire. DFPC was established under the Department of Public Safety in 2012, after the Lower North Fork Fire (ignited from a prescribed fire that was declared a wildfire). DFPC's founding legislation, HB12-1283, identifies first and foremost that, "Fire prevention and control are public safety functions best addressed by a public safety agency." It is not until much lower in the bill that prescribed fire is mentioned, stating that, "The director shall establish training and certification standards for users of prescribed fire…(and) create certified burner and noncertified burner designations for users of prescribed fire on private and non federal land." C.R.S. § 4-33.5-1217. Yet shortly after that, the law states, "Nothing in this section requires a user of prescribed fire to be certified by the Division." *Id*. Adding complexity to this language is another state statute that waives the State's governmental immunity from liability "resulting from a prescribed fire started or maintained by the state or any of its employees…" C.R.S. § 24-10-106.1.

Operating within this complex mandate, where prescribed fire is prioritized yet DFPC has limited authority and unlimited liability, DFPC developed the Colorado Prescribed Fire Planning and Implementation Policy Guide (DFPC Guide) in 2015, last updated in January of 2019. The purpose of this Guide is to, "provide consistent state-wide direction, establish common terms and definitions, and identify planning and implementation processes for prescribed fire," and through compliance with the policy guidance contained in the Guide, Colorado Certified Burners may be protected from civil liability arising from prescribed fire. The Colorado Policy Guide is substantially very similar to the NWCG Interagency Prescribed Fire Planning and Implementation Procedures Guide (PMS-484), differing only in the separation of a Mop Up and Patrol element from the Holding Plan Element, and a Public Information Plan Element (contained in a few PMS-484 elements).

Within the DFPC Guide, it is made clear that private landowners are not required to follow any State standard or policy, but they will be subject to all liability unless they meet all requirements of the Certified Burner Program and NWCG standards. In addition, if a private landowner wants to utilize DFPC resources on a prescribed fire, they must adhere to the DFPC Guide, including having the DFPC Unit Chief for Prescribed Fire and Fuels review and approve the prescribed fire plan.

Since its inception, DFPC has not provided implementation assistance on any private land prescribed fire.

The ECU4 Rx Fire Plan was forwarded to the DFPC Unit Chief for Prescribed Fire and Fuels prior to implementation, but there was not a formal review requested by TNC nor provided by DFPC. While the DFPC Unit Chief briefly looked to see if all DFPC required elements were included or referenced, the content of the prescribed fire plan was not scrutinized. It was sent as more of a heads up in case DFPC fielded any questions about the prescribed fire. DFPC

resources were not requested to be present on either Elkhorn Prescribed Fire Unit 4a or 4b, though the DFPC Northeast Region Battalion Chief did make a site visit on October 16th.

This background information is important to understanding how DFPC's founding legislation and prescribed fire policy frame prescribed fire, and how that framing could have influenced the outcome on the ECU4 Rx Fire. The frame through which you view a subject influences the risk decisions you are willing to make around that subject. If you view prescribed fire as a safe and effective tool to manage fuels, you are more likely to view possible outcomes as gains, and are likely to take more risks in order to realize the potential benefits. If you view prescribed fire as a potential public safety hazard, you are more likely to view possible outcomes as losses, and are likely to take fewer risks in order to reduce the potential losses. This framing can become cemented through statutes that conflict with one another, as in the case of DFPC.

Among the TNC employees interviewed, prescribed fire is viewed very positively. As a land managing NGO, prescribed fire is the most common tool TNC uses to reduce fuels on NGO and partner lands managed by TNC. There is certainly a recognition of risks associated with prescribed fire, but organizationally these seem outweighed by potential benefits, which makes sense for an organization like TNC that manages land for conservation and has very little suppression responsibility.

The Division of Fire Prevention and Control is housed in the Colorado Department of Public Safety. DFPC does not have any land management responsibilities, but can provide suppression support to counties as requested, act as Agency Administrator for large fires if delegated by the County Sheriff, and provide prescribed fire planning and implementation support on State or privately owned lands as requested. The majority of statutes relevant to DFPC focus on suppression of wildfires regardless of cause, with an overarching aim of limiting loss from wildfires. While DFPC's authorizing legislation does recognize the need for prescribed fire and attempts to support its usage, DFPC to date has not expanded its use and support of implementing prescribed fire, focusing instead on policy guidance and implementation of its Certified Burner program.

Requiring DFPC review and approval of all nonfederal prescribed fire plans prior to DFPC resources assisting with implementation is effective in limiting the amount of risk the agency takes on prescribed fires, but it does little to reduce the overall risk to private practitioners. The added barrier of an extra plan review (in the case of the ECU4 Rx Fire, a full DFPC review would have been the fourth one, after technical and fire program manager reviews) adds time to an already long process. Obtaining a full review by DFPC may be a worthwhile step to go through if the goal is to utilize DFPC resources for prescribed fire implementation or if no other reviews are being performed, but if neither of these conditions are present, an additional review is likely viewed as unproductive. Even if all private land prescribed fires in the state requested DFPC plan review, there is only one individual at DFPC who reviews prescribed fire plans, and capacity would quickly become a challenge.

The mission statement of DFPC reads, “DFPC is dedicated to serving and safeguarding the people of Colorado while protecting property, resources, environment, and quality of life.” The vision of the National Cohesive Wildland Fire Management Strategy is, “To safely and effectively extinguish fire when needed; use fire where allowable; manage our natural resources; and as a nation, to live with wildland fire.” While DFPC’s mission mirrors much of the National Cohesive Strategy’s language, conflicting state statutes and unlimited liability in prescribed fire limits what DFPC can actually address. This has resulted in an agency that is built for and exclusively focused on wildfire suppression, with extremely limited ability to proactively and holistically address wildfire risk.

Finally, it is worth noting that upon hearing the radio traffic about spot fires beginning to move, the DFPC Battalion Chief ordered DFPC resources to respond, despite the fact that a wildfire had not yet been declared. This action shows that DFPC employees are willing to and have been empowered to take decisive action when necessary, regardless of a fire’s current status.

7. Recommendations & Commendations

The following are commendations and recommendations developed from review of all of the interviews conducted, the data and documentation collected, and additional research conducted during the course of the entire review process.

7.1. Commendations

While there are many lessons learned from the ECU4 Rx Fire, there were things that went right on October 15th and 16th from which other prescribed fire practitioners can also learn.

- Burning adjacent to WUI is inherently more difficult, but significantly more impactful than burning far away from assets that require protection from wildfire. The goals of the Coalition for the Poudre River Watershed, Elkhorn Creek Forest Health Initiative, and Elkhorn Creek #4 Prescribed Fire are in concert with those of the National Cohesive Wildland Fire Management Strategy, which are:
    - Resilient Landscapes
    - Fire Adapted Communities
    - Safe and Effective Wildfire Response
- The Nature Conservancy, Colorado, fills a vital gap between private landowners and State and Federal agencies who are not as well equipped to navigate the complexities of implementing broadcast prescribed fire on private lands.
- The difficulty of suppressing the spot fires that eventually led to the wildfire declaration was rapidly recognized by all involved.

- The decision to declare a wildfire was made very quickly, and a smooth transition into a suppression organization occurred.
- The prescribed fire organization rapidly shifted into a suppression organization, with predefined roles and responsibilities, limiting a loss of situational awareness during a very dynamic situation.

7.2. Recommendations for all prescribed fire practitioners and agencies

- A strong understanding of fire weather is critical to mitigating risk and responding to changing conditions. Review fire weather concepts presented in the NWCG Intermediate Wildland Fire Weather Behavior (S-290) course and fire weather data acquisition and analysis concepts presented in the NWCG Intermediate National Fire Danger Rating System (S-491) course before each fire season utilizing an IMET, LTAN, FBAN, or other knowledgeable individuals, and incorporate these concepts into development of prescribed fire plans.
    - Review and remain diligent regarding the differences between 20-ft sustained ten minute average winds, gusts, eye level, and midflame wind speeds.
    - Ensure wind measurement techniques are consistent with the parameters used in the prescribed fire plan. Either list eye-level wind speeds (converted from a 20-ft wind speed using wind adjustment factors) in the prescribed fire plan and measure those on-site, or measure wind speed at the 20-ft level using the appropriate equipment.

7.3. Recommendations for The Nature Conservancy, Colorado

- Evaluate and refine the collaborative burning approach, including considerations for additional cooperative or partnership agreements to increase the experience level below that of overhead or trainee positions on high consequence prescribed fires.
- Consider the full adoption of the DFPC Colorado Prescribed Fire Planning and Implementation Policy Guide as well as the Prescribed Fire Complexity Rating System Guide (NWCG PMS-424-1).
    - Adoption of these guides would increase consistency and support cooperation between TNC and DFPC and other Colorado partners.

7.4. Recommendations for the Division of Fire Prevention and Control

- Evaluate all DFPC statutory and policy frameworks and craft solutions to align with all three co-equal goals of the National Cohesive Wildland Fire Management Strategy.
    - Changes to DFPC's organizational focus and statutory authority may be necessary to reduce wildfire risk to communities and create resilient landscapes. In the face of an increasingly complex wildland fire environment, the ability to implement proactive measures must be part of a holistic strategy to reduce risk.

7.5. Lessons Re-Learned

The following list was compiled from past prescribed fire reviews to highlight common lessons learned between the ECU4 Rx Fire and other prescribed fires that were eventually declared wildfires. Many common factors below were first identified in "Prescribed Fire Lessons Learned Escape Prescribed Fire Reviews and Near Miss Incidents," by Dierdre Dether in 2005, but are as relevant now as they were then. Because these factors were also present on the ECU4 Rx Fire, another hard look at these common factors and best practices by all prescribed fire practitioners is warranted.

- Utilize portable remote automated weather stations to gather site-specific weather data.
- Blackline depth is not sufficient to contain potential spotting from fuels within the unit.
- Fuels and weather generated surprising fire behavior, even though it was outlined in the prescribed fire plan.
- Fuel models selected in prescription development do not accurately represent potential fire behavior.
- Unexpected winds (strength, duration, direction) occur.
- Burning adjacent to lands where no agreements exist with the adjacent landowner(s).
- Notifications to adjacent landowners prior to ignition is viewed as inadequate after the prescribed fire is declared a wildfire.
- A systematic tendency to underrate overall prescribed fire complexity.
- 43% of declared wildfires occur in six hours or less from the time of ignition.
- Lighting at the upper end of the prescription, where prescription parameters are often exceeded during the peak of the day.
- Prescribed fire plans lack enough depth and detail for the complexity of the project.
    - There is always a desire to make plans broad to increase their utility, but all plan elements must still be cohesive with one another
- Finding a balance between prescribed fire and containment objectives is often difficult. Ensuring both can be met simultaneously must occur to reduce risk to either objective.

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9. Appendices

Appendix A - Elkhorn Creek Unit #4 Prescribed Fire Plan

Appendix B - Elkhorn Creek Unit #4 FEMO Summary Report

Appendix C - Fire Weather Review Report

Appendix D - Fuels and Fire Behavior Review Report

COLORADO
Department of Public Safety
Executive Director's Office

Compliance & Professional Standards Office

Elkhorn Creek Unit #4 Prescribed Fire Review

Appendix A

Elkhorn Creek Unit #4 Prescribed Fire Plan [Names Redacted]

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Elkhorn Creek Unit #4
PRESCRIBED FIRE PLAN

State: Colorado
Location: 2331 County Rd 68C, Red Feather Lakes, CO 80545
Burn Unit: Elkhorn Creek Unit #4
Permit #: TNC-19-186
Burn Complexity (RXB1, RXB2, RXB3)

Attachments:

Vicinity Map (Appendix A):	Yes / No
Project Area/Burn Unit Map (Appendix A):	Yes / No
Smoke Impact Map (Appendix A):	Yes / No
Evacuation/Hospital Map (Appendix A):	Yes / No
Public Relations Map (Appendix A):	Yes / No
Burn Permit application/approval:	Yes / No
Complexity Analysis (Appendix B):	Yes / No
Consequence Analysis Guidance & Worksheet (Appendix C):	Yes / No
Conflict of Interest and Private Benefits Analysis (Appendix D):	Yes / No
Fire Manager Preparations Checklist (Appendix E):	Yes / No
Technical Review Documentation (Appendix F):	Yes / No
Behave Plus Documentation (Appendix G):	Yes / No
Review of Laws (Appendix H):	Yes / No
Exemptions, and Justifications (Appendix I):	Yes / No
Landowner Permissions and Waivers (Appendix J):	Yes / No

Table of Contents and Key to Burn Plan Elements

(*CO State/NWCG Equivalent)

Element 1: Signature Page

Element 2: Go/No Go Checklist (*Prescribed Fire Go/No Go Checklist)

Element 2A: Prescribed Burn Screening Form including Consequence Analysis (*Agency Administrator Ignition Authorization, Burn Boss Delegation-(CO-DFPC)

Element 3: Complexity Rating Summary (*Complexity Analysis Summary)

Element 4: Description of Prescribed Fire Area - Geographic Location, Narrative Description of Area/Boundaries, Vegetation/Fuels, Map Reference; Vicinity, Project Area/Burn Unit, Smoke Impact

Element 5: Objectives

Element 6*:* (*Funding – If Applicable)

Element 7: Prescription – Fuels, Weather, Fire Behavior, Smoke

Element 8: (*Scheduling – See Element 9)

Element 9: Pre-Burn Considerations – Scheduling, Burn Duration; days, night/day, site preparation, LCES, Unique Hazards, Forecasts, Pre-Burn Monitoring

Element 9A: Notifications & Public Relations (*CO-DFPC Element 10, 22)

Element 9B: Partner & Other Notifications (*CO-DFPC Element 10, 22)

Element 10: *Briefing – See Element 2, Go/No Go Checklist

Element 11: Organization & Equipment (*CO-DFPC Element 12)

Element 12: Communication (*CO-DFPC Element 13)

Element 13: Safety & Medical (*CO-DFPC Element 14)

Element 14: *Test Fire – See Element 2, Go/No Go Checklist (*CO-DFPC Element 15)

Element 15: Ignition Plan (*CO-DFPC Element 16)

Element 16: Holding Plan – Procedures, Mop-Up Standards, Water Sources (*CO-DFPC Element 17, 18)

Element 17: Contingency Plan – Location & Response Time of Resources, Contingency Lines, Declaring an Escape (*CO-DFPC Element 19, NWCG Element 18)

Element 18: *Wildfire Declaration (*CO-DFPC Element 20)

Element 19: Smoke Management (*CO-DFPC Element 21)

Element 20: Monitoring – Objectives, Weather, Fire Behavior, Smoke (*CO-DFPC Element 23)

Element 21: Post-burn Activities – Acres Treated, Fire Checked (Name/Date), Fire Declared Out (Name/Date), Notifications (*CO-DFPC Element 24)

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Element 1: Signature Page

Prepared By:
Name(s): [redacted]
Qualification/Position: Prescribed Fire Specialist

[redacted] Signature

9/4/19 Date

Technical Reviewer:
Name: [redacted]
Qualification/Position: RXB2

[redacted] Signature

9/4/19 Date

Approved By:
Name: [redacted]
Title: Colorado Fire Manager

[redacted] Signature

9/4/2019 Date

Jurisdictional Authority
Name: [redacted]
Title: Longs Peak Council Operations Director

[redacted] Signature

10/1/19 Date

for Longs Peak Council, INC
Boy Scouts of America

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Element 2: Go/No-Go

GO/ NO GO CHECKLIST: PRE-BURN, CREW BRIEFING, TEST FIRE and POST-BURN CHECKLIST
Prescribed Burn (Broadcast Burning)

Site Name: **Ben Delatour Scout Ranch** **Burn Unit:** Elkhorn Unit #4 4a/4b **Date:** 10/15/2019

	YES	NO
Has the area (inside and outside the unit) experienced unusual drought conditions or does it contain above-normal fuel loadings which were not considered in the prescription development? If YES, go to question below. If NO, continue with Section A.		✓
If YES, have appropriate changes been made to plans for ignition, holding, mop-up and patrol? If YES, continue with Section A. If NO, stop and consult with Fire Manager.		

A. PRE-BURN (Prior to Crew Briefing)

- ☑ Fire Unit is as described in plan and copy of plan is on site.
- ☑ Required firebreaks complete and are consistent with current and predicted conditions.
- ☑ Certified Burn Boss present, permits obtained. Give permit #'s: TUG-19-184
- ☑ Required number of crew present with required protective clothing.
- ☑ Weather forecast obtained and within prescription. Long-range forecast checked for severe weather.
- ☑ Official and neighbor notifications complete.
- ☑ Required equipment for holding, weather monitoring, ignition and suppression is on-site and functioning.
- ☑ Crew has reviewed equipment.
- ☑ Planned ignition and containment methods are appropriate for current and predicted conditions.
- ☑ Planned contingencies and mop-up are appropriate for current and predicted conditions.
- ☑ List of emergency phone numbers are in each vehicle.
- ☑ Off-site contingency resources are operational and available.

B. CREW BRIEFING

- ☑ Each crew member has a map

Each item below has been discussed with crew:

- ☑ Burn unit size and boundaries.
- ☑ Burn unit hazards and safety issues, including LCES (IRPG pg. 7)
- ☑ Purpose of burn, anticipated fire and smoke behavior.
- ☑ Organization of crew and assignments.
- ☑ Methods of ignition, holding, mop-up, communications.
- ☑ Contact with the public; traffic concerns.
- ☑ Location of main roads, vehicles, keys, and nearest phone.
- ☑ Location of back-up equipment, supplies, and water.
- ☑ Contingencies for escaped prescribed fire.
- ☑ Planning for medical emergency (IRPG pg. 2)
- ☑ WUI concerns.
- ☑ Answer questions from crew.
- ☐ Ask crew if they wish to "turn down" an assignment or participation in the burn (IRPG pg. 19-20)

C. TEST FIRE

- ☑ On-site weather and fuel conditions are within prescription and consistent with forecast.
- ☑ Test burn conducted; fire and smoke behavior within prescribed parameters.

D. POST BURN CHECKLIST

- ☐ Mop-up completed as described in burn plan.
- ☑ Night patrol assigned, if needed.
- ☑ Day shift assigned for days following burn, if needed.
- ☑ Notifications of completed burn, if required.
- ☑ After Action Review (AAR) completed with crew

[redacted] [redacted]

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Element 1: Signature Page

Prepared By:
Name(s): [redacted]
Qualification/Position: Prescribed Fire Specialist Signature Date

Technical Reviewer:
Name: [redacted]
Qualification/Position: RXB2 Signature Date

Approved By:
Name: [redacted]
Title: Colorado Fire Manager Signature Date

Jurisdictional Authority
Name: [redacted]
Title: Longs Peak Council Operations Director Signature Date

Element 2: Go/No-Go

GO/ NO GO CHECKLIST: PRE-BURN, CREW BRIEFING, TEST FIRE and POST-BURN CHECKLIST
Prescribed Burn (Broadcast Burning)

Site Name: Ben Delatour Scout Ranch **Burn Unit:** Elkhorn Unit #4 **Date:** 10/16/19

	YES	NO
Has the area (inside and outside the unit) experienced unusual drought conditions or does it contain above-normal fuel loadings which were not considered in the prescription development? If YES, go to question below. If NO, continue with Section A.		✓
If YES, have appropriate changes been made to plans for ignition, holding, mop-up and patrol? If YES, continue with Section A. If NO, stop and consult with Fire Manager.		

A. PRE-BURN (Prior to Crew Briefing)

- ☑ Fire Unit is as described in plan and copy of plan is on site.
- ☑ Required firebreaks complete and are consistent with current and predicted conditions.
- ☑ Certified Burn Boss present, permits obtained. Give permit #'s: TJC-19-198
- ☑ Required number of crew present with required protective clothing.
- ☑ Weather forecast obtained and within prescription. Long-range forecast checked for severe weather.
- ☑ Official and neighbor notifications complete.
- ☑ Required equipment for holding, weather monitoring, ignition and suppression is on-site and functioning.
- ☑ Crew has reviewed equipment.
- ☑ Planned ignition and containment methods are appropriate for current and predicted conditions.
- ☑ Planned contingencies and mop-up are appropriate for current and predicted conditions.
- ☑ List of emergency phone numbers are in each vehicle.
- ☑ Off-site contingency resources are operational and available.

B. CREW BRIEFING

- ☑ Each crew member has a map

Each item below has been discussed with crew:

- ☑ Burn unit size and boundaries.
- ☑ Burn unit hazards and safety issues, including LCES (IRPG pg. 7)
- ☑ Purpose of burn, anticipated fire and smoke behavior.
- ☑ Organization of crew and assignments.
- ☑ Methods of ignition, holding, mop-up, communications.
- ☑ Contact with the public; traffic concerns.
- ☑ Location of main roads, vehicles, keys, and nearest phone.
- ☑ Location of back-up equipment, supplies, and water.
- ☑ Contingencies for escaped prescribed fire.
- ☑ Planning for medical emergency (IRPG pg. 2)
- ☑ WUI concerns.
- ☑ Answer questions from crew.
- ☑ Ask crew if they wish to "turn down" an assignment or participation in the burn (IRPG pg. 19-20)

C. TEST FIRE

- ☑ On-site weather and fuel conditions are within prescription and consistent with forecast.
- ☑ Test burn conducted; fire and smoke behavior within prescribed parameters.

D. POST BURN CHECKLIST

- ☐ Mop-up completed as described in burn plan.
- ☐ Night patrol assigned, if needed.
- ☐ Day shift assigned for days following burn, if needed.
- ☐ Notifications of completed burn, if required.
- ☐ After Action Review (AAR) completed with crew

[redacted]

Burn checked (if applicable)

Name_____ Date _____ Status: _____

Name_____ Date _____ Status: _____

Burn Declared Out

Burn Boss: _____ Date: _____

Accomplishment Summary

Acres Treated: _____

Unit Completed: Yes / No

Participating Resources:

Location of Photos & Documentation:

Objectives Met/Notes:

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Element 2A: Prescribed Burn Screening Form

Operating Unit (state or country program) Colorado
Site/Managed Area Ben Delatour Boy Scout Ranch
Burn Unit(s) Elkhorn Creek Unit #4
Burn Plan Date (if already approved) _____
Screening Date 11/27/2018
Ownership/ Management status Private Land – Boy Scouts of America

Fire Manager Approval [redacted] (Signature or email) 9/4/2019 (Date)

1. Consequence Analysis (To be completed for all burns on TNC property or led/contracted by TNC. *See Attachment C).
Does this burn have the potential for High Consequences from smoke or an escape fire?
__X__Yes ____ No
If yes, the OU Director must be briefed on the burn prior to conducting the burn.

Date OU Director briefed: 10/9/19 0930AM Done By [redacted]

Primary Factors		Notes
Off-Site Values/WUI	☒ Yes ☐ No	Potential for significant damage claims due to risk to improvements or other fire sensitive resources in the area are low
Smoke Sensitive Areas	☐ Yes ☒ No	Project is not in, or close to, any smoke sensitive areas
Public/Political Sensitivity	☐ Yes ☒ No	Burn is not likely to attract significant negative public, political, or media attention
Secondary Factors		
Burn Complexity	☐ Yes ☒ No	This burn does not present a high degree of technical difficulty or the possibility for multiple adverse operational events or situations to occur
Escape Containment	☐ Yes ☒ No	Contingency planning does not identify a high degree of difficulty in Initial Attack and containment of escaped fire
Residual Burning Fuels	☐ Yes ☒ No	Burn unit does not contain masticated or other fuels with a high potential for unexpected prolonged smoldering combustion resulting in extended potential for fire escape or smoke intrusions
Third Party Lands	☐ Yes ☒ No	Burn is located on third party lands, but landowner is willing to provide liability waivers and indemnification to the Conservancy against third part claims

2. Conflict of Interest (TNC-led or contracted burns on third party private lands. *See Attachment D).

Check here if N/A ____ (govt.-owned land or firebreak/buffer of minimal size in relation to entire burn unit)

Has TNC's Disclosure Form for Conflicts of Interest been completed by the landowner, or has an alternative conflict analysis been completed if the landowner refuses to complete the Disclosure Form?
_X___ Yes ____No (If No, consult with TNC attorney)

Has the conflict screening identified a "covered person"? ____Yes __X__ No (no further analysis required)

If Yes, has the proposed burn been approved by TNC's Conflict Committee and are any conditions imposed by the Committee being followed?
____Yes ____No (If No, consult with TNC attorney, and explain how resolved)

Comments _____

3. Private Benefit (for all TNC-led or contracted burns on third party private lands).

Check here if N/A ____ (govt.-owned land or firebreak/buffer of minimal size in relation to entire burn unit)

Does the Private Benefits analysis indicate that:
Conservation is the primary purpose for performing the burn?
__X__ Yes ____No
Any landowner benefit is de minimis or incidental to the conservation outcome?
__X__ Yes ____No

If "No" to any of the above, consult with TNC attorney and attach/explain how resolved.

Comments _____

See Memo entitled Conflict and Private Benefit Issues for Prescribed Burns on Private Lands, Attachment D.

Element 3: Complexity Rating Summary

Site: Ben Delatour Boy Scout Ranch	Unit: Elkhorn Creek Unit #4	State: CO	Date: 11/27/2018
Complexity Score (check)			
☐ Low (44-80 pts)	☒ Moderate (81-150 pts)	☐ High (151-220 pts)	

Narrative (Complexity level, staffing, mitigations, risk disclosure):

This prescribed fire is of moderate complexity. At 505 acres, it will require a moderately-sized organization and 2-5 days to complete ignition. The unit can be sub-divided into two smaller units using an old two-track road. Boundaries for the unit consist of roads and hiking trail/handline reinforced with wetline or Elkhorn creek. There are structures and values to be protected directly adjacent to the burn area, and other values within ½-1 mile of the burn. While there are no contingency lines between the southeast corner of the unit and a private structure, fuel loading is low in the area in between and there are defensible spaces around the structures in this area. Black lining the east boundary would also be a possible tactic to further buffer this area. Staging an engine in this neighborhood during ignition operations for both contingency purposes as well as social perception could be beneficial. In all other areas contingency lines are available and include multiple fuel model transitions, road systems and natural barriers. There are multiple water sources available and contingency resources are less than 1 hour away. The fire behavior necessary to achieve the objectives is low to moderate. Close communication between the Firing Boss and Holding Specialist(s) will help mitigate holding concerns. No smoke sensitive areas have been identified; smoke will be produced for 2-3 burning periods. Most safety concerns are related to the remote location; driving exposure and travel/transport time in the event of a medical incident. Steep terrain, loose footing, rattlesnakes and snags are present but are easily mitigated.

Element 4: Description of Prescribed Fire Area

See Appendix A for maps

GEOGRAPHIC LOCATION						
County	State	Ownership / Management	Latitude/ Longitude	Total Property Area	Total Unit Area	Other Relevant Info: T/S/R, Quad Map, Drainage
Larimer	CO	Boy Scouts of America	N 40° 44.5333' W 105° 29.633'	3,200 Acres	505 acres	T 9N R 72W Sections 16,17,18,19, 20

Vegetation Types	Fuel Models	% of Unit Area	% Slope	Aspect
Grass, Sage and Mountain Mahogany with stringers of ponderosa pine	GR2 TU1 NB9	50% 35% 15%	Variable, 5% - 35%	All

A. Burn Unit Description

The prescribed fire project area lies within the Ben Delatour Boy Scout Ranch, located 17 miles west of Livermore, CO. The property (3,200 acres) is surrounded by Forest Service and privately-owned lands. The burn unit is directly north of Elkhorn Creek, a sub-watershed of the greater Cache la Poudre watershed.

Topography: The project ranges from 7,333 feet (Elkhorn Creek) to 7,890 feet in elevation. This unit has a southern aspect but is topographically diverse with all aspects present. Slopes range from 5%-35%.

Fuels Description: The open southerly facing slopes and meadows contain low grasses, forbs and shrubs with ponderosa pine woodlands interspersed between drainages and rocky outcrops. The rocky outcrops lie mostly in the northeastern half of the unit and comprise approximately 15% of the unit. The unit also has several northeast- and northwest-facing slopes with higher forest densities dominated by ponderosa pine with a small percent of Douglas-fir. These areas make up approximately 35% of the unit acreage.

B. Unit Boundaries

Elkhorn Creek forms the western half of the southern boundary of the unit. It flows year round, ranging from 2-8 feet in width. It has a large willow component on both banks. There is a hiking trail adjacent to the willows on the northern side of the creek. The remainder of the unit is bordered by roads. The east and west roads are native-surface two-tracks The road on the northern boundary is a gravel county road, 68C.

C. Adjacent Fuels

A steep, heavily treed (> 35%) north-facing slope borders the unit to the south. Terrain continues to rise to the south topping out at Lonetree Mountain (8,356 ft) 1.5 miles to the south. To the west and north, the Elkhorn Creek corridor is relatively flat and open. North of the unit the topography and fuels remain similar to those in the unit. East of the project area slopes range from 10-30%, moving up and away from Elkhorn Creek. There is more grass within the creek corridor and valley bottom (GR2), but otherwise adjacent fuels are similar with those within the project area.

D. Description of Proximate Values

Multiple values lie adjacent to the project area.

- The Jack Nicol Cub Scout Camp is located on the west unit boundary.
- The Ben Delatour shooting range with infrastructure also can be found to the west of the project site
- 1 cabin and two outbuildings are located adjacent to the northeast corner.
- 3 private homes and 7 outbuildings .9 miles to the north.
- 5 private homes and 12 outbuilding .33 miles to the east.
- 1 home and numerous Boy Scout camp structures .34 miles to the west.

Element 5: Objectives

PROJECT GOALS AND OBJECTIVES				
MANAGEMENT SUMMARY AND GOALS				
1. Provide for firefighter and public safety during all burn operations. 2. Reduce accumulated thatch shrubs, ponderosa and Douglas-fir seedlings and saplings, and reduce dead fuels to minimize the potential for high-severity effects following wildfires. 3. Reintroduce fire as a natural process in the ponderosa pine ecosystem. 4. Provide training opportunities where appropriate based on conditions and staffing.				
OBJECTIVES ARE S.M.A.R.T.	Specific Measurable Attainable Reasonable Time Related	Type of burn: (Check all that apply)	X	Ecological Management
			X	Fuels Reduction
			X	Training
			X	Research
				Other – specifically:
PRESCRIBED FIRE OBJECTIVES				
□ Reduce conifer regeneration (<6" DBH) by at least 20% within 1 year of the burn. □ Reduce 1-, 10- , and 100-hour fuels by 30% immediately post burn. □ Limit mortality of trees greater than 10" DBH to 20% or less. □ Increase native herbaceous vegetative cover by 20% within 2 years of the burn.				
RESOURCE MANAGEMENT OBJECTIVES				
The Management Goals in the Forest Management Plan (2017 Update) for the Ben Delatour Scout Ranch area as follows: 1. To keep a healthy forest through maintenance of functional ecosystems; restoration and maintenance of forest stands; control of insects, diseases and invasive plants; and following sustainable grazing practices. 2. To maintain a forest that protects water quality and quantity, riparian areas, and wildlife habitat. 3. To manage a forest that provides multiple uses including wildlife habitat, recreation and educational opportunities, forest products, and feed for cattle. 4. To enhance the forest through thinning, fuels reduction, and reforestation. 5. To be an example of excellent natural resource stewardship through such practices as: erosion control, quality trail construction and maintenance, grazing improvements and wildlife habitat improvements. 6. To involve Scouts and other publics in experiential learning of conservation methods. 7. To meet the guidelines set forth in the Forest Legacy Agreement.				
IDENTIFY CONSTRAINTS				
Grasses are the primary carrier of the fire. This unit receives considerable grazing pressure. If grazing is not restricted there may be challenges to meeting the resource objectives across 100% of the unit.				

Element 6: (*Funding – If Applicable)

Funding derived from private and grant sources.

Element 7: Prescription

(Fuels, Weather, Fire Behavior, Smoke)

Fuel Parameters:	LOW	PREFERRED	HIGH	OUT*
1-Hour Fuel Moisture (%)	**13**	**6-8**	**4**	Sustained 20' winds > 24 without blacklining or other mitigating factors** or high Fuel Parameters + more than one of the following Weather parameters
10-Hour Fuel Moisture (%)	**15**	**8-10**	**6**	
100-Hour Fuel Moisture (%)	**17**	**12**	**8**	
Live Fuel Moisture (%) (Herb/Woody%)	**60/90**	**40/70**	**30/60**	
Weather Parameters:				
Air Temperature (F)	40	70	85	--
Probability of Ignition	17	40-60	80	--
20 ft wind speed (mph)	**10**	**18**	**24**	25
Wind Direction(s)	*Refer to smoke permit. Southwesterly component would be preferred from a tactical perspective.			--

BOLD numbers indicate values used in Behave runs when a range of variables existed but all were not modeled.
**Other parameters could include: environmental or fuels conditions that moderate fire behavior, black lines are in place, natural barriers/sparse fuels that would limit fire spread

Fire Behavior			
Fuel Model – GR2, TU1	**Acceptable Fire Behavior Range**		
	LOW	**PREFERRED**	**HIGH**
Rate of spread (ch/hr)	15.8 / .8	78.5 / 6.3	153.9 / 11.3
Headfire flame length (feet)	2.5 / .2	6.5 / 2.6	9.0 / 3.6
Backfire flame length (feet)	.7 / .2	1.3 / .5	1.5 / .6
Scorch height (feet)	5 / 0	29 / 4	58 / 7
Spotting distance (mi)	.2	.4	.5
Probability of ignition (%)	17	40	76

Narrative

A low to moderate intensity burn will be needed to meet the resource objectives of reducing conifer seedlings and saplings (<6") by 20% and removing 30% of 1-hour, 10-hour, and 100-hour fuels from the burn unit. The desired fire intensity will also support the Forest Management Objective of creating and supporting the maintenance of forest stand structures that will be consistent with low and mixed-severity fires.

In the areas with mixed conifers, heavier pockets of fuel loading exist and an increase in fire behavior and single-tree torching can be expected. Fire intensities in these areas will likely lead to isolated pockets of mortality due to higher flame lengths and increased residence time in larger diameter fuels.

Proximity to Nearest RAWS: Red Feather (Station ID: RFRC2) – Approximately 5 miles northwest of the project area at an elevation of 8214 ft.

SMOKE VENTILATION REQUIREMENTS			
Ventilation	Acres	End ignition by X Hours before sunset	Wind
Excellent or Very Good	546	1	E to NW
Good	300	2	E to NW
Fair	100	4	E to NW
Poor	0	No burning	N/A

List conditions that would prohibit or impede burning:

*Element 8: (*Scheduling – See Element 9)*

Element 9: Pre-Burn Considerations

SCHEDULING			
SEASON(S) OF BURN:	Fall, Winter or Spring	TIME OF DAY:	Any
EARLIEST DATE:	Check with Camp for Camper Conflicts Each Year	BLACKLINE PHASE LENGTH:	1-2 Days
LATEST DATE:	N/A	BURNOUT PHASE LENGTH:	2-3 Days

Burn day pre-checks: Pre-checks will be completed prior to burn by the Burn Boss for condition and status of access roads, egress routes, burn fuel staging and safety zones. These will be labeled as needed on the ground with flagging and signs. This will be covered during the briefing and identified on the maps and or aerial photos.

PREPARATIONS	
On Site: Project Area	**Description**
Line to be Constructed/ Critical Holding Points	Units will be scouted prior to burn operations for lines that need to be improved, jackpots of fuel or other factors that could cause problems during implementation and mop up. Contingency lines such as roads, creeks, natural and manmade barriers, or where fuel model transitions exist between grass and timber should be scouted and communicated to resources on scene prior to ignitions. All engines/personnel should scout roads/handlines and hoselays to which they are assigned before implementation to ensure their fire containment/holding effectiveness.
Boundaries, Drop-points, Roads, Access, etc. Identified and Marked as Necessary	All boundaries, division breaks, pump sites, sections of handline with hoselays, and roads will be identified on the ground, and identified on the unit map.
Equipment to be pre-positioned (hose lays, tanks, structure wrap, etc)	If used, pumps and hoselays will need to be pre-positioned and tested, prior to ignitions. See prescribed fire unit map (Appendix A).
Special Features to be protected	Multiple buildings and infrastructure are within and adjacent to the prescribed fire unit. Holding resources should scout and become familiar with these special features prior to ignitions. The burn boss may consider staging resources in these locations.
Hazards	Footing, rocky terrain, light flashy fuels, fences, and snags are all present in the unit. See also Element 13, Safety and Medical Plan.
Warning signs placed	Placing prescribed fire/smoke management signage on Red Feather Lakes Rd and County Rd 68C would be advised.
Off Site: Administrative	**Description**
Notifications and press release	See Element 9A Notifications and Press Releases. Coordination with camp staff will ensure that camp activities are not scheduled that could impede or prevent burn implementation
Method and Frequency for Obtaining Weather and Smoke Management Forecast(s):	See Element 9A, Notifications and Press Releases, and Element 19, Smoke Management
Weather: Spot weather forecasts will be obtained by the burn boss on all ignition days and any days the fire is still active. A copy of the spot weather forecasts will be included in the IAP or fire report. Weather forecasts will be obtained and distributed (by hard copy or briefing) each day personnel go to the unit for mop-up and patrol.	
Smoke: Smoke management information will be submitted and/or obtained by the burn boss prior to any ignition operations taking place.	

Element 9A: Notifications & Public Relations (*CO-DFPC Element 10, 22)

AGENCY	CONTACT INFORMATION	CONTACT/TIMING (Burn Boss, PIO, Fire Manager, or delegated individual)/P,D,A - Prior to day of burn (P), Day of Burn (D), After completion (A)	DATE
DISPATCH CENTERS			
Fort Collins Interagency Dispatch Center	970-295-6800 coftc@firenet.gov	Burn Boss: Email RX Notification P Call D, A	10/11/19 [redacted] 10/15/19 [redacted]
Larimer County Dispatch, 900	970-416-1985	Burn Boss: D, A	10/15/19 [redacted]
AIR QUALITY			
CDPHE-APCD	2-48 hrs prior cdphe_fireapps@state.co.us	Burn Boss: Email "Form D" P Email "Form E" A	10/14/19 [redacted] 10/16/19 [redacted]
Larimer County Health and Environment, [redacted]	[redacted]@co.larimer.co.us	Burn Boss: P, A	10/14/19 [redacted] 10/16/19
CDPHE-APCD Health and Safety Message	*See notes below	*See notes below	✓
LAW ENFORCEMENT			
Larimer County Sherriff's Office	Via Larimer County Dispatch	See above under Dispatch Centers	✓
FIRE DEPARMENTS			
Glacierview / [redacted]	970-493-3353 [redacted]@gmail.com and via Larimer County Dispatch	Burn Boss: D	10/15/19 [redacted] Email 10/16/19 [redacted]
Poudre Canyon Fire / [redacted]	970-881-2902 [redacted]@poudrecanyonfiredistrict.org and via Larimer County Dispatch	Burn Boss: D	
Livermore Fire Protection	970-472-5592 [redacted]@gmail.com	Burn Boss: D	
TNC			
[redacted]	[redacted]	Burn Boss: P, D, A	10/14/19 RP 10/15/19 [redacted]
[redacted]	[redacted]	Burn Boss: P, A	
[redacted]	[redacted]	Burn Boss: P, A	
[redacted]	[redacted]	Burn Boss: P, A	
[redacted]	[redacted]	Burn Boss: P, A	
[redacted]	[redacted]	Burn Boss: P, A	
[redacted]	[redacted]	Burn Boss: P, A	✓
CO Department of Fire Prevention and Control			
[redacted]	970-222-8996 [redacted]@state.co.us	Burn Boss: D	RP 10/15/19 [redacted] 10/16/19 [redacted]
[redacted]	720-413-2917 [redacted]@state.co.us	Burn Boss: D	
FEDERAL AGENCIES			
USFS	Via Fort Collins Interagency Dispatch Center	See above under Dispatch Centers	✓ 10/16

INDIVIDUALS			
[redacted]	970-430-8651 [redacted]@colostate.edu	Burn Boss: P, D, A	10/11/19 RP 10/15/19 email 10/16/19 RP email
Shambhala	landsteward@shambhalamountain.org	Burn Boss: P, D, A	
Scout Ranch Ranger	Position currently open	Burn Boss: P, D, A	
MEDIA			
Scout Ranch - [redacted]	[redacted]		

Element 9B: Partner and Other Notifications (*CO-DFPC Element 10, 22)

AGENCY	CONTACT INFORMATION	CONTACT/TIMING (Burn Boss, PIO, Fire Manager, or delegated individual)/P,D,A - Prior to day of burn (P), Day of Burn (D), After completion (A)	DATE
PARTNERS			
[redacted] - CPRW	[redacted]@poudrewatershed.org 858-775-7965	P, A	10/14/19 [redacted]
[redacted] - CPRW	[redacted]@poudrewatershed.org 970-222-5754	P, A	
[redacted] - CPRW	[redacted]@poudrewatershed.org 502-395-0018	P, A	
[redacted] (Red Feather Lakes Resident)	[redacted]@gmail.com	D	10/15/19 email [redacted] 10/16/19 email
[redacted] - WRV	[redacted]@wlrv.org 970-389-5746	P, A	
[redacted] - WRV	[redacted]@wlrv.org 970-493-2075 Ext. 3#	P, A	
[redacted] - LCCC	[redacted]@larimer.org 970-498-6630	P, A	

Element 10: *Briefing – See Element 2, Go/No Go Checklist

Element 11: Organization & Equipment (*CO-DFPC Element 12)

Minimum Workforce and Equipment Needed to Conduct Burn							
Positions							
		LOW		***MODERATE***		***HIGH***	
Position	ICS Code or Unit of Measure	Total Amount	Line Building Rate (ch/hr)	Total Amount	Line Building Rate (ch/hr)	Total Amount	Line Building Rate (ch/hr)
Prescribed Fire Burn Boss	RXB2	1	--	1	--	1	--
Medical Responder	WOFR (or higher)	1	--	1	--	1	--
Ignition Specialist	FIRB	1	--	1	--	1	--
Holding Specialist	STLD/TFLD	1 (SRB/ICT4 okay)	--	1	--	1	--
Fire Effects Monitor	FEMO	1	--	1	--	1	--
Lookout	FFT1	0	--	0	--	1	--
Engine Boss	ENGB	2		3		4	28
Ignition Crew	FFT2	6	0	6	0	6	0
Holding Crew Lead	FFT1	1	0	1	0	2	0
Holding Crew and Engine Crewmembers	FFT2	6		16		20	24
Total Line Production							52
Total Personnel		10		32		36	
Equipment							
Engine	Type 6	2	14	3	21	4	28
Total Line Production Rate			14		21		28
Supplies							
Drip Torches	20						
Chainsaws	2						
Handtools	All Personnel						
Portable Pumps and/or Engine Pumping Platform	1 Portable						
Drip Torch Mix	50 gallons						
Pump Fuel	50 Gallons						
Portable Water Tank	1						

Staffing Notes: "Low, Moderate, and High prescription levels shown in Element 7 correspond to the required organization levels above. Under all organization levels the RXB2, FEMO, FIRB, Holding Specialist, and Lookout are separate positions from the resources listed. Medical Responders, may be a part of the listed engine, holding, or firing resources.

If Engines are serving as pumping platforms in lieu of portable pumps, these engines must be in addition to the required number of engines needed for implementation.

With Fire Manager approval, variations to the above "Minimum" organizational requirements are permissible if safety considerations are mitigated. Additional resources can be added at the burn boss' discretion. Monitoring and patrol may be overseen by a ICT5/Single Resource Boss as delegated by the RXB2.

As modeled, fire behavior shows that spot/slop containment will be unobtainable with resources on scene under Moderate and High conditions in fuel model GR2. Black lines will be developed at a minimum of 100 feet utilizing backing fire before main ignitions begin. At moderate and high conditions, it is recommended that an additional engine be in place at the closest downwind value at risk.

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Element 12: Communication (*CO-DFPC Element 13)

RADIO GROUP 1	1. Incident Name: TNC NORTHERN C)	2. Date/ Time Prepared: 5/20/2019	3. Operational Period Date/Time: 2019

4. Basic Radio Channel Utilization

Mode: W=Wideband Analog, N=Narrowband Analog, D=Digital, M=Mixed

Channel	Display	Frequency	Tone	Mode	Assignment	Remarks
1	TNC FIRE	RX: [redacted]		N	COMMAND	NATIONAL TNC CHANNEL
		TX:				
2	VFIRE22	RX:		N	TAC	
		TX:	156.7			
3	VFIRE23	RX:		N	TAC	
		TX:	156.7			
4	LC FIRENET	RX:		N	COUNTY 911 DISPATCH CENTER	LARIMER COUNTY FIRENET
		TX:	156.7			
5	VFIRE21	RX:		N	MEDICAL EVACUATIONS	MEDICAL EVACUATIONS (Sometimes IA TAC)
		TX:	156.7			
6	EMS NORTH/ VMED28	RX:		N	MEDICAL EVACUATIONS 2nd	MEDICAL EVACUATIONS (AKA VMED 28)
		TX:	156.7			
7	A/G 9	RX:		N	A/G PRIMARY	[redacted]
8	A/G 58	RX:		N	A/G SECONDARY	[redacted]
		TX:				
9	N DIRECT	RX:		N	FTC DISPATCH CENTER	NORTH DIRECT
		TX:				
10	DEADMAN	RX:		N	FTC DISPATCH CENTER	FTC DISPATCH REPEATER
		TX:	110.9			
11	RENO HILL	RX:		N	FTC DISPATCH CENTER	FTC DISPATCH REPEATER
		TX:	167.9			
12	JELM	RX:		N	FTC DISPATCH CENTER	FTC DISPATCH REPEATER
		TX:	146.2			
13	OPEN					
14	OPEN					
15	OPEN					
16	OPEN					

ICS 205 NFES 133

Element 13: Safety & Medical (*CO-DFPC Element 14)

MEDICAL AID STATION, CLINICS, TRAUMA CENTERS OR HOSPITALS						
NAME OF FACILITY	PHYSICAL ADDRESS	TRAVEL TIME (MINUTES) AIR/GND		PHONE NUMBER	BURN CENTER (Yes/No)	HELIPAD (Yes/No)
Poudre Valley Hospital	1024 South Lemay Ave. Fort Collins, CO 80524	20	60	970-495-7000	NO	YES
Medical Center of the Rockies	2500 Rocky Mountain Ave Loveland, CO 80538	25	70	970-624-2500	NO	YES
Northern Colorado Medical Center	180 1 16th St Greeley, CO 80631	35	90	970-810-4121	YES	YES

AIR AND GROUND PATIENT TRANSPORTATION			
NAME OF TRANSPORT AGENT	PHYSICAL ADDRESS	PHONE NUMBER	PARAMEDICS (Yes/No)
Poudre Valley Hospital	1024 South Lemay Ave. Fort Collins, CO 80524	911	YES
Air Link/Medical Center of the Rockies	2500 Rocky Mountain Ave Loveland, CO 80538	855-405-5454	YES
Northern Colorado Medical Center	180 1 16th St Greeley, CO 80631	970-810-4121	YES

MEDICAL EMERGENCY PROCEDURES

The Burn Boss will be immediately notified of any medical emergency. The closest and most qualified medical responder (WFR, EMT, Medic, etc.) will, per burn boss discretion, take charge of the scene. Operations will be suspended if necessary, and the medical emergency will be treated as an incident within an incident. Depending upon the severity of the injury, the patient's method of evacuation to a treatment facility will be determined by the medical responder in charge and the burn boss.

Use the Medical Incident Report, located on pages 118-119 in the 2018 IRPG to provide dispatch and incoming medical providers with information related to the medical incident.

Helicopter/Medivac location(s) will be identified ahead of burn operations and will be communicated to burn personnel during the pre-burn briefing.

The location of first aid supplies and equipment, as well as the designated medic / highest qualified medical personnel will be identified at the operational briefing prior to implementation.

DIRECTIONS FROM NEAREST MEDICAL FACILITY TO PROJECT VIA GROUND TRANSPORTATION and DIRECTIONS FROM PROJECT AREA TO NEAREST MEDICAL FACILITY

Directions To Poudre Valley Hospital from Scout Camp:

Head northeast on CR 68C towards the main camp access road.
Turn right onto W CR 74E/Red Feather Lakes Rd towards Livermore, travel 16.1 miles.
Turn right onto US 287 S, travel 20.6 miles.
Turn left onto Jefferson St, travel 0.4 miles.
Continue straight onto Riverside Ave, travel 0.6 miles.
Use the right 2 lanes to turn right to stay on Riverside Ave, travel 0.4 miles.
Turn right onto S Lemay Ave, travel 0.5 miles.
Poudre Valley Hospital will be on the left.

Directions to Scout Camp from Poudre Valley Hospital:

Head north on S Lemay, travel 0.5 miles.
Turn left onto Riverside Ave, travel 1.0 mile.
Turn right onto Jefferson St, travel 0.4 miles.

Turn right onto US 287, travel 20.6 miles. Turn left onto W CR 74E/Red Feather Lakes Rd, travel 16.1 miles. Turn left onto CR68C and follow signs for Ben Delatour Boy Scout Ranch (2331 CR 68C Livermore, CO 80536).

LAT/LONG, GROUND CONTACT FREQUENCY OF PROJECT MEDIVAC HELISPOTS					
LATITUDE:	N 40 44.225"	LONGITUDE:	W 105 30.997"	FREQUENCY:	[redacted]

Element 14: Test Fire (*CO-DFPC Element 15)

The Elkhorn 4 prescribed fire contains three fuel models, GR1, GR2 and TU4. Due to the variation in moisture retention in these fuel models, locating the test burn where all three can be ignited would be preferable, if conditions permit.

Element 15: Ignition Plan (*CO-DFPC Element 16)

A. Firing Methods

Firing will be achieved using any methods and sequences necessary to achieve the goals and objectives of the prescribed fire. Ignition tactics should be adjusted accordingly as weather, topography and fuels change. The specifics of firing plan should be developed onsite taking into account the current and forecasted weather and communicated to the prescribed fire team during briefing.

Fire sensitive areas: There are three areas that have been cut out of the burn area that fire should be excluded from. One is the former dump site located along the north line near the northwest corner and the second is an areas of tree plantings on the east side near the sawmill (see Unit Map in Appendix A). Coordination with holding resources and scouting prior to ignition is advised to ensure holding is met. The third area is adjacent to the Cub Scout camp structures. They have been excluded from the burn but additional communication with holding prior to igniting this area is recommended.

Depending on resource availability for large-scale ignitions, a blackline operation should be considered to allow for ignition of a unit of this size with a smaller burn organization.

B. Devices

Any approved devices can be used to ignite this unit. Drip torches, Very pistols and if possible, an ATV torch will likely be the most available devices for ignition.

C. Minimum Ignition Staffing

Due to the size of the unit, it is recommended that two ignition squads of three people each or two squads of two and one ATV/UTV torch be used. Refer to Element 11 for greater in-depth guidance.

Element 16: Holding Plan Procedures, Mop-Up Standards, Water Sources (*CO-DFPC Element 17, 18)

A. Holding Plan

Holding assignments will be given the day of the burn by the Holding Specialist to allow for changing ignition patterns and resource availability. Good communication between the Burn Boss, the Firing Boss and the Holding Specialist is necessary to ensure that holding resources are not being overwhelmed.

Primary Control Lines: Boundaries for the unit include a combination of roads and constructed hand line reinforced with wet lines where appropriate.

Secondary Control Lines: The area around the prescribed burn unit contains numerous roads, drainages, natural barriers, and fuel model transitions to use as contingency lines. Those that will be used as contingency lines will be scouted and communicated to resources on scene prior to ignitions. (Refer to the Contingency Map, Appendix A.)

Spot Fires: Holding personnel will monitor and patrol along all containment lines during and after ignition operations. All personnel will monitor the unburned area outside the burn unit for slop-overs and spot fires. Spots/slops over containment lines will be sized up and immediately suppressed. The Burn Boss will be notified of all spots/slops and the status of containment efforts. If containment becomes too difficult or is a safety risk, ignition firing patterns will be modified as necessary to aid in containment. If containment continues to fail, ignitions will be terminated and will be managed for containment objectives. Once these spots/slops are contained, ignitions may continue at the Burn Boss' discretion.

Mop-Up: Any heavy fuels near the containment lines will be moved into the burn unit to lessen the chance of the fire escaping. Mop-up may be needed along containment lines to secure the perimeter. Mop-up standards will be identified by the Burn Boss based on current and expected fuels and weather conditions.

B. Critical Holding Points (See Appendix A for Project Area Maps)

- The eastern boundary of the burn unit is within 1,800 ft. of private property. It is very important that fire does not cross this boundary. If a spot or slopover does occur, the burn boss should be immediately notified.
- The southern boundary of the unit borders Elkhorn Creek. If fire crosses to the south of the creek, the heavier fuel load and steep topography in this area will make control of a fire challenging if it becomes established. Immediate action to control a spot or slopover should be taken.

C. Minimum Capabilities Needed

Refer to Element 11 to determine staffing needs.

D. Water Sources

Multiple water sources are available directly adjacent to the burn unit. Elkhorn Creek borders the unit on the south side. There are multiple sites where a pump and porta-tank could be located. These will be identified on a map at briefing. There is a small pond at the Jack Nicol Cub Scout Camp on the west side of the unit. On the east side of the unit there is a stock tank that has a year-round source. If burning during cold weather, check for ice depth. There are other lakes in the area that are also available as water sources. (See Unit and Area Map in Appendix A)

Element 17: Contingency Plan (*CO-DFPC Element 19, NWCG Element 18) Location & Response Time of Resources, Contingency Lines, Declaring an Escape

A. Management Action Points:

The burn boss has the authority and discretion to determine any condition that warrants the need to activate the contingency plan. Conditions under the contingency plan could include the follow conditions; this list is not all inclusive.

1. Fire crosses primary control lines and exhibits resistance to control.
2. Fire crosses onto private property not included in the prescribed fire plan.
3. More than three spot fires or slops are ongoing at any one time.
4. Structures are imminently threatened.
5. Fire behavior results in undesirable effects ie. excessive mortality, undesired impacts to soils.

B. Actions Needed:

Ignitions will be discontinued, and suppression of the uncontrolled fire occur. Should ignition operations be suspended, the Burn Boss will meet with the Firing Specialist, and Holding Specialist. Ignition operations may

resume with consensus from the Burn Boss, Holding Specialist, and Ignition Specialist that operations can safely continue after the threat has been controlled.

C. Contingency Resources and Response Time(s):

Closest Resources: check for contingency availability. If contingency resources are needed, the Burn Boss will contact Fort Collins Interagency Dispatch and then coordinate with Larimer County Dispatch.

Agency	Contact Person	Contact Method (phone, radio frequency)	Availability	Response Time (from time of call to arrival on scene)
Poudre Canyon FPD	[redacted]	Fort Collins Interagency Dispatch Deadman Repeater	24/7	30 minutes
Glacierview FD	[redacted]	Fort Collins Interagency Dispatch Deadman Repeater	24/7	40 minutes
Livermore Fire Dept.		Fort Collins Interagency Dispatch Deadman Repeater	24/7	50 minutes

Element 18: *Wildfire Declaration (*CO-DFPC Element 20)

A. Wildfire Declared By:

The Burn Boss will declare an escaped fire if any of the following occurs:

1. Fire spots across the primary control line and exhibits resistance to immediate control or containment is unlikely in the same operational period.
2. The Burn Boss determines that structures are threatened.
3. The Burn Boss elects to declare an escape.
4. If any spots or slop-overs spread onto adjacent private property not owned by the Ben Delatour Boy Scout Ranch, an escape fire will be declared, a size up will be given to the burn boss and suppression actions will be taken.

If can be done SAFELY, all ignitions will stop if an escape is declared. Maximum effort will be made to suppress the escape.

B. IC Assignment

In the event of an escape, the Burn Boss will suspend ignition operations if it can be done safely. The highest qualified NWCG Incident Commander (IC) will assume role of IC until the jurisdictional authority arrives. This individual will be identified during the pre-burn briefing. The burn boss and jurisdictional authority will form a Unified Command once they arrive. The Burn Boss will notify Fort Collins Interagency Dispatch Center, and the Escape IC will notify Larimer County Dispatch. Jurisdictional responsibility for wildfire suppression actions at this site resides with Poudre Canyon Fire Protection District.

The Burn Boss will continue to manage the prescribed fire and release any resources not necessary to the Escape IC. Objective of Burn Boss will be to control the prescribed fire and if possible suppress it so all resources can be dedicated to the suppression response. If off-site resources arrive, they will assimilate with on-site resources and be assigned roles under the Unified Command. All TNC and contracted resources will remain on scene assisting in suppression efforts until released by the Burn Boss and Escape Incident Commander.

C. Notifications

The Burn Boss will notify Fort Collins Interagency Dispatch Center, and the Jurisdictional Authority IC will notify Larimer County Dispatch.

Element 19: Smoke Management (*CO-DFPC Element 21)

Smoke Management *Refer to Appendix A: Map of Smoke Sensitive Areas					
SMOKE PERMIT #	TNC-19-186		WIND DIRECTION NEEDED:	E to NW	
Smoke Sensitive Areas Potentially Impacted					
RECEPTOR	DIRECTION	DISTANCE	RECEPTOR	DIRECTION	DISTANCE
Glacierview Estates	E/NE	2.4	Red Feather Lakes	N/NW	5.6
Livermore	E	15.5			
SMOKE BEHAVIOR (Describe desirable smoke behavior and smoke management actions.)					
See attached smoke permit.					
TRANSPORT WIND AND STABILITY CONDITIONS NEEDED (Include location of any smoke sensitive areas and distance from unit.)					
See attached smoke permit.					
RESIDUAL SMOKE ISSUES AND MITIGATION ACTIONS					
Press releases and public notifications will be made in advance of the burn to communities potentially impacted by smoke. Notifications and updates will be made to dispatch centers located in Element 9A.					
SPECIAL CONSTRAINTS / CONSIDERATIONS					
See attached smoke permit.					
MONITORING REQUIREMENTS					
See attached smoke permit.					
SMOKE MANAGEMENT TECHNIQUES					
Ensure compliance with state and local permits, ozone alerts, and favorable forecasted dispersal conditions Adjust firing patterns and fire behavior intensity to achieve best smoke dispersal. Burn on days when air is unstable for better dispersion. Patrol surrounding roads and neighbors to monitor for smoke impact. Aggressively mop-up periphery of the burn and any fuels producing significant smoke. Discontinue firing operations if: significant negative impacts to receptors is observed or reported or if conditions exceed prescription parameters.					

Element 20: Monitoring (*CO-DFPC Element 23)
Objectives, Weather, Fire Behavior, Smoke

A. Weather & Smoke

Weather will be taken onsite throughout the burn operations to ensure adherence to the prescribed fire prescription and smoke monitoring requirements. This task can be delegated to the FEMO by the Burn Boss.

Smoke monitoring requirements outlined in Smoke Permit will be adhered to.

B. Vegetative and fire behavior monitoring requirements will be as follows:

1. Ecological monitoring will be conducted both before and after the burn to determine if the burn objectives are being met. Understory herbaceous and shrub vegetation cover, fuel loads, and overstory tree mortality will all be measured. Measurements will follow sampling protocols developed by the Colorado Forest Restoration Institute (CFRI) at Colorado State University. See Appendix K for protocols.

2. CFRI is the entity tasked with managing all monitoring for the Elkhorn Project. They should establish plots for photographing and longer-term measurement. Plots should also be established in areas immediately adjacent to the burn unit to serve as controls.
3. Fire Behavior and Fire Effects Monitoring: During the burn, basic fire behavior metrics including rates of spread and flame lengths should be recorded. Weather variables including air temperature, relative humidity, average and gust wind speeds, and wind direction should be measured at least hourly. Immediately following the burn, percent consumption of fuels should be assessed within the plots established for vegetation monitoring.

Element 21: Post-Burn Activities (*CO-DFPC Element 24)

***Refer to Element 2 - Acres Treated, Fire Checked (Name/Date), Fire Declared Out (Name/Date), Notifications**

A. Daily Post-Burn Activities during Project:

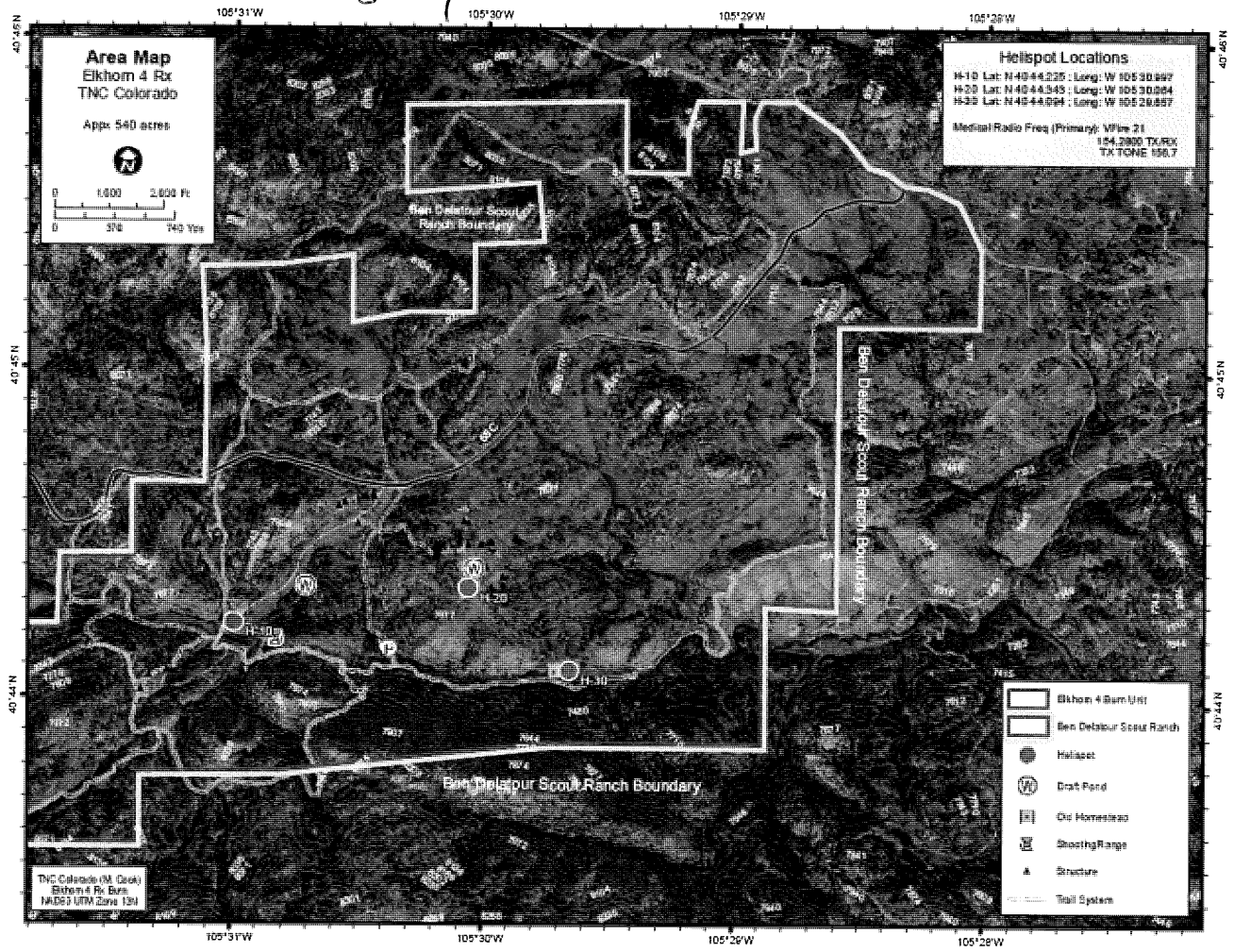
1. Develop operations plan for the following day and communicate to resources prior to their departure.
2. If necessary, brief night patrol resources and execute assignment for night operations.
3. Complete AAR with burn resources before departure.
4. Make notifications to appropriate agencies and stakeholders that burning and mop-up operations have ceased for the day. Refer to Element 9A: Notification

B. Post Burn Activities:

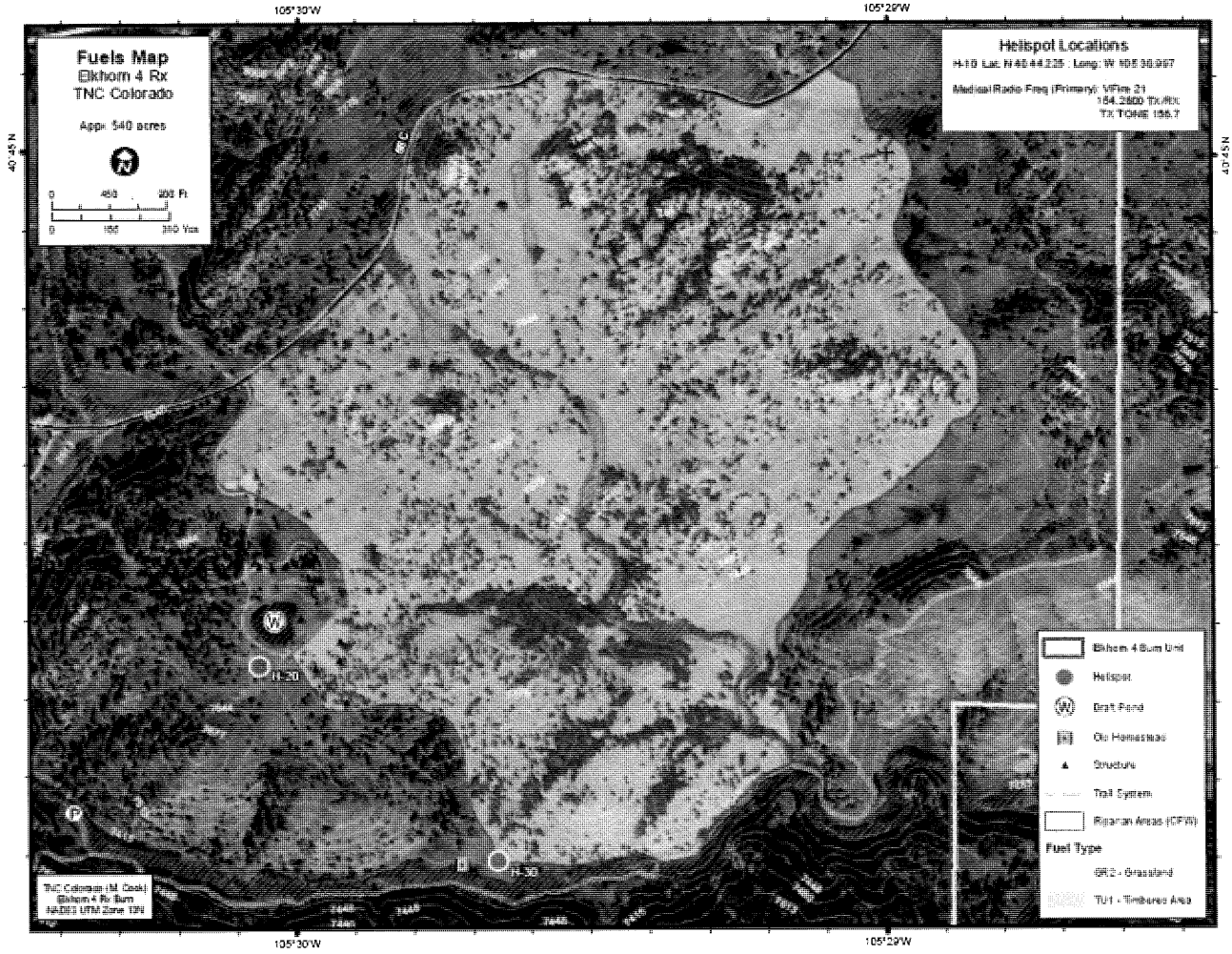
1. Establish mop-up, monitoring, and patrol plan for prescribed fire area relative to long-term forecast and fire remaining within the interior of the unit.
2. Obtain weather forecasts until burn is declared out.
3. Follow-up with necessary notifications to appropriate agencies and stakeholders once the prescribed fire has been declared out by the Burn Boss.
4. Complete an evaluation of burn results relative to objectives.
5. Final AAR with key agencies, stakeholders, and personnel.

Appendix A: Maps

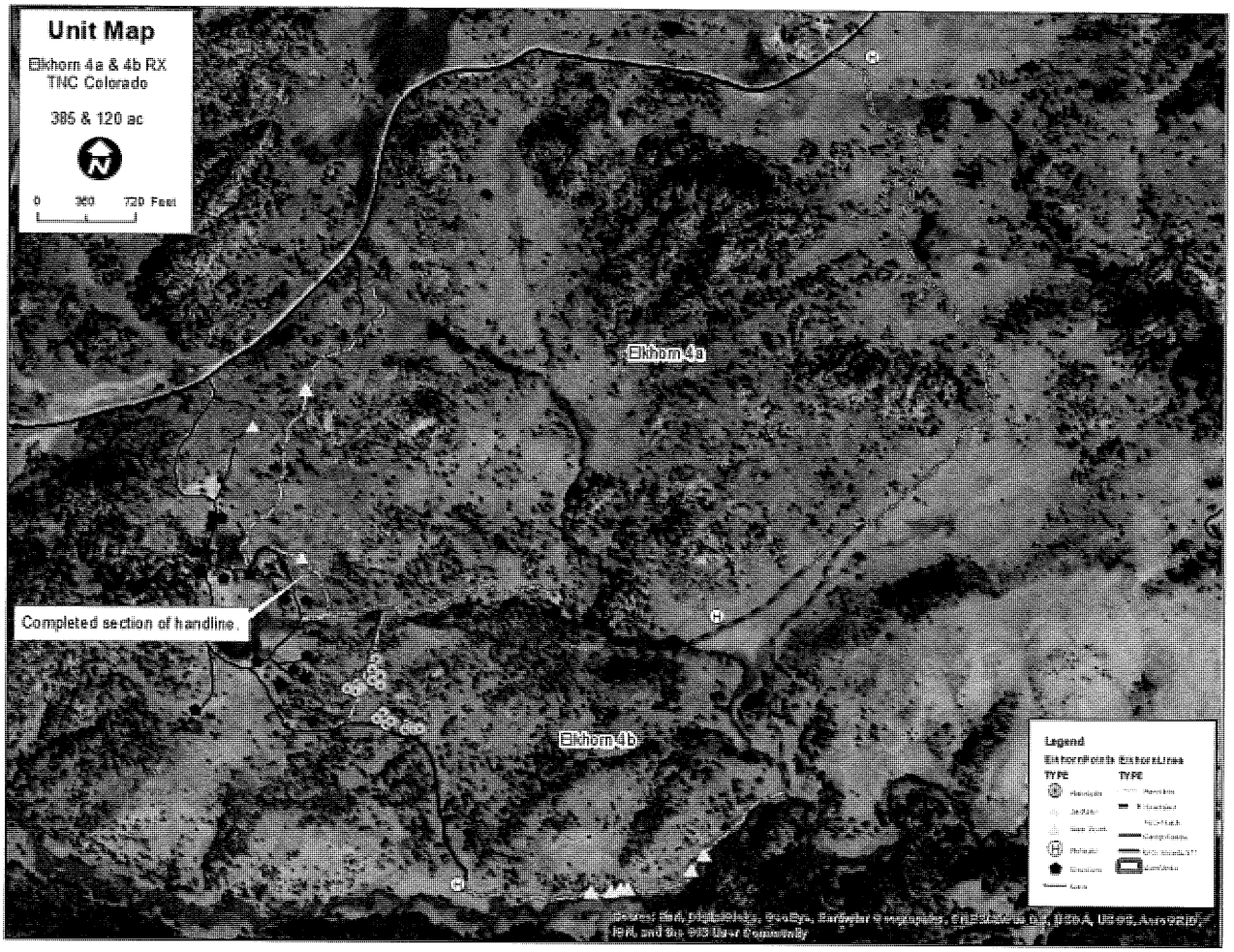
Project Area Map/contingency



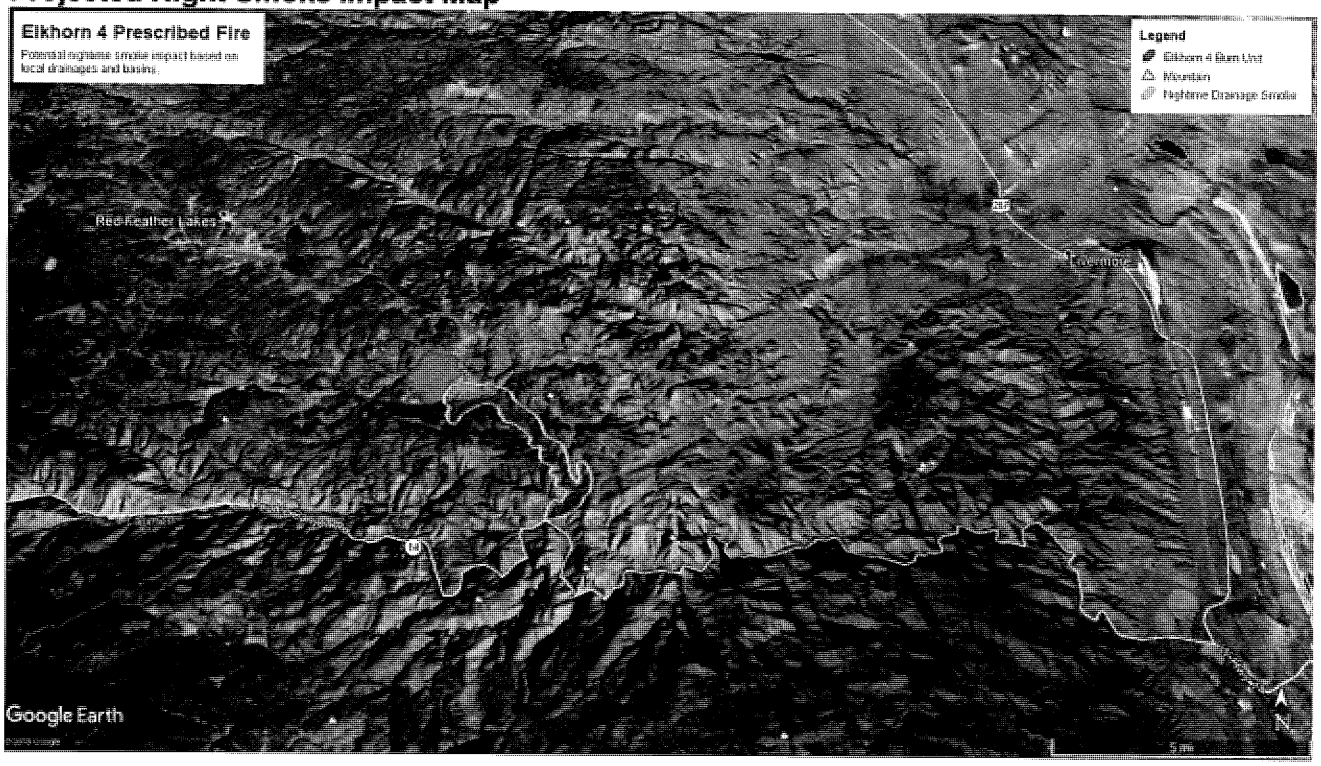
Fuel Type Map



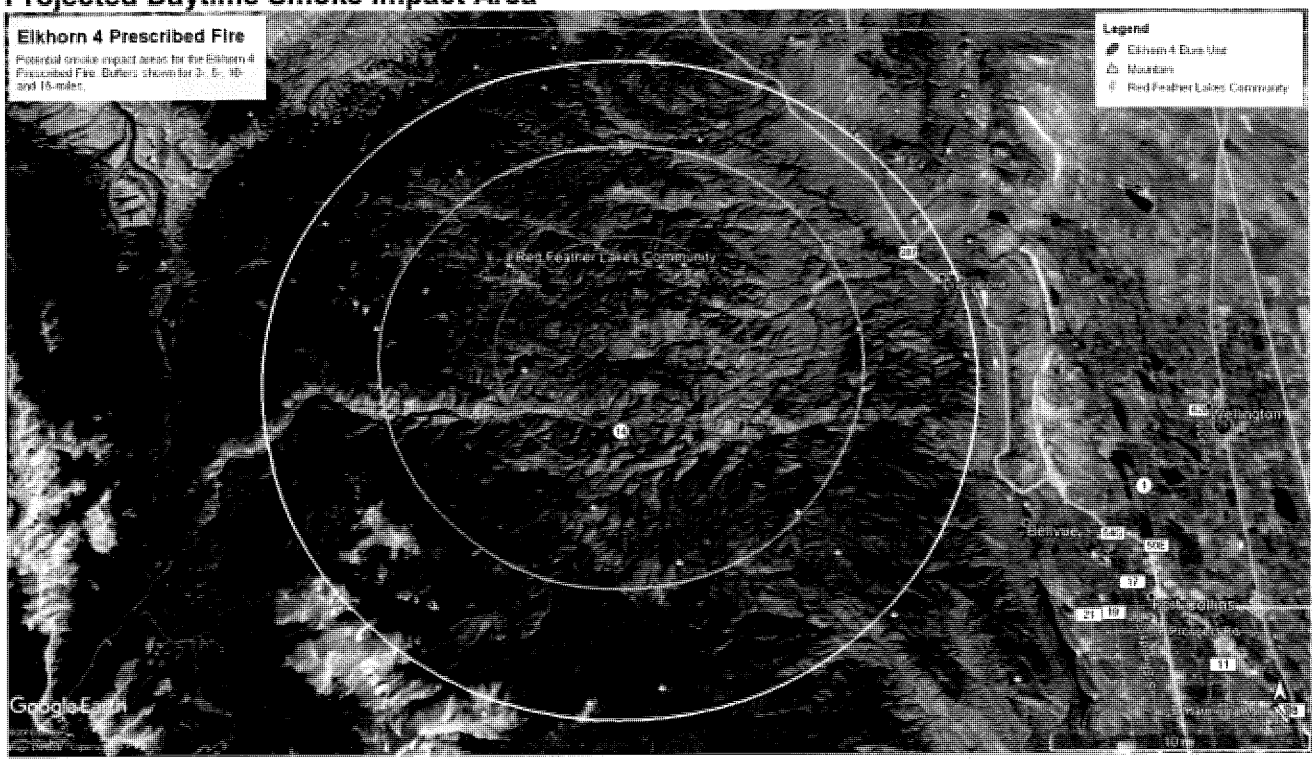
Unit Map



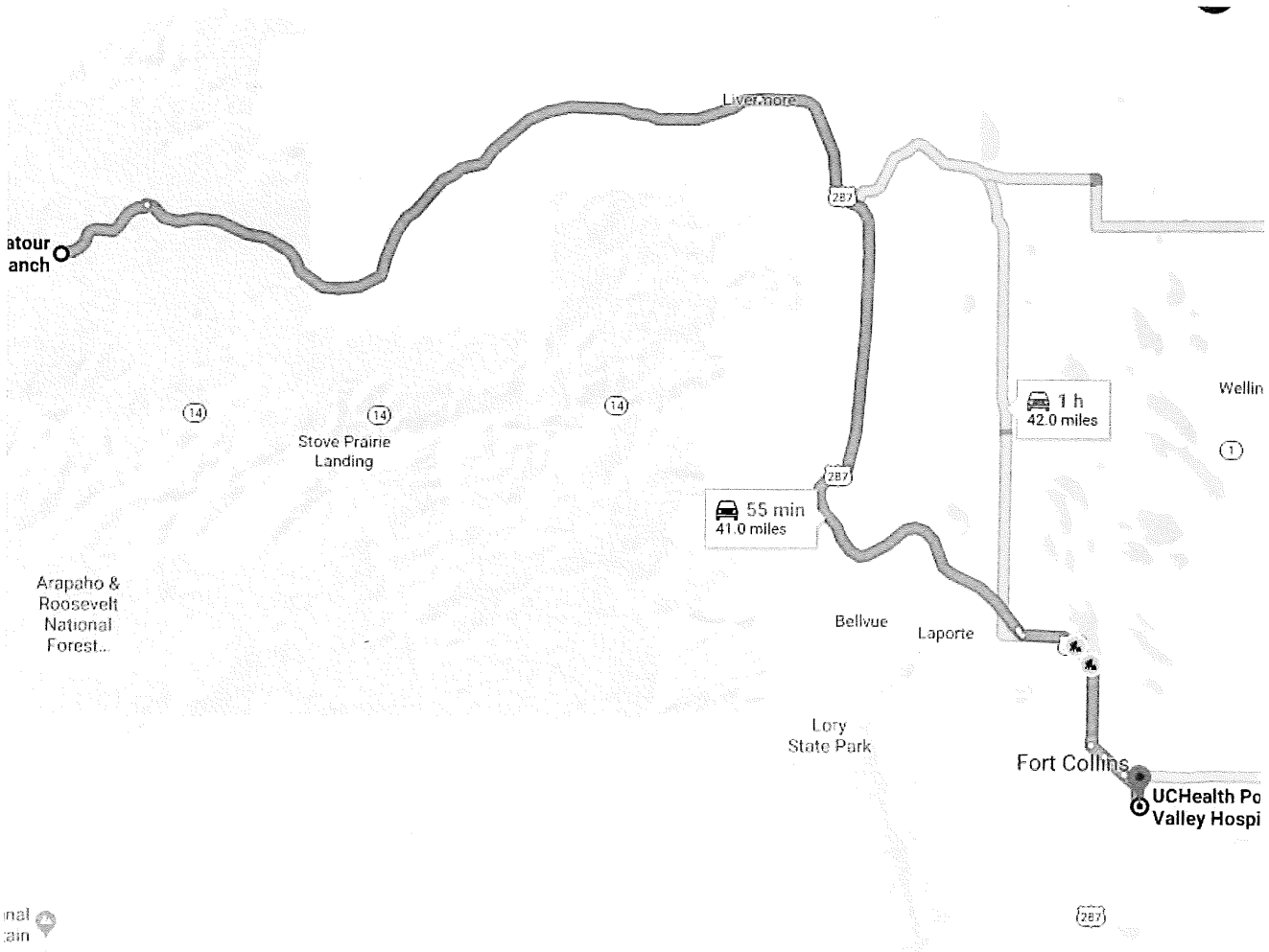
Projected Night Smoke Impact Map



Projected Daytime Smoke Impact Area



Travel Route from Ben Delatour Scout Ranch to UC Health PV Hospital



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Appendix B: Complexity Rating Worksheet

Weighting Factor x Complexity Value = Total points. Sum of Total points = Complexity Score

Complexity Element	Weighting Factor	Complexity Value (1-5)	Total Points	Rationale and/or Mitigation Procedures (Use for clarification of rationale and/or actions.)
1. Safety	5	2	10	Owing to the remote location of the burn, adverse impacts to public safety are limited. The primary safety concern is related to the remote location. This is two-fold, increased driving exposure and the length of time to definitive care in the event of a medical incident. Steep terrain, loose footing, rattlesnakes and snags are present but are easily identified and addressed by identification, communication and good situational awareness.
2. Difficulty of Containment	5	2	10	Boundaries for the unit consist of roads, two-tracks and hiking trail/handline. Where necessary these can be reinforced with hoselays/wetline. Elkhorn Creek is the southern boundary. Multiple fuel model transitions, including heavily grazed areas, road systems and other topographic features provide contingency options. All lines will be checked and prepped to meet to meet the specifications of the Burn Boss.
3. Fuels and Fire Behavior	5	3	15	The primary carrier of the fire will be grass and shrub understory beneath open ponderosa pine stands. Terrain within the unit is diverse with slopes ranging from 5-35% slopes. Fire behavior is expected to remain at low-moderate intensities due to limited quantity of fuel resulting from grazing. Close coordination between the Burn Boss, Firing Boss, and Holding Specialist will aid in keeping fire behavior at desired levels of intensity
4. Wildland / Urban Interface	5	3	15	There are structures and values to be protected directly adjacent to the burn area, and other private residences within 1/2 miles of the burn. Contingency lines and fuel model changes exist between these private residences and structures/values directly adjacent will be easily defendable with required onsite resources.
5. Objectives	4	1	4	Objectives for this unit are easily achievable. Denser areas of the unit have been thinned and the associated debris piled and burned in the Spring of 2016. The majority of the unit is open ponderosa pine, and about 15% of the entire area is rock, allowing for the expected obtainment of objectives without any difficulty.
Sub Total (Page 1)			54	

Complexity Element	Weighting Factor	Complexity Value (1-5)	Total Points	Rationale and/or Mitigation Procedures
6. Management Organization	4	3	12	The size of this unit will require a moderately large organization. Multiple teams are recommended to adequately staff the burn and prevent personnel fatigue. Span of control will be held to 3-5 resources. Team members may come from agencies other than TNC; there are good relationships in place to assist with filling this need.
7. Contingency Planning and Resources	4	3	12	Adequate resources will be onsite based on the prescribed burn organizational staffing level identified in the burn plan. There are excellent water sources available and contingency resources can be available in less than 1 hour.

8. Natural, Cultural, Social Values	3	2	6	No historic cultural values have been identified within the burn area. Threats to natural and social resources are low. The Scout Camp, if negatively impacted, could have some impacts. The community would also react negatively should a large-scale escape occur. Planning and preparation will aid in mitigating concerns.
9. Air Quality Values	3	3	9	No smoke sensitive areas are identified, but smoke will be produced for 2-3 burning periods. There are multiple resources and agencies willing to assist with this project so scheduling conflicts should not create concerns. Frequent communications with air quality agencies will take place to ensure compliance.
10. Logistics	3	3	9	The unit is easily accessible but burning operations will take 2-5 days. Logistics will be easily supported through planning and proper preparation.
11. Tactical Operations	2	3	6	Multiple firing methods, sequences, and resources will be needed and do add to the complexity of the unit. Burning operations and resources will be required for 2-5 days. There are two interior areas to check-up operations if needed but all concerns are easily mitigated through planning and preparation.
12. Cooperator Coordination	1	2	2	This project is reliant upon support from multiple partners, but effective working relationships are in place and good support has been provided for previous projects.
Sub Total		Page 2	56	Additional Comment:
		Page 1	54	
Complexity Score		110		Rated by: [redacted]

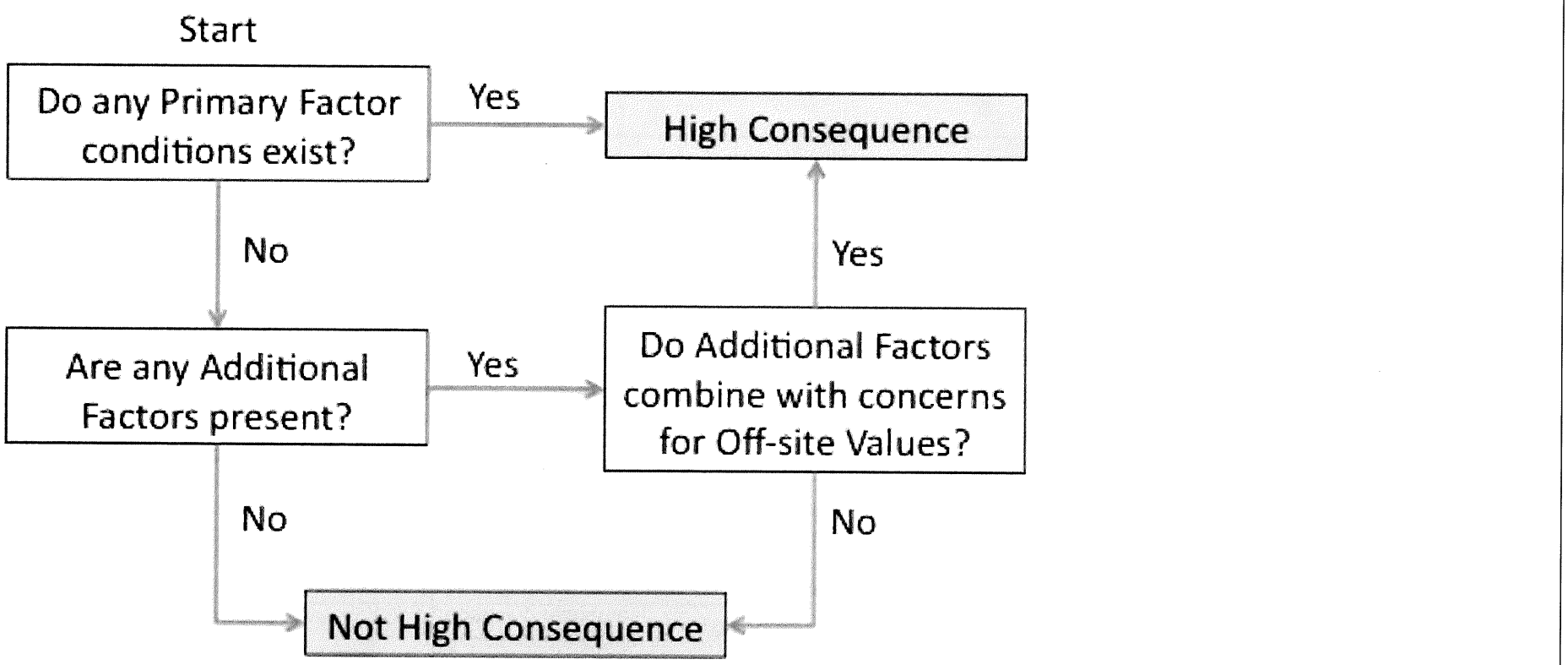
Complexity Element	Complexity Value Evaluation Examples		
	1	3	5
1. Safety Weighting Factor - 5	All safety issues have been identified and mitigated.	A number of significant issues have been identified and some of them are difficult to address through mitigation.	Complex safety issues exist.
2. Difficulty of Containment Weighting Factor - 5	Low threat of escape past unit boundaries. Probability of Ignition<50%. Boundaries naturally defensible or firebreaks easily installed and defended. Secondary control lines strong and easily accessed by vehicles and/or crew.	Moderate threat of escape from unit boundaries. 50<Probability of Ignition<70% Moderate risk of slopover or spot fires. Fuel type produces numerous firebrands. Secondary control lines difficult to access or not secure.	High threat of escape from unit boundaries. Probability of Ignition>70%. High risk of slopover or spot fires. Secondary control lines non-existent or inadequate without significant resource commitment.
3. Fuels and Fire Behavior Weighting Factor - 5	Low variability in slope & aspect. Weather uniform and predictable. Surface fuels (grass and/or needles) only. No drought present or predicted within burn period. Duff or organic soils will not ignite.	Moderate variability in slope & aspect. Weather variable but predictable. Ladder fuels present and torching expected. Fuel types/loads variable. Dense, tall shrub or mid-seral forest communities. Drought index indicates normal to moderate drought conditions; present expected within burn period. Upper level of duff or organic soil will burn.	High variability in slope & aspect. Weather variable and difficult to predict. Extreme fire behavior and/or stand replacement fire. Fuel types/loads highly variable. Altered fire regime, hazardous fuel /stand density conditions. Drought index indicates severe drought conditions; present or expected within burn period. Significant portions duff or organic soils will burn.
4. Wildland / Urban Interface Weighting Factor - 5	No risk to people or property within or adjacent to fire, or values to be protected are easily mitigated. Potential damage from escape low.	Several values to be protected. Mitigation through planning and/or preparations is complex. May require some commitment of specialized resources. Potential damage from escape moderate.	Numerous values and/or high values to be protected. Severe damage likely without significant commitment of specialized resources with appropriate skill levels. Potential damage from escape high.

Complexity Element	Complexity Value Evaluation Examples		
	1	3	5
5. Objectives Weighting Factor - 4	Maintenance objectives. Prescriptions broad. Easily achieved objectives.	Restoration objectives. Reduction of both live and dead fuels. Moderate to substantial changes in two or more strata of vegetation. Objectives judged to be moderately hard to achieve. Objectives may require moderately intense fire behavior.	Restoration objectives in altered fuel situations. Precise treatment of fuels and multiple ecological objectives. Major change in the structure of 2 or more vegetative strata. Conflicts between objectives and constraints. Requires a high intensity fire or a combination of fire intensities that are difficult to achieve.
6. Management Organization Weighting Factor - 4	Span of control held to 2 - 3. 6 - 12 person crew and 1 - 2 engines.	Span of control held to 4 – 5. Multiple resources required (engines, dozers, aerial ignition, terra torch, etc.). 8 - 20 person crew and 1 - 3 engines.	Span of control greater than 5 – 7. Multiple branch, divisions or groups. Specialized resources needed to accomplish objectives. Organized management team required (Fire Use or Incident Management).
7. Contingency Planning and Resources Weighting Factor - 4	Adequate contingency resources on site.	Contingency resources limited or have more than a 15 - 30 minutes response time.	Contingency resources limited or have more than a 30+ minutes response time.
8. Natural, Cultural, and Social Values Weighting Factor - 3	No risk to natural, cultural, and/or social resources within or adjacent to fire, or mitigation through planning and preparations is adequate.	Several values to be protected. Mitigation through planning and/or preparations is complex. May require some commitment of specialized resources.	Numerous values and/or high values to be protected. Severe damage likely without significant commitment of specialized resources with appropriate skill levels.
9. Air Quality Values Weighting Factor - 3	Few smoke sensitive areas near fire. Smoke produced for less than 1 burning period. Air quality agencies generally require only initial notification and/or permitting. No potential for scheduling conflicts with cooperators.	Multiple smoke sensitive areas, but smoke impact mitigated in plan. Smoke produced for 2-3 burning periods. Daily burning bans are sometimes enacted during the burn season. Infrequent consultation with air quality agencies is needed. Low potential for scheduling conflicts with cooperators.	Multiple smoke sensitive areas with complex mitigation actions required. Health or visibility complaints likely. Smoke produced for greater than 3 burning periods. Multi-day burning bans are often enacted during the burn season. Smoke sensitive Class I air-sheds. Frequent consultation with air quality agencies is needed. High potential for scheduling conflicts with cooperators.

Complexity Element	Complexity Value Evaluation Examples		
	1	3	5
10. Logistics Weighting Factor - 3	Easy access. Duration of fire is 1 day (holding or monitoring).	Difficult access. Duration of fire support between 2 and 3 days. Logistical position assigned. Anticipated difficulty in obtaining resources.	No vehicle access. Duration of support is greater than 3 days. Multiple logistical positions assigned. Remote camps and support necessary.
11. Tactical Operations Weighting Factor - 2	Simple ignition patterns with only one igniter inside the unit. Ignition complete within one burning period. Single ignition method used. Resources required for 1 day. Holding requirements minimal.	Multiple firing methods and/or sequences with two igniters inside the unit at once. Use of specialized ignition methods (i.e. terra-torch or Premo-Mark III). Ignition continues for two burning periods. Resources required for 2 to 3 days. Holding actions to direct or delay fire spread.	Complex firing patterns highly dependent upon local conditions. Simultaneous use of multiple firing methods and/or sequences, greater than 2 igniters inside unit. Simultaneous ground and aerial ignition. Use of heli-torch. Resources required for over 3 days. Multiple mitigation actions at variable temporal and spatial points identified. Aerial support for mitigation actions desirable or necessary.
12. Cooperator Coordination Weighting Factor - 1	Cooperators not involved in operations. No concerns.	Simple joint-jurisdiction fires. Some competition for resources. Some concerns.	Complex multi-jurisdictional fires. High competition for resources. High concerns.

Attachment C: TNC Consequence Analysis Guidance

TNC CONSEQUENCE ANALYSIS GUIDANCE



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Overview:
The Consequence Analysis, a required element of TNC Prescribed Burn Unit Plans, evaluates the potential for financial loss or significant harm to TNC reputation or partnerships, should damage to third parties occur from escaped fire or from smoke. As part of the burn planning process, the Consequence Analysis identifies burns with characteristics that may result in a high level of exposure to financial or reputational loss from an adverse unexpected event. These "High Consequence" burns will require the OU Director to be briefed on the burn prior to implementation. The date of this briefing will be noted in the approved Burn Unit Plan, or on a completed stand-alone form, such as the Prescribed Burn Screening Form.

Analysis Factors:
The Prescribed Burn Unit is screened for factors related to potential consequences. Primary Factors (see Table 1) are assessed for the burn unit. The presence of any of these Primary Factors conditions or circumstances will rate the burn as High Consequence. Additional Factors are related to burn complexity, contingency plans or third party liability and insurance. When combined with concern for off-site values, the Additional Factors may also rate a burn as High Consequence.

For more information on filling in this element, see TNC document "TNC Complexity Analysis Guidance".

TNC CONSEQUENCE ANALYSIS

	Factor identified for planned units		CONSEQUENCE ANALYSIS FACTORS		
	YES	NO	DESCRIPTION	EXAMPLE	SITE CONDITIONS
PRIMARY FACTORS	X		**Offsite Values High** Potential for significant damage claims due to risk to improvements or other fire sensitive resources in the area	Highly flammable wildland fuels contiguous to high value (>$1,000,000) improvements, such as housing developments, historic buildings, high public use recreation areas, or commercial or industrial developments.	Multiple offsite values are present. These include Glacierview Estates, Shambala Mountain Center, and other private property and infrastructure are within 1 miles of burn unit.
		X	**Smoke-Sensitive Areas** Burn Plan identifies one or more highly smoke sensitive areas that are not easily mitigated	Hospitals, schools, major roads, airports or factories, each with low tolerance for smoke intrusion, nearby on multiple sides of a burn unit	No smoke sensitive areas lie within 20 miles of burn unit.
		X	**Public/Political Sensitivity** The burn is likely to attract significant negative public, political, or media attention; significantly aggravated by any unexpected or adverse event	Burn to be conducted in area that has been impacted recently by damaging wildfire or escaped prescribed fire; or in an area with frequent hostile political/ community response to planned burning	No significant negative public, political or media attention is expected.

ADDITIONAL FACTORS		X	**Burn Complexity** A high degree of technical difficulty or the possibility for multiple adverse operational events or situations to occur.	Complexity Rating of High, after mitigation measures incorporated into planning.	The logistics and operational complexities are consistent with a Type 2, moderate complexity burn.
		X	**Escape Containment** Contingency planning identifies high degree of difficulty in Initial Attack and containment of escaped fire.	Contiguous wildland fuels outside burn unit extend into neighboring lands with potential for rapidly moving wind-driven escaped fires and limited avenues for secondary containment or indirect attack of escaped fire; or burn objectives require burning under drought or other conditions typically regulated by burn bans or public burn safety warnings	Heavily grazed pastures and man-made and geographic features are present in the event they are needed for contingency holding actions. Multiple contingency resources/response agencies are located within 30 minutes of the burn unit.
		X	**Residual Burning Fuels** Burn unit contains fuels with potential for prolonged smoldering combustion, resulting in extended potential for fire escape or smoke intrusions.	Burn unit contains peat, heavy slash, or other fuels that will likely ignite and burn for many days, weeks or even months	No concerns with high fuel loads or prolonged residual burning potential
		X	**Third Party Lands** Conservancy burn on third party lands where landowner is unwilling to provide liability waiver, indemnification to the Conservancy against third party claims, or possess adequate insurance.	Conservancy to burn on a farm as part of an ongoing private-lands conservation project, but landowner does not have insurance and/or is unwilling to indemnify the Conservancy from potential damage claims resulting from the burn	This project is located on third party lands but all liability waivers, indemnifications to the Conservancy, and adequate insurance are in place.
	X		**Final Rating**	High Consequence?	High consequence due to potential damage to offsite values in the event of an escape.
	X		Result		

TNC Technical Reviewer Checklist:

State CO Site Ben DeLatour Boy Scout Ranch

Prescribed burn unit name: Elkhorn 4

Rate each element in the following table with an "S" for Satisfactory or "U" for Unsatisfactory. Use Comment field as needed to support the element rating.

PRESCRIBED FIRE PLAN ELEMENTS	RATING	COMMENTS
Signature page	S	
Description of Prescribed Burn Area	S	
Goals and Objectives	S	
Prescription	S	
Smoke Management	S	
Personnel and Equipment	S	
Pre-Burn Considerations	S	
Communication	S	
Safety and Medical	S	
Ignition Plan	S	
Holding Plan	S	
Contingency Plan	S	
Monitoring (on-site weather, fire and smoke)	S	
Post-Burn Activities	S	
Attachment: Go/No Go Checklists	S	
Attachment: Complexity Analysis	S	
Attachment: TNC Documentation	S	
Attachment: Maps- Burn Unit Map	S	
Attachment: Maps- Vicinity Map	S	
Attachment: Maps- Contingency Map	S	
Attachment: Maps- Smoke Map	S	
Attachment: Maps- other maps	S	
Other		

☑ **Approval is recommended** subject to the completion of all requirements listed in the comments section, or on the Prescribed Fire Plan.

☐ **Recommendation for approval is not granted**. Prescribed fire plan should be re-submitted for technical review subject to the completion of all requirements listed in the comments section, or on the Prescribed Fire Plan.

Technical Reviewer Signature: [redacted]

Date Signed: 9/4/19

Qualification and Currency: RXB2

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Attachment D: Conflict of Interest, Private Benefit Analysis

Memo
To: Fire Staff, Legal Staff
From: [redacted], Chief Ethics & Compliance Officer and
[redacted], General Counsel
Date: October 13, 2009
Re: Conflict and Private Benefit Issues for Prescribed Burns on Private Lands
Fire Staff and Legal Staff:

Below please find requirements and guidance regarding conflict of interest and private benefit issues that might be presented by conducting prescribed burns on private lands:

Conflict of Interest Policy and SOP Apply: Prescribed burns conducted by TNC on private lands, as with other landowner agreements and transactions, are subject to the Conflict of Interest Policy and SOP.

a. No Conflict if Not "Covered Person": No conflict of interest is present where the landowner is not a "Covered Person" under the Conflicts SOP.

b. Govt. Land & Firebreak Exception: Burns on federal, state and other government lands do not require conflict analysis. In addition, a de minimis exception exists for firebreaks or buffers on neighboring land that are no greater than 10% of the area of the entire burn unit.

Identify Conflicts Early: Waiting until the development of a burn plan to identify and resolve any conflicts is arguably too late from the standpoint of TNC staff time and landowner expectations. The key to identifying conflicts is determining whether the landowner is a "Covered Person" under the Conflicts SOP.

a. Obtain Conflict Disclosure form from landowner, preferably at the same time as the Permission to Burn – Waiver/Release form. The Disclosure form is available on the Legal Intranet site in the Conflicts of Interest section http://home.tnc/legal/references/conflicts.html. Parts I and II are to be completed by fire staff, and the remaining sections are completed by the landowner.

b. Landowner Refuses to Complete/Sign Disclosure form: A landowner may refuse to complete or sign the form. In such instances, fire staff should conduct and document an internal conflict analysis to determine whether the landowner falls into any of the Covered Person categories. Please contact Legal if you have questions about how to conduct or document this analysis.

3. Submit to Review Process if Conflict: If a conflict is disclosed or fire staff become aware of a conflict, the preferred course of action at TNC is to simply avoid the conflict. However, if fire staff still desire to conduct the burn, the conflict must first be submitted and approved through TNC's conflict review process. The Conflicts Committee meets twice each week to render final decisions on how conflicts will be handled.

a. Notify your supervisor and Legal upon learning of conflict. Your supervisor and Legal can help in determining whether a conflict is actually present.

b. In addition to the private benefit analysis described below in Section 4, document the extent to which burns have been offered, solicited or performed on other non-conflicted landowners' property in the area and whether the conflicted party will be held to similar or higher standards. This documentation is important for purposes of showing that no preferential treatment has been offered to the conflicted party. Some conflicted parties (e.g., Board of Directors, Chapter Trustees) may be

held to higher conservation standards due to their relationships with TNC, which may also serve to mitigate the risk of adverse perception by the public. Under some circumstances, the Conflicts Committee may require that these conflicted parties make a commitment to long term conservation of the property, for example, through a conservation easement or restrictions on the property or entering a long term burn management or conservation agreement.

c. Prepare Request for Approval form. Approval of a particular conflict begins with the completion of a form entitled "Request for Approval" that is available on the Legal Intranet site in the Conflicts of Interest section http://home.tnc/legal/references/conflicts.html. Fire staff will prepare the initial draft of this form for review by Legal. Once drafted, the request will be routed to various TNC levels for approval (e.g., Legal, OU Director, Division Director). Please allow at least 2 weeks for the routing and approval process. The Recommended Course of Action may require certain disclosures of the conflicted person's involvement prior to the burn being conducted. For example, conflicts involving Chapter Trustees need to be disclosed to the Chapter's board, and if public funds are used for the burn, disclosure should be made to the funding agency or entity.

d. Analysis in Request for Approval: The following questions should be considered and, if relevant to the situation, addressed in the Conflict Analysis (Section 3) of the Request for Approval.

- Is the prescribed burn being conducted to obtain appropriate conservation benefits?

- Have all TNC policies and procedures for prescribed burns been followed?

- Would the prescribed burn be conducted on the property regardless of ownership (i.e. the property meets TNC conservation standards and objectives)?

- Is the landowner receiving any preferential treatment or being allowed exceptions to standard TNC prescribed burns? Note whether similar burns have been offered or conducted on property owned by other landowners in the area.

- Does TNC or other conservation entities/agencies (ex. USFWS, other land trust) have any property interests in the land (e.g. conservation easement, grant match) or is the land adjacent to other conservation sites (e.g. TNC preserves, parks, refuges)?

- Has the proposed burn on the covered person's land been disclosed in writing to the agencies that are providing funding for the burn program?

- What, if anything, is the landowner contributing to the burn (funding, labor, etc.)?

- What other costs or risks is the landowner undertaking by allowing the burn on his/her land?

- What are the potential economic benefits to the landowner from the burn? Please indicate if the benefits are minimal or incidental to the conservation benefit and if any are contingent on other conditions (e.g. weather, follow-up treatments).

- What are the risks and benefits to the Conservancy?

- What are the alternatives, if any?

- How will this appear in the eyes of the public when tested against the value of "integrity beyond reproach?"

4. Private Benefit Analysis: TNC, as a tax exempt organization, has to be very careful that any private benefit flowing to an individual or entity is incidental to the conservation benefit to be gained from the activity. This analysis is particularly important in situations involving "covered persons" under TNC's Conflict of Interest SOP, but is required even when no conflict is present. In general, private burns are likely an example of "incidental" private benefit provided that (i) conservation is TNC's primary purpose for performing the burn, and (ii) any landowner benefit is incidental to the conservation outcome. As with conflicts of interests, the private benefit analysis is not required for burns on government lands or firebreaks or buffers on neighboring land that are of minimal size in relation to the entire burn unit.

a. An explicit analysis should be conducted early in the burn planning process to evaluate the potential economic benefit to the landowner from the burn. Burn plans should continue to document factors indicating conservation as the primary purpose. Documentation of these facts is necessary for supporting the argument of incidental private benefit.

Factors supporting conservation as primary purpose:

Conducted on lands subject to Conservation Easements or Conservation Area Plans/Portfolios.
Ecological Management burn or Research/Hazard Reduction burns with conservation focus.
Pursuant to TNC obligations under grants with conservation objectives.
Focus on habitat improvement for federal or state listed species.
Part of established TNC regional burn program.
Conducted to benefit nearby parks, refuges, wildlife management areas, or other conservation properties.
Federal/state agencies (ex. USFWS) provide staff for the burn.

Factors that may indicate the incidental nature of any landowner benefit:

Land improvement speculative (ex. post-fire results dependent on the timing and amount of subsequent rainfall).
Private burns not an established practice in the region.
No developed/competitive market for private burn contractors.
Landowner pays TNC a reasonable amount tied to TNC's costs (not a nominal amount or donation) or cost-sharing through equipment, labor, or supplies.
Landowner to forego grazing, haying, or other use of property prior to and/or after the burn.
De minimis area burned (no greater than 10% of entire burn unit).

Examples of burns where private benefit may be an issue:

Non Broadcast burns (ex. brush piles) unless conservation is an equally important objective in conducting the burn.
Burn conducted on an isolated parcel of land, not connected to overall conservation management plan for the area.
Primarily initiated at the landowner's request or by the landowner's offer of a donation.
No charge (or nominal/reduced rate) by TNC in a developed/competitive burn market or where TNC customarily charges fees.
Desired by the landowner for purposes of meeting government farm program requirements or converting land into valuable, income generating property (limited harvest seed income should only be an incidental benefit).

b. Additional recommendations for implementing private benefit analysis into TNC burn programs:

Decision to burn on a particular property and burn plan should continue to be guided by Conservation Action Planning and Conservation by Design under the Fire Management SOP and Burn Manual.

Continue to document factors in post-burn monitoring reports that reflect conservation as the primary purpose (as to TNC and landowner), variables affecting post-burn success (ex. timing and amount of rainfall after burn), and material contributions by landowner to the burn (including restrictions on land use adopted before or after burn).

Inform Legal and Fire Managers of each OU with respect to private benefit issues for private burns and those situations where private benefit might present an issue.

Fire Managers should instruct/inform fire staff on the private benefit issue to allow staff to recognize situations where private benefit might be an issue.

Fire staff should notify the burn supervisor or Fire Manager (who should then contact Legal) early in burn planning process if factors are present where private benefit might be an issue.

If a donation is offered in connection with a burn on the donor's land, the funds should be placed in a general cost center for the OU's burn program (or regional burn program if applicable) and not dedicated to the burn on the donor's land. These funds may constitute program revenue and should not be an inducement for conducting the burn. Legal should be consulted with respect to these donations prior to acceptance.

5. Implementation by Management: In order to efficiently integrate conflict and private benefit analysis into the prescribed burn planning process, fire staff need to be informed and aware of the conflict requirements and potential for private benefit. This can be provided in a variety of ways, for example, by FMAT, Division/OU Directors, or Fire Managers/supervisors. Reminders could be included in burn plan checklists, annual refresher training, etc. The implementation process will likely vary given the diversity of private burn programs conducted by TNC.

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Attachment E: Fire Manager Preparations Checklist

Information about the burn unit (area to be burned):

Unit name:	Elkhorn Creek Unit #4	Site name:	Ben Delatour Boy Scout Ranch
Acres:	505	State/County:	Larimer County, CO

Approved burn plan?		Yes		No	Date Approved:	9/4/2019
TNC burn plan?		Yes		No	Approved by:	[redacted]
Approved Consequence Analysis?		Yes		No	[redacted]	
If Yes, and High Consequence, date of OU Director notification:	NA 10/9/19 see, Pg 6, Element 2A					

Review of Laws and local regulations

Burn Permits required?	X	Yes		No	
Air Quality permits required?	X	Yes		No	
Special Notifications required (e.g. Fire Manager and OU staff pre-burn?)	X	Yes		No	

Information about property to be burned:

Ownership:	Boy Scouts of America		
Last date burned:	N/A	Last burned by:	N/A
Any issues or problems from last burn?	N/A		

[redacted]

TNC Owned:	Site fire planning in place or exemption justification in burn plan?		Yes	X	No
Gov't owned:	Written permission with liability waiver, or other legal-reviewed agreement?		Yes	X	No
Privately owned:	Landowner permission and liability waiver forms?	X	Yes		No
	Conflict of Interest disclosure form?	X	Yes		No
	Private Benefits screening completed?	X	Yes		No
	Privately owned land is less than 10% of total burn area?		Yes	X	No

Information about approved Burn Boss:

If TNC Rep., name:	[redacted]	OU of Rep:	Colorado		
Qualification up to date and current?		X	Yes		No
Burn Boss with TNC Designation letter in place for the state where the burn is located?		X	Yes		No

[redacted]

Contractor name:	N/A				
	TNC reviewed and approved contract in place?		Yes		No
	Documentation of Fire Manager review and approval of contractor's qualification?		Yes		No
	Conflict of Interest screening?		Yes		No
	Contractor with liability insurance (minimum USD $1 million)?		Yes		No

Information about crew members:

TNC Staff used?	X	Yes		No	[redacted]				
Contractor providing crew?		Yes	X	No					
Partner Agencies assisting?	X	Yes		No	MOU Agreements in place?	X	Yes		No
Volunteers used?	X	Yes		No	Volunteer liability waivers signed?	X	Yes		No
Young Adult crews used?		Yes	X	No	Adequate youth fire line supervision identified?		Yes		No
All crew qualifications current?	X	Yes		No	[redacted]				

Who is responsible for burn unit prep?	The Nature Conservancy of Colorado, Southern Rockies Wildland Fire Program

Completed by:	[redacted]	Date:	December 11, 2018

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Appendix F: Technical Review Documentation

Fill out this checklist based on the guidance provided in the Technical Review section in the *Interagency Prescribed Fire Planning and Implementation Procedures Guide*, PMS 484. Rate each element in the following table with an "S" for Satisfactory or "U" for Unsatisfactory. Use Comment field as needed to support the element rating.

PRESCRIBED FIRE PLAN ELEMENTS	RATING	COMMENTS
1. Signature Page		
2. A. Agency Administrator Ignition Authorization		
2. B. Prescribed Fire GO/NO-GO Checklist		
3. Complexity Analysis Summary		
4. Description of Prescribed Fire Area		
5. Objectives		
6. Funding		
7. Prescription: Prescription Narrative and Prescription		
8. Scheduling		
9. Pre-Burn Considerations and Weather		
10. Briefing		
11. Organization and Equipment		
12. Communication		
13. Public and Personnel Safety, Medical		
14. Test Fire		
15. Ignition Plan		
16. Holding Plan		
17. Contingency Plan		
18. Wildfire Declaration		
19. Smoke Management and Air Quality		
20. Monitoring		
21. Post-Burn Activities		
Appendix A: Maps		
Appendix C: Complexity Analysis		
Appendix D: Agency-Specific Job Hazard Analysis or Risk		
Appendix E: Fire Behavior Modeling Documentation or Empirical Documentation		
Appendix F: Smoke Management Plan and Smoke Modeling Documentation (Optional)		
Other		

☐ **Approval is recommended** subject to the completion of all requirements listed in the comments section, or on the Prescribed Fire Plan.

☐ **Recommendation for approval is not granted**. Prescribed Fire Plan should be re-submitted for technical review subject to the completion of all requirements listed in the comments section, or on the Prescribed Fire Plan.

Technical Reviewer Signature: _____

Qualification and Currency: _____

Date Signed:_____

Appendix G: Behave Plus Documentation

BehavePlus 5.0.5 (Build 307)
Elkhorn 4 - Low
Mon, Jan 28, 2019 at 07:34:50

Input Worksheet

Inputs: SURFACE, SPOT, SCORCH, MORTALITY, IGNITE

Input Variables	Units	Input Value(s)
Fuel/Vegetation, Surface/Understory		
Fuel Model		GR2, TU1
Fuel/Vegetation, Overstory		
Canopy Height	ft	15
Downwind Canopy Height	ft	60
Torching Tree Height	ft	50
Crown Ratio	fraction	.8
Mortality Tree Species		PINPON
Spot Tree Species		PSEMEN
D.B.H.	in	16
Fuel Moisture		
1-h Moisture	%	13
10-h Moisture	%	15
100-h Moisture	%	17
Live Herbaceous Moisture	%	60
Live Woody Moisture	%	90
Weather		
20-ft Wind Speed (upslope)	mi/h	10
Wind Adjustment Factor		.4
Air Temperature	oF	50
Fuel Shading from the Sun	%	20
Terrain		
Slope Steepness	%	30
Ridge-to-Valley Elevation Difference	ft	250
Ridge-to-Valley Horizontal Distance	mi	.5
Spotting Source Location		MW
Fire		

Number of Torching Trees 3

Notes

Run Option Notes

Maximum reliable effective wind speed limit IS imposed [SURFACE].

Calculations are only for the direction of maximum spread [SURFACE].

Fireline intensity, flame length, and spread distance are always for the direction of the spread calculations [SURFACE].

Wind is blowing upslope [SURFACE].

Results

Fuel Model	ROS (max)	Flame Length	Torch Tree Spot Dist	Scorch Height	Prob of Mortality	Firebrand Ignition
	ch/h	ft	mi	ft	%	%
gr2	15.8	2.5	0.2	5	7	17
tu1	0.8	0.6	0.2	0	0	17

End

BehavePlus 5.0.5 (Build 307)
Elkhorn 4 - Mid
Mon, Jan 28, 2019 at 07:36:18

Input Worksheet

Inputs: SURFACE, SPOT, SCORCH, MORTALITY, IGNITE

Input Variables	Units	Input Value(s)
Fuel/Vegetation, Surface/Understory		
Fuel Model		GR2, TU1
Fuel/Vegetation, Overstory		
Canopy Height	ft	15
Downwind Canopy Height	ft	60
Torching Tree Height	ft	50
Crown Ratio	fraction	.8
Mortality Tree Species		PINPON
Spot Tree Species		PSEMEN
D.B.H.	in	16
Fuel Moisture		
1-h Moisture	%	8
10-h Moisture	%	10
100-h Moisture	%	12
Live Herbaceous Moisture	%	40
Live Woody Moisture	%	70
Weather		
20-ft Wind Speed (upslope)	mi/h	18
Wind Adjustment Factor		.4
Air Temperature	oF	70
Fuel Shading from the Sun	%	20
Terrain		
Slope Steepness	%	30
Ridge-to-Valley Elevation Difference	ft	250
Ridge-to-Valley Horizontal Distance	mi	.5
Spotting Source Location		MW
Fire		

Number of Torching Trees 3

Notes

Run Option Notes

Maximum reliable effective wind speed limit IS imposed [SURFACE].

Calculations are only for the direction of maximum spread [SURFACE].

Fireline intensity, flame length, and spread distance are always for the direction of the spread calculations [SURFACE].

Wind is blowing upslope [SURFACE].

Results

Fuel Model	ROS (max)	Flame Length	Torch Tree Spot Dist	Scorch Height	Prob of Mortality	Firebrand Ignition
	ch/h	ft	mi	ft	%	%
gr2	78.5	6.5	0.4	29	80	40
tu1	6.3	2.6	0.4	4	6	40

End

BehavePlus 5.0.5 (Build 307)
Elkhorn 4 - High
Mon, Jan 28, 2019 at 07:36:47

Input Worksheet

Inputs: SURFACE, SPOT, SCORCH, MORTALITY, IGNITE

Input Variables	Units	Input Value(s)
Fuel/Vegetation, Surface/Understory		
Fuel Model		GR2, TU1
Fuel/Vegetation, Overstory		
Canopy Height	ft	15
Downwind Canopy Height	ft	60
Torching Tree Height	ft	50
Crown Ratio	fraction	.8
Mortality Tree Species		PINPON
Spot Tree Species		PSEMEN
D.B.H.	in	16
Fuel Moisture		
1-h Moisture	%	4
10-h Moisture	%	6
100-h Moisture	%	8
Live Herbaceous Moisture	%	30
Live Woody Moisture	%	60
Weather		
20-ft Wind Speed (upslope)	mi/h	24
Wind Adjustment Factor		.4
Air Temperature	oF	85
Fuel Shading from the Sun	%	20
Terrain		
Slope Steepness	%	30
Ridge-to-Valley Elevation Difference	ft	250
Ridge-to-Valley Horizontal Distance	mi	.5
Spotting Source Location		MW
Fire		

Number of Torching Trees 3

Notes

Run Option Notes

Maximum reliable effective wind speed limit IS imposed [SURFACE].

Calculations are only for the direction of maximum spread [SURFACE].

Fireline intensity, flame length, and spread distance are always for the direction of the spread calculations [SURFACE].

Wind is blowing upslope [SURFACE].

Results

Fuel Model	ROS (max)	Flame Length	Torch Tree Spot Dist	Scorch Height	Prob of Mortality	Firebrand Ignition
	ch/h	ft	mi	ft	%	%
gr2	153.9	9.0	0.5	58	80	76
tu1	11.3	3.6	0.5	7	12	76

End

Appendix H: Review of Laws

See attached smoke and county burn permits (county permits tied to smoke permits)

Appendix I: Exemptions, and Justifications

N/A

Appendix J: Landowner Permissions and Waivers

See TNC/Boy Scout MOU, Permission Waiver and Conflict of Interest Disclosure on file

BROADCAST PRESCRIBED FIRE SMOKE PERMIT APPLICATION

For help on individual boxes, hold mouse over an underlined word or see Forms Hover Hints.

Burn Name: Elkhorn 4 Prescribed Fire

Maximum Perimeter Acres for Year: 546

Permit Year: 2019

Renewal ?: NO

Allocation of Split Bill:

Payer	%	Payer	%
TNC	100%		

Administrative Unit ID(s): TNC

District or Zone:

Contact Person's Name: [redacted]

Phone: 970-667-4993

Email: [redacted]

Cell: 605-641-3526

Address: 418 8th St. SE Unit A3

City, st, zip: Loveland, CO 80537

For non-federal agencies or owners who are not approved significant users of prescribed fire:

Name and Address for Billing: The Nature Conservancy, 418 8th St SE Unit A3, Loveland, CO 80537

Landowner's Name: Longs Peak Council, Boy Scouts of America

Does this landowner own or manage ≥10,000 acres in Colorado? yes no X

Street Address of Project: 2331 County Rd 68C

City or Town: Red Feather Lakes

Local Fire Department Name: Poudre Canyon FPD

Fire Department's contact person for fire control permits: [redacted]

Fire Department contact person's email: [redacted]@poudrecanyonfiredistrict.org

If you are burning on private land or non-federal public land, you may need a fire control permit in addition to this application's smoke permit.

(All projects, continued:) Lat/Long or TRS: N 40° 44.5333' W 105° 29.633'

County(s): Larimer

Minimum Elevation: 7,333

Smoke Receptors	Miles from Edge of Burn	Direction from Burn	Concern: Day, Night, Both
Glacierview Estates	2.4	E/NE	Both
Livermore	15.5	E	Day

Red Feather Lakes	5.6	NNW	Day

Miles to nearest home, actual .33 and mitigated distance, if relevant: ____

Burn area within APCD's Mapped Smoke Sensitive Areas: All or part ____ none X

Purposes of project:

X	Ecosystem management	____	Site prep	____	Insect / beetle kill removal
____	Logging slash reduction	____	Wildlife	X	Range improvement
X	Hazard fuel mitigation	____	Pest control	X	Other: Watershed protection

Burn is part of a project that includes the following non-burning fuel treatments:

____	Invasive/exotic species management intended to reduce total site productivity		
____	Livestock grazing	____	Other mechanical treatment - all material left on site
____	Timber sale	____	Other mechanical treatment - some material removed
____	Firewood removal or sale	____	Other: ____

Non-burning fuel treatments alone would not meet resource objectives because:

____	Legislative or management restrictions	____	Safety concerns
X	Fuel to be burned has no commercial value.	____	Access or physical barriers
____	Not economically reasonable	____	Other: ____

Emission reduction techniques planned to reduce consumption and/or increase combustion efficiency:

____	Burn before scattered slash cures, with intent to leave it unburned indefinitely.		
____	Burn some fuel within unit(s) in piles at a separate time than broadcast ignition.		
X	Burn a mosaic. Expected area within perimeter to remain unburned	25	%
____	High moisture in heavy fuel and duff. Min. 1000-hr fuel moisture	____	%
____	Rapid mop-up. Give details in notes section above signature line.		

Emission reduction techniques planned to redistribute emissions:

____	Aerial ignition (may also increase combustion efficiency)
____	Second(+) fire on this site within historically typical interval
____	Backing fire only will be used (not strip head).
____	Recording weather station will be set out within the project boundary.
____	Other: ____

Brief description of fuels:

Grasses and timber litter.

Method(s) used to estimate fuel loads:

Colorado Front Range Photo Series

Site fuel load, average

Duff depth, inches	0	1-hr wood (< ¼" diam.), tons/acre	0
Litter depth, inches	1	10-hr wood (1/4 - 1") , tons/acre	1.2
Grass & forbs, tons/ acre	.2	100-hr wood (1-3") , tons/acre	2.9
Woody shrubs, tons/ acre	.1	1000(+) hr wood (>3") , tons/acre	0
		Tree canopy closure, percent	35 %

Ignition Method(s): Ground Only X Aerial Only or Both X

Might part of this fire's edge be left uncontained overnight on any unit(s)? yes X no

Wind directions NW, W, SW, S, SE, E or any. Except for burns in grass or brush at least 5 miles from an occupied home, if 'any' is requested then apply for a non-standard permit.

Health Message: Which format(s) will you use to distribute the required health message?

X Project-specific press release. Before using permit, send a copy to cdphe_fireapps@state.co.us.

Seasonal press release. Before using permit, copy to cdphe_fireapps@state.co.us.

Other:

APCD's neighbor letter, to all homes within miles

(Optional) Additional outreach planned or completed:

Notification fliers will be distributed to the local fire stations and within Glacierview Estates prior to the burn.

Smoke Contingency:

If unhealthful or excessive smoke impacts develop, implement the smoke contingency plan you describe below. If the smoke contingency plan does not mitigate smoke impacts by sunset of the next day, additional smoke mitigation measures will be developed in collaboration with APCD. If agreement on a collaborative plan cannot be reached and the plan implemented, APCD may rescind this permit immediately.

- Ignition operations will discontinue and the burn unit area already lit will be aggressively mopped up.
- AND advise APCD within 2 hours. See permit conditions for phone numbers.

Conditions category: 3C

Other Notes or Considerations:

Attachments:

None

Unit map(s)

Vicinity map

Smoke planning map, required for categories 2c, 3 and 4

Application for non-standard conditions

Other:

Applicant name (if emailed) or signature: [redacted]

Date: 1/23/2019

- Submit applications including any attachments
  (best) via email to cdphe_fireapps@state.co.us OR
  via fax att: [redacted] to 303-782-5493 or 303-782-0278 OR
  via mail to [redacted] APCD-TS-B1, CDPHE, 4300 Cherry Creek Drive South, Denver CO 80246-1530.
- This application is for standard permit conditions unless you attach a supplemental request for non-standard conditions. The broadcast worksheet summarizes standard conditions.
- Most significant users of prescribed fire are billed once a year. Most other permitees are billed within a couple weeks and for each permit.
- If you haven't heard back from APCD within a week please contact us to be sure your application arrived. It may take up to 30 days to review a completed application.

Burn Name **Elkhorn 4 Rx Fire**

2019 COLORADO BROADCAST SMOKE MANAGEMENT PERMIT

[x] If feasible, phone or email APCD 36(+) hrs before ignition. Also still submit a Notification of Ignition.

PROJECT-SPECIFIC PERMIT CONDITIONS:

Conditions category 3c rural Maximum annual perimeter acres 546

Ventilation[1]	Acres[2]	End Ignition by X Hour(s) before Sunset:	Wind Directions[3]
Excellent or Very Good	**546**	**1**	**E to NW**
Good	**300**	**2**	**E to NW**
Fair	**100**	**4**	**E to NW**
Poor	0	No burning	n/a

[x] Send a copy of your press release to cdphe_fireapps@state.co.us. The press release must include the required health message and be issued at least 7 days before the first day of ignition. If you use a seasonal press release for several projects, then in the cover email to APCD include a list of permit numbers to which it pertains.

[x] Burn ≥ 250 acres per day on at most 2 days in any 7-day period. Days when fewer acres are burned do not count as one of the two days.

GENERAL PERMIT CONDITIONS:

1. Notify the public at least 24 hours but no more than 120 hours before planned ignition. Include the name of a person whom the public may contact regarding the burn.
2. Send APCD a Notification of Ignition 2-48 hours before each day of expected ignition. Also notify the Local Air Quality Contact. For specifics, see the notification form.
3. Unless otherwise specified above, this permit is not valid during periods of publicly announced air pollution emergencies or alerts in the area of the proposed burn.
4. Use a National Weather Service forecast to establish compliance with the permit's weather conditions. Keep a copy of the forecast for 18 months.
5. The burn supervisor must have a copy of this permit on site.
6. Burn only clean forest fuel as described in the application. Burn no milled or treated wood.
7. Document visual monitoring of the burn's smoke.

[1] National Weather Service's forecast of day's best ventilation adjective
[2] Maximum daily black perimeter acres, including blacklining
[3] Range of acceptable transport wind directions, listed clockwise and precise to 2 letters.

8. This project has not been reviewed for fire safety or road or other transportation safety.
9. Send APCD a Daily Actual Activity form by 10:00 on the business day after each notified ignition day even if no burning occurred.
10. Send APCD an Annual Fire Activity form by March 1 of the following year, even if no burning occurs.
11. This permit is for compliance with state air pollution control requirements only. It is not a permit to violate any existing local laws, rules, regulations, or ordinances regarding fire, zoning, or building.
12. APCD may revise permit conditions at any time as circumstances warrant.

Questions: [redacted], 303.692.3224 or [redacted] 303.692.3255

APPLICATION, incorporated as part of this permit:

Burn Name Elkhorn 4 Prescribed Fire Maximum Perimeter Acres for Year 546

Permit Year 2019 Allocation of Split Bill:

Payer	%	Payer	%
TNC	100%		

Renewal? NO

Administrative Unit ID(s) TNC District or Zone

Contact Person's Name [redacted] Phone 970-667-4993

Email [redacted] Cell 605-641-3526

Address 418 8th St. SE Unit A3 City, st, zip Loveland, CO 80537

For non-federal agencies or owners who are not approved significant users of prescribed fire:

Name and Address for Billing The Nature Conservancy, 418 8th St SE Unit A3, Loveland, CO 80537

Landowner's Name Longs Peak Council, Boy Scouts of America

Does this landowner own or manage ≥10,000 acres in Colorado? yes ☐ no ☒

Street Address of Project 2331 County Rd 68C City or Town Red Feather Lakes

Local Fire Department Name Poudre Canyon FPD

Fire Department's contact person for fire control permits [redacted]

Fire Department contact person's email [redacted]@poudrecanyonfiredistrict.org

If you are burning on private land or non-federal public land, you may need a fire control permit in addition to this application's smoke permit.

(All projects, continued:) Lat/Long or TRS N 40° 44.5333' W 105° 29.633'

County(s) Larimer Minimum Elevation 7,333

Burn Name **Elkhorn 4 Rx Fire**

Smoke Receptors	Miles from Edge of Burn	Direction from Burn	Concern: Day, Night, Both
Glacierview Estates	2.4	E/NE	Both
Livermore	15.5	E	Day
Red Feather Lakes	5.6	NNW	Day

Miles to nearest home, actual .33 and mitigated distance, if relevant: _____

Burn area within APCD's Mapped Smoke Sensitive Areas: All or part ☐ none ☒

Purposes of project:

- X Ecosystem management
- _____ Logging slash reduction
- X Hazard fuel mitigation
- _____ Site prep
- _____ Wildlife
- _____ Pest control
- _____ Insect / beetle kill removal
- X Range improvement
- X Other: Watershed protection

Burn is part of a project that includes the following non-burning fuel treatments:

- _____ Invasive/exotic species management intended to reduce total site productivity
- _____ Livestock grazing
- _____ Timber sale
- _____ Firewood removal or sale
- _____ Other mechanical treatment - all material left on site
- _____ Other mechanical treatment - some material removed
- _____ Other: _____

Non-burning fuel treatments alone would not meet resource objectives because:

- _____ Legislative or management restrictions
- X Fuel to be burned has no commercial value.
- _____ Not economically reasonable
- _____ Safety concerns
- _____ Access or physical barriers
- _____ Other: _____

Emission reduction techniques planned to reduce consumption and/or increase combustion efficiency:

- _____ Burn before scattered slash cures, with intent to leave it unburned indefinitely.
- _____ Burn some fuel within unit(s) in piles at a separate time than broadcast ignition.
- X Burn a mosaic. Expected area within perimeter to remain unburned 25 %
- _____ High moisture in heavy fuel and duff. Min. 1000-hr fuel moisture _____ %
- _____ Rapid mop-up. Give details in notes section above signature line.

Emission reduction techniques planned to redistribute emissions:

- _____ Aerial ignition (may also increase combustion efficiency)
- _____ Second(+) fire on this site within historically typical interval
- _____ Backing fire only will be used (not strip head).
- _____ Recording weather station will be set out within the project boundary.
- _____ Other: _____

Brief description of fuels:

Burn Name **Elkhorn 4 Rx Fire**

Grasses and timber litter.

Method(s) used to estimate fuel loads:
Colorado Front Range Photo Series

Site fuel load, average

Duff depth, inches	0	1-hr wood (< ¼" diam.), tons/acre	0
Litter depth, inches	1	10-hr wood (1/4 - 1") , tons/acre	1.2
Grass & forbs, tons/acre	.2	100-hr wood (1-3") , tons/acre	2.9
Woody shrubs, tons/acre	.1	1000(+) hr wood (>3") , tons/acre	0
		Tree canopy closure, percent	35 %

Ignition Method(s): Ground Only [X] Aerial Only [ ] or Both [X]

Might part of this fire's edge be left uncontained overnight on any unit(s)? yes [ ] no [X]

Wind directions NW, W, SW, S, SE, E or [ ] any. Except for burns in grass or brush at least 5 miles from an occupied home, if 'any' is requested then apply for a non-standard permit.

Health Message: Which format(s) will you use to distribute the required health message?

[X] Project-specific press release. Before using permit, send a copy to cdphe_fireapps@state.co.us.

[ ] Seasonal press release. Before using permit, copy to cdphe_fireapps@state.co.us.

[ ] Other:

[ ] APCD's neighbor letter, to all homes within _____ miles

(Optional) Additional outreach planned or completed:

Notification fliers will be distributed to the local fire stations and within Glacierview Estates prior to the burn.

Smoke Contingency:

If unhealthful or excessive smoke impacts develop, implement the smoke contingency plan you describe below. If the smoke contingency plan does not mitigate smoke impacts by sunset of the next day, additional smoke mitigation measures will be developed in collaboration with APCD. If agreement on a collaborative plan cannot be reached and the plan implemented, APCD may rescind this permit immediately.

- Ignition operations will discontinue and the burn unit area already lit will be aggressively mopped up.
- AND advise APCD within 2 hours. See permit conditions for phone numbers.

Conditions category 3C

Other Notes or Considerations:

Burn Name **Elkhorn 4 Rx Fire**

Attachments:

None	Smoke planning map, required for categories 2c, 3 and 4
Unit map(s)	Application for non-standard conditions
Vicinity map	Other:

Applicant name (if emailed) or signature [redacted] Date 1/23/2019

Colorado Department of Public Health and Environment

Date completed 2/19/2019 Date received 1/23/2019

Date approved 2/20/2019 by [redacted] sets condits 1

ConditID	Units Name	Std	Details	Visit?	Report?
.0	all	Y	Flex,std	Y	N

Documentation of 2019 permit request:

from: [redacted]

to: "cdphe_fireapps@state.co.us" <cdphe_fireapps@state.co.us>

date: Jan 23, 2019, 2:04 PM

subject: Broadcast Burn Permit Application

Here is the form and associated maps for our broadcast burn application for the Elkhorn 4 Prescribed Fire. Thank you for your help last week over the phone. If you have any questions or need more information, please just let me know! Thank you! [redacted]

Additional Notes on Smoke mitigation from TNC:

from: [redacted]

to: "cdphefireapps - CDPHE, cdphe" <cdphe_fireapps@state.co.us>

date: Feb 19, 2019, 10:55 AM

subject: RE: Broadcast Burn Permit Application

Here's the additional information you requested. If more clarification is needed or additional information required, please let me know.

The reason for omission of burning with north winds would be because it would potentially lead to putting fire at the bottom of a slope. If the wind were to lessen or change directions it could lead to fire running up the slope. The effect of fire running up the slope could lead to fire intensities and effects that are undesirable.

This fuel loading in this unit is predominantly grass fuels that have been moderately grazed. These fuels tend to have fairly quick smoke dispersal with less residual smoke. I expect the most significant smoke impacts to be during daytime burn window with evening smoke impacts being less significant as smoke dispersal will be down drainage and away from Glacierview. This limits the smoke impacts to the daytime burning period where smoke dispersal will be greatly improved.

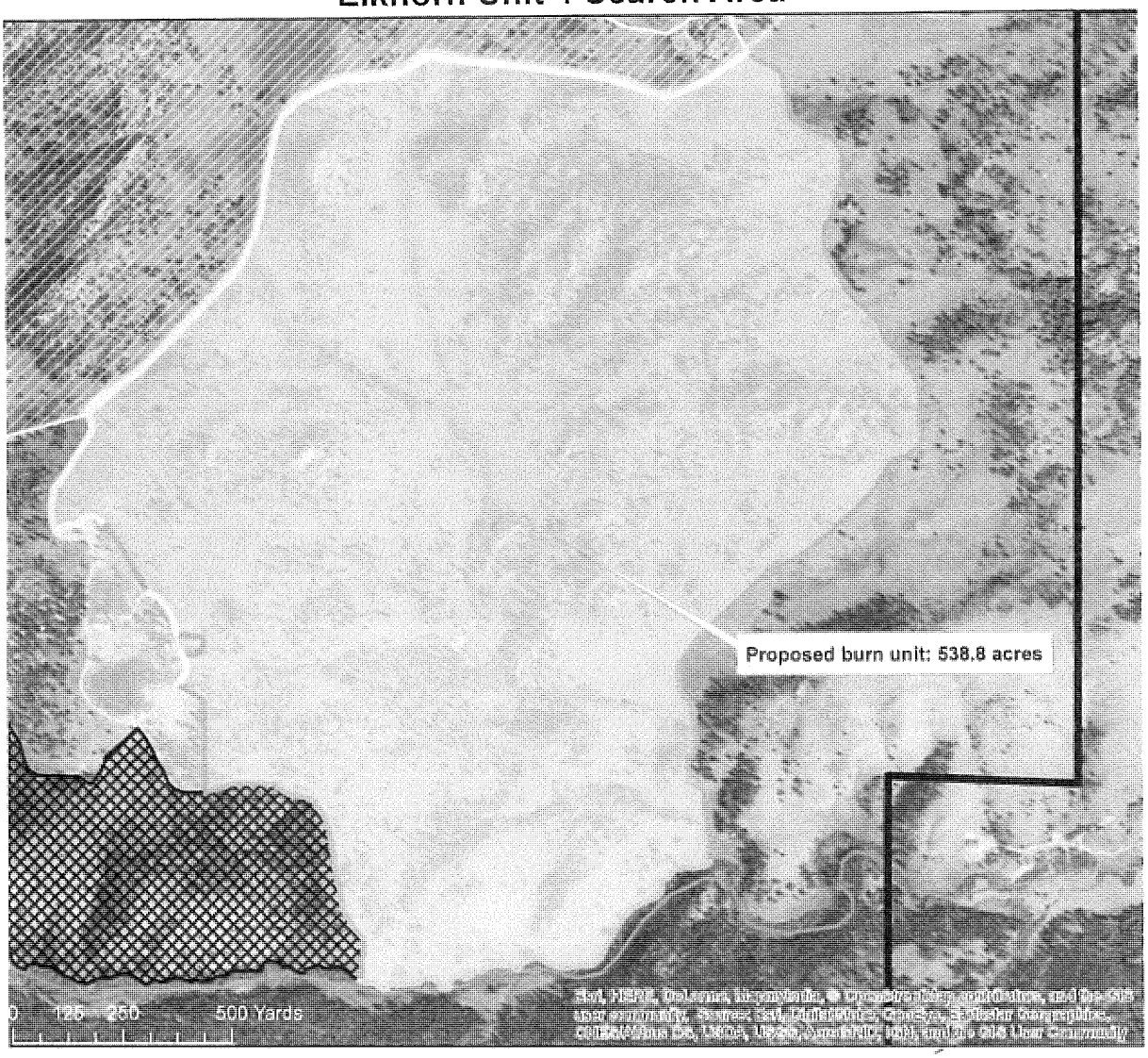
Also, the Glacierview neighborhood will also be notified using NextDoor. Historically, NextDoor has been used for burns previously done in the area with no complaints received.

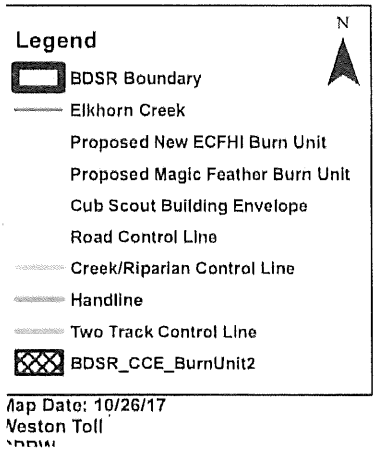
Non-Standard Notes:

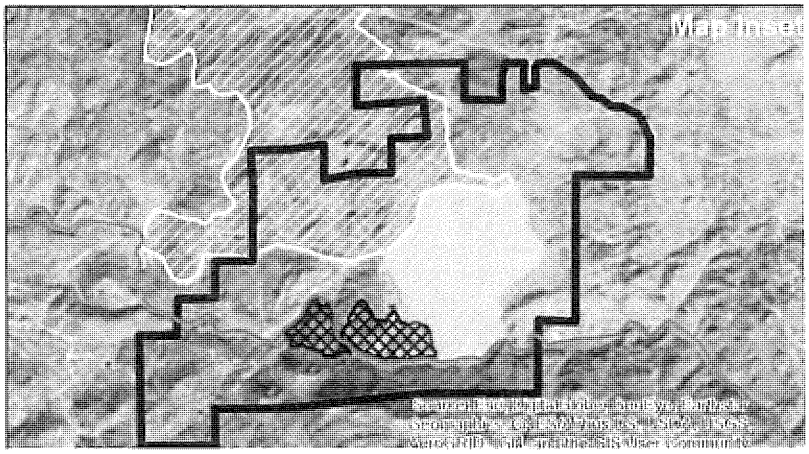
The original application had uncontained line overnight as a possibility. This was checked because the total acres for the project are 546 and the max daily acres at excellent/very good dispersion is 500 acres. The crew would not be able to blackline and burn the entire project in one day possibly leaving some uncontained line. Increasing the daily max by 46 acres for very good/ excellent dispersion would allow for the burn to be completed in one day. This should limit the length of time and possibly the amount of smoke impacts to the nearby residences. The uncontained line language has been removed from the application. CC 2/20/2019 SL Concurrence on 2/20/2019

Burn Name **Elkhorn 4 Rx Fire**

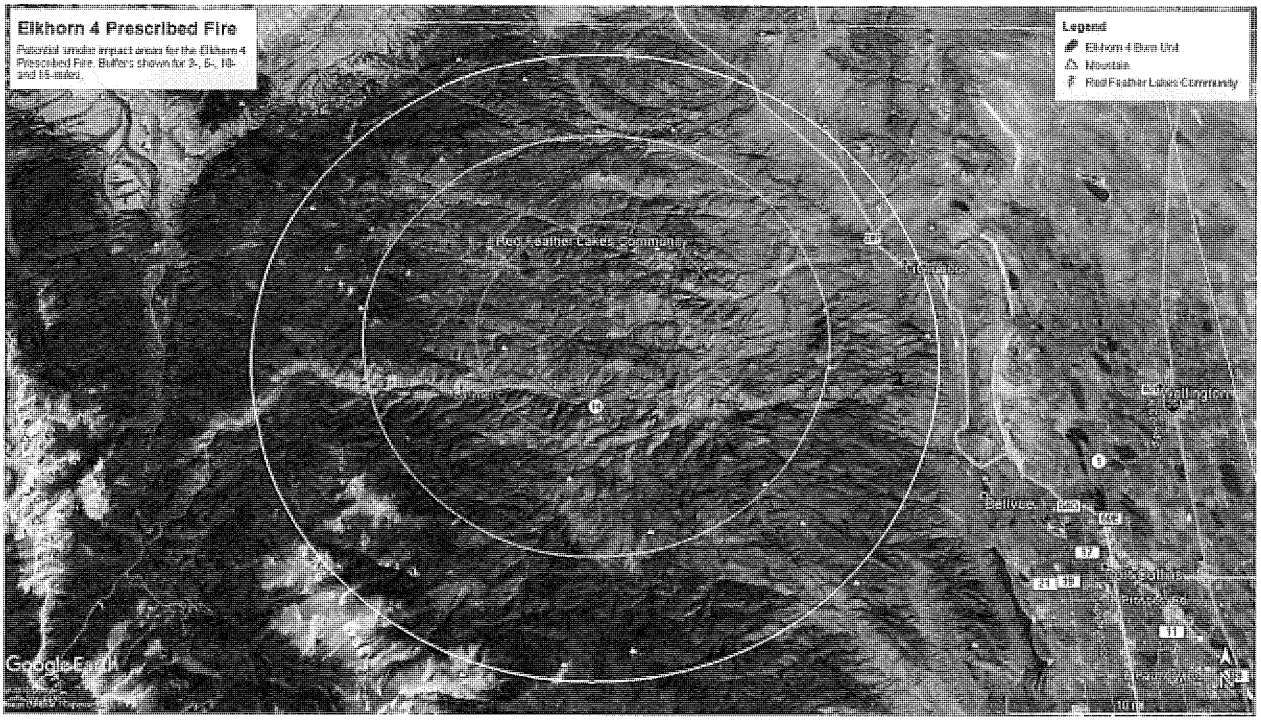
Elkhorn Unit 4 Search Area



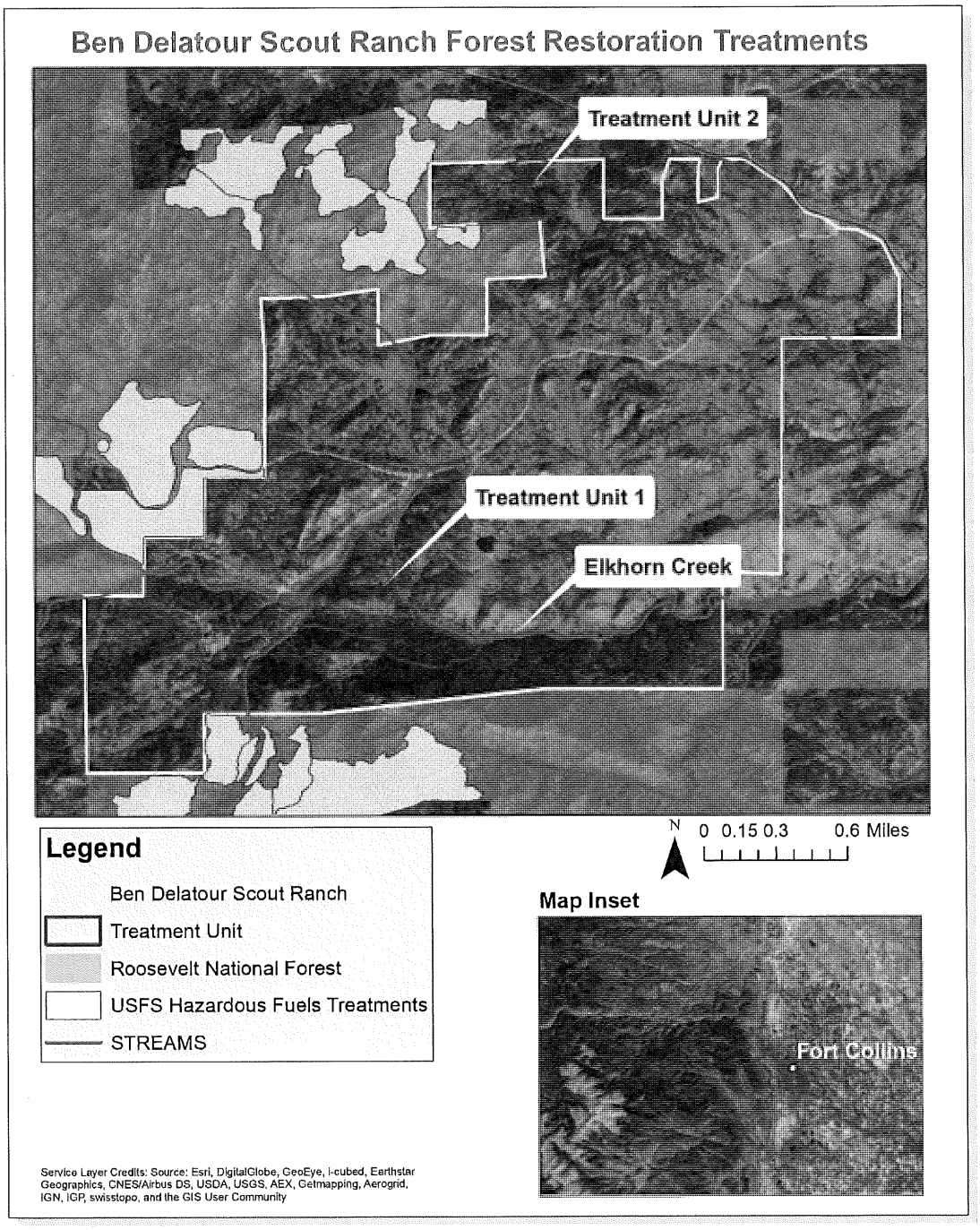




Burn Name **Elkhorn 4 Rx Fire**



Burn Name **Elkhorn 4 Rx Fire**



The Nature Conservancy

CONFLICT OF INTEREST DISCLOSURE FORM

It is the policy of The Nature Conservancy ("TNC") to identify actual, potential or perceived conflicts of interest in any situation in which TNC has a significant business interest. To assist TNC in complying with this policy, we request that all individuals and/or organizations that will be involved in a proposed transaction with TNC complete this form.

TRANSACTION

For **Real Estate transactions**, describe the property, its size and the type of deal (e.g., purchase or sale, gift, fee, easement, or other).

For **all other transactions**, describe the type of agreement (e.g., service contract, grant, etc.).

Agreement between TNC, and Billy Riley (Longs Peak Council, Boy Scouts of America Representative) to conduct forest health and restoration projects on property such as mechanical thinning, handpiling, monitoring, and prescribed fire operations.

Total dollar value of transaction: $ NA

[For cashless barter transactions, provide the value of the benefits being provided each party.]

PARTIES

Please check the box to indicate the type of party for which this form is being completed, list all individuals and/or organizations that will be involved in this transaction, then complete the applicable section that follows. An "organization" includes a for profit corporation, partnership, trust, estate, joint venture, limited liability corporation, professional corporation or unincorporated entity of any kind, a foundation, public board, commission, and a 501(c)(3) or other charitable organization.

☐ **Individuals (list all, then complete Section 1):** _____

☒ **For Profit Organizations (list all, then complete Section 2):** _____

☐ **Not for Profit Organizations (list all, then complete Section 3):** _____

Note: Please refer to the attached list of TNC key employees and current and prior members of TNC's Board of Directors when completing the rest of this form.

1. **INDIVIDUALS:**

Please check all that apply and attach an explanation for any "Yes" answers.

	Yes	No
a. Are you now, or have you been at any time since July 1, 2011, a **TNC "key employee"** or a **member of the TNC Board of Directors** as identified on the attached list?		X
b. Are you now or have you been in the past 12 months a **TNC employee** (other than a key employee), a **Chapter Trustee** or member of a **Country Program Advisory Council**?		X
c. Have you **contributed to TNC** U.S. $5 million or more during the current year, or U.S. $25 million or more, cumulatively, in this year and the prior five (5) years?		X
d. To your knowledge, are you a **Family Member** of any individual identified in paragraph a, b or c above? (For these purposes, the term "Family Member" includes the individual's spouse, ancestors, brothers and sisters (whether whole or half-blood), children (whether natural or adopted), grandchildren, great-grandchildren, and spouses of brothers, sisters, children, grandchildren, and great-grandchildren; and any person with whom the covered person shares living quarters under circumstances that closely resemble a marital relationship or who is financially dependent upon the covered person.)		X

2. **FOR PROFIT ORGANIZATIONS:**

Please check all that apply and attach an explanation for any "Yes" answers.

	Yes	No
a. Has the organization made total aggregate contributions to TNC (i) during the current year of U.S. $5 million or more, or (ii) during the current and last five (5) years of U.S. $25 million or more?		X
b. Now or at the time of the proposed transaction, does or will any **TNC employee (includes former TNC employee who left within the past 12 months); member of TNC's Board of Directors or key employees (see list attached); or TNC Chapter Trustee or Advisory Council member (includes former ones who served within the last year)**, individually or collectively with other such persons (including **Family Members** of such persons; see Section 1(d) above for definition of Family Members), **own more than 35% of the stock or value of the organization** (directly or indirectly), or have the legal or *de facto* **power to exercise a controlling influence over the organization's management or policies**, e.g., as an officer, key management employee, board member or partner?		X
c. Now, or at the time of the proposed transaction, have or will any members of **TNC's current Executive Team or Board of Directors** (see attached list) serve as: • an officer, director, trustee, key employee, or partner; or • if the entity is a limited liability corporation, a member; or • if the entity is a professional corporation, a shareholder?		X

3. **NON PROFIT ORGANIZATIONS**

Please check all that apply and attach an explanation for any "Yes" Answers.

	Yes	No
a. Now or at the time of the proposed transaction, have or will any **TNC employee (includes former TNC employee who left within the past 12 months); member of TNC's Board of Directors; Chapter Trustees, Country Program Council Advisors (includes former ones who served within the last year)**, or **Family Members** of any of these, individually or collectively, **have the ability to control management of the entity**? See Section 1(d) above for definition of Family Members.		X

Individuals who in the current fiscal year (FY17) are or during the preceding five fiscal years have been a Conservancy "key employee" or a member of the Board of Directors:

Key Employees
Current Executive Team

[redacted]

[redacted]

Other/Former Key Employees

[redacted]

[redacted]

Current Board of Directors (FY '17)

[redacted]

Prior Board Members (FYs '12-'16)

[redacted]

SIGNATURES

The undersigned certifies that the information in the disclosure form is true and correct to the best of his/her knowledge.

Signatures for Organizations:

Name of Organization: Longs Peak Council, INC

Signature: [redacted]

Printed name of person: [redacted]

Title: Camping/Operations Director

Date: 7 OCT 16

Signatures for Individuals

Signature: _____

Printed name: _____

Date: _____

Signature: _____

Printed name: _____

Updated July 2016

COLORADO
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Compliance & Professional Standards Office

Elkhorn Creek Unit #4 Prescribed Fire Review

Appendix B

Elkhorn Creek Unit #4 Fire Effects Monitor (FEMO) Summary Report [Names Redacted]

Elkhorn4 Prescribed Fire – Fire Effects Summary

October 15-16, 2019

Introduction

The Elkhorn4 Prescribed Fire took place on the Ben Delatour Scout Ranch in Larimer County, CO, and was hosted by The Nature Conservancy of Colorado with an array of participants from different organizations. The unit was 505 acres divided into two sub-units measuring 380 (Alpha unit) and 125 (Bravo unit) acres. Both sub-units were considered first-entry burns and control lines were a combination of road systems, handline, plumbed hose lay, and natural vegetation breaks. Monitoring plots were previously installed by the Colorado Forest Research Institute (CFRI) throughout both sub-units and will be read within one year post-burn to determine first order effects and overstory mortality.

Resource objectives:

1. Reduce conifer regeneration (<6” DBH) by at least 20% within 1 year of the burn.
2. Reduce 1-, 10-, and 100-hour fuels by 30% immediately post-burn.
3. Limit mortality of trees greater than 10” DBH to 20% or less.
4. Increase native herbaceous vegetative cover by 20% within 2 years of the burn.

Alpha Unit – October 15 -- FEMOs: [redacted] (Z), [redacted] (A)

Two FEMOs took observations over the course of Alpha Unit operations, each taking a separate division (A and Z). FEMOs took weather together at the test fire location to calibrate weather collection devices and then monitored their respective divisions separately. The Spot Weather Forecast for the day predicted max temperatures around 56°, minimum humidity around 21%, and variable surface winds due to conflicting air masses aloft. Fire behavior was predicted at the higher end of the prescription, but still within desired range and behavior was predicted to be within containment capabilities.

The test fire was initiated at 1204 in the northeast corner of the unit near DP 10. Initial fire behavior had flame lengths of 1-3' (head/flanking) and <1' (backing) in grass with shifting winds of 5-10 MPH. Fire produced flame lengths of 4-6' in brush. The Burn Boss trainee called the fire a "go" at 1220 after approving conditions.

Following the test fire, firing teams continued along the northern and eastern unit boundaries. Divisions mostly worked independently; Alpha blacklined from DP 10 to DP 30 to DP 110 and Zulu blacklined from DP 10 to DP 120 to DP 110 with minimal interior igniters. Fire carried well in grass and shrubs and would cause some individual torching in juniper and fir trees. Flame lengths observed in grass, litter, and shrub fuels were under 6' for the duration of the firing period. Mature Ponderosa pine trees were resistant to torching and fire was observed climbing into canopies only when heavy brush or ladder fuels were adjacent to low branches. Shifting winds slowed firing operations due to unpredictable heat pulses and fluctuating flame fronts. Fire carried into the center of the unit on its own without interior lighting teams and would make short runs up drainages with wind/slope alignment. Topography and winds tended to push fire from east to west and from south to north within the unit. There was little spotting across the line and holding had no trouble on either division. Both firing teams produced heavy smoke with dispersed columns leaning primarily to the SW. Fire behavior quickly moderated beginning at 1700 and firing teams tied in together at DP 110 at 1730.

Immediate post-fire assessment is that resource objectives were met regarding minimizing overstory mortality, reducing woody surface fuels, and stimulating herbaceous vegetation response.

Weather Summary ([redacted] observations)

Time	Location	Dry Bulb (°F)	RH (%)	Winds (MPH)	% Cloud Cover	Fine Dead Fuel (unshaded / shaded %)	Prob. Of Ignition (unshaded / shaded %)	Notes
1045	DP 10	46	43	3 (5), NE	1	9/12	30/20	
1140	DP 10	54	18	7 (13), SSW	1	5/7	60/40	
1300	DP 10	60	11	5 (10), var W	1	3/6	80/50	
1350	DP 20	54	39	4 (7), var SE	1	7/10	40/30	
1500	Between DP 20 & 30	54	38	3 (8), ENE	1	7/10	40/30	
1600	Between DP 30 & 80	50	40	3 (6), E	1	8/11	40/20	
1700	DP 100	48	43	2 (6), SSE	0	9/11	30/20	

Bravo Unit – October 16 -- FEMO: [redacted]

Although smaller than the previous day's unit, the Bravo Unit was identified as being more technical for firing teams. The Spot Weather Forecast predicted > 50% cloud cover for the day, a high temp of 67^{o}, a minimal RH of 12%, and west winds 9-15 MPH with gusts around 20. Weather conditions that morning included heavy cloud cover and consistently strong winds beginning around 0430 that calmed by 0930.

The test fire was initiated at 1121 southwest of DP 30 with weather conditions at that time near the predicted high temp and low RH for the day with high cloud cover. Initial fire behavior produced flame lengths of 1-3' and moderate rate of spread (14 chains/hour) in grass with 3-6' torching in juniper and brush. Winds were slightly stronger than the previous day but mainly terrain-dominated and more predictable. The Burn Boss trainee approved of the observed fire behavior and fire effects and continued forward with operations.

The Zulu Firing team planned to build a blackline along the eastern edge of the unit and began to build black adjacent to the two-track that designated the eastern unit boundary. Zulu firing moved slowly to avoid throwing spots across the eastern line and burned out between the two-track and a willow-lined creek, stopping just short of DP 40. At 1140, the heavy cloud cover began to thin but fuels in full sun were not observed to have an immediate uptick in fire behavior. At 1150, dark smoke was reported near DP 80 from the previous day's ignitions and resources were sent to scout and patrol.

Beginning at 1215, Alpha's firing group established fire on the ridgeline just north of DP 40. Fire backed very slowly from the ridgetop in all directions with low flame lengths (1-2') with occasional torching in brush and juniper. Fire was somewhat protected on the knob from prevailing winds and smoke was observed leaning to the ESE. At 1240, the FEMO moved west along the south line to start the Mark-3 pump that provided water to the southern hoselay. She set-up the pump and opened the hoselay back to DP 40 by 1340 where she then observed fire had backed down to within 200' of the southern line from the ridge on slopes with lighter fuels.

After the 1430 weather observation in the drain, the FEMO joined the Alpha firing team on the top of the ridge to gauge interior weather and fire behavior conditions. Winds were measured as averaging 4 MPH in the drain while gusts of 23 MPH were recorded at the top of the ridge. Flame lengths of 6-8' were observed in brush and ROS in grass and pine litter was high (+20 ch/hr in grass). The high winds and exposed fine fuel moistures were at the high-end of the prescription which was communicated to the Burn Boss trainee by radio. Burn Boss trainee acknowledged the increase in potential fire behavior and began a patrol of the east holding line. Fire behavior had picked up in the fire backing down the ridge from Alpha's ignition pattern. With increased winds, fire would back down in grasses and make a flanking push when western wind gusts would align in the drainage. Some torching was observed in mature PIPO, but fire behavior was still producing desirable ecological results.

Resources picked up a spot east of DP 30 and interior ignition teams held up operations. The initial spot was in 1000 HR dead and down fuels and was easily contained. While patrolling for more spots along the east line, two 10'x20' wind-driven spots were found in grass between DP 30 and 40. Before adequate resources could arrive to the location, the spots quickly grew together and made an eastern run in grass with wind/slope alignment. This spot was declared an escape wildfire within a half hour and aerial resources were ordered. Prescribed operations transitioned into full-suppression and fire was checked-up where possible.

Weather Summary ([redacted] observations)

Time	Location	Dry Bulb (°F)	RH (%)	Winds (MPH)	% Cloud Cover	Fine Dead Fuel (unshaded / shaded %)	Prob. Of Ignition (unshaded / shaded %)	Notes
0945	DP 30	56	20	Light, W	80	6/8	50/40	
1050	DP 40	62	17	2 (8), terrain-driven	70	5/7	60/40	RH of 14% recorded at 1120 at test fire location
1200	Between DP 30 and 40	62	14	2 (6), WSW	80	3/6	80/50	
1330	Between DP 40 and 50	65	14	2 (8), W	70	3/6	80/50	Cloud cover reduced at 1350
1430	DP 50	70	13	4 (10), W	40	3/6	80/50	Gusts of 23 MPH recorded on ridgetop

Photos

Image 1. Test fire for Elkhorn4(a) at DP 10; time was 1210.

Image 2. Elkhorn4(a) - Division Zulu on blacklining operation between DP 10 and DP 120; time was 1330.

Image 3. Elkhorn4(a) - From Zulu Division near DP 120 looking south to Alpha firing operation near DP 80; time was 1500.

Image 4. Elkhorn4(a) - Fire effects near DP 100 as firing teams tied in; time was 1730.

Image 5. Test fire for Elkhorn4(b) at DP 30; time was 1130.

Image 6. Elkhorn4(b) - Fire behavior during Zulu blacklining operation; time was 1145.

Image 7. Elkhorn4(b) – Wet-lining in DP 30 meadow; time was 1145.

Image 8. Elkhorn4(b) – Alpha's fire backing downhill at 1350.

Image 9. Elkhorn4(b) – Same location with decreased cloud cover at 1410.

Image 10. Elkhorn4(b) – Fire behavior from Alpha's ignitions along ridgeline shortly before first spots were located; time was 1500.

Report prepared by [redacted]

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Elkhorn Creek Unit #4 Prescribed Fire Review

Appendix C

Fire Weather Review Report

Appendix C – Fire Weather Review Report

Submitted by Timothy O. Mathewson, Fire Meteorologist, DOI/BLM

Fire Weather Executive Summary: Key Meteorological Factors and Findings

1. Antecedent conditions leading up to the Elkhorn Creek Unit #4 Prescribed Fire ("Elkhorn #4 Rx Fire") were characterized by below average precipitation, periods of above average temperatures, and frequent episodes of low humidity combined with wind. A meager monsoon season resulted in total precipitation amounts from August 1 thru October 14, 2019 of just over an inch (1.09") for the area, including 2-3 inches of snow on October 10-11, 2019. Though these amounts are much higher than what occurred in other parts of the state of Colorado during the same period, this value is below the seasonal average. Additionally, climate data from Red Feather RAWS (located 5.5 miles NW of the Elkhorn Creek Unit #4) provide insight on the frequency and strength of low humidity and wind episodes that occurred in the period immediately preceding the prescribed fire operations (September 1-October 14, 2019). During that approximately 6-week period, wind data analysis shows 23 of the 44 days above the 90th percentile in terms of wind gust speeds. Many of these windy periods combined with near or record low relative humidity (RH), and in some cases, minimum RH had dropped into the single digits with poor overnight recovery. The corresponding Evaporative Demand Drought Index (EDDI) for a 4-week period ending on October 9, 2019 identified periods in which the index ranged from 90th-98th percentile in terms of the combination of temperature, humidity, wind speed, and solar radiation.

2. Meteorological analysis for October 15th and 16th indicates a substantial change in temperatures and humidity, and increase in wind from the Day 1 operational period to the Day 2 operational period. On Day 1, on-site FEMO observations indicate RH dropped to 11% by 1300 hrs, 10% lower than was forecasted. However, a stationary frontal boundary shifted west and into the Elkhorn Creek Unit #4, supporting cool temperatures, much higher RH (35%-40%) and variable or shifting wind flow for the remainder of the operational period that day. In comparison, the Red Feather RAWS located 5.5 miles to the northwest was positioned just west of the frontal boundary and experienced dry and gusty conditions during the entire operational period (16% RH and gusts to 33 mph). On Day 2, dry and breezy conditions developed during the early morning hours, likely related to an upper air ridge and warm front passage through the Elkhorn Unit as the stationary front weakened and upper trough exited east. Supporting area observations showed a striking drop in RH just after midnight local time with values in the 20% range. The FEMO Summary Report (Appendix D) also noted gusty winds at 0430 hrs until about 0930 hrs, with the first on-site observation taken at 0945 hrs. The 0945 hrs observation yielded a dry-bulb temperature of 56°F, RH 20%, and a light westerly wind. The Day 2 operational period started about 10 degrees warmer and 23% drier (possibly more) than the previous day's operational period.

3. Sustained wind speeds that occurred on October 16, 2019 were within the prescription written in the Elkhorn Creek Unit #4 Prescribed Fire Plan ("Elkhorn #4 Rx Fire Plan"). On-site FEMO observations measured sustained eye-level winds of 2 to 6 mph, depending on the time of day. When converting observed eye-level wind to the 20-ft wind, using the same wind adjustment factor as the burn plan of 0.4, the values range from 5 to 15 mph. These values would be in the "Low" to "Preferred" range as indicated by Element 7 of the burn plan. However, multiple fireline personnel indicated during interviews that the forecast 20-ft wind speed was on the "high" end of the prescription in the prescribed fire plan. Interviewees often referenced the "20 mph" wind gust in the spot forecast as being at the "high" end of the prescription, yet no wind gust breakpoints were included in the plan, only sustained wind speeds. Moreover, multiple fireline personnel interviewed did not decipher between sustained 20-ft wind speed and gusts, treating them as one and the same.

4. Related to Finding #3 above, sustained wind speed breakpoints as written in the prescribed fire plan were unrealistic and, in some cases, would be characterized as rare wind events based on historical climate data analyzed for the area using the Red Feather Remote Automated Weather Station (RAWS) as a surrogate (located 5.5 miles from Elkhorn Creek Unit #4). Specifically, Element 7 of the plan provides sustained wind speeds for "Moderate" and "High" ends of 18 mph and 24 mph, respectively. These values equate to the 97th and 99th percentiles (rare occurrence). The plan's "out" of prescription sustained wind criteria of 25 mph occurs only 0.73% of the time in September through mid-October.

5. All but one of the fireline personnel interviewed did not differentiate between eye-level wind observations measured by the FEMO versus the 20-ft wind speeds contained in the spot weather forecasts. Moreover, all but one fireline personnel referred to the 20-ft wind speed and eye-level wind speed as equivalent or interchangeable. For example, the FEMO documented an eye-level wind gust of 23 mph at the ridgetop during the 1430 observation time on Day 2. When the interviewees were asked whether they felt the spot forecast accurately reflected on-site wind observations, all but one felt the spot forecast lined up with observations. The consensus was that the 23-mph gust taken at eye-level, corresponded well to the gust speed of "around 20 mph" in the spot forecast. However, when converting the eye-level wind gust of 23 mph to the 20-ft wind gust speed using the 0.4 wind adjustment factor used in the prescribed fire plan, the 20-ft wind gust equates to 57 mph. Analysis of other area observations sites for the same time suggests that this calculation likely overestimates the 20-ft wind speeds for the Elkhorn Creek Unit #4 that day. But, according to other weather stations in the area, including Red Feather RAWS, 20-ft wind gusts over 30 mph were frequent on October 16, 2019 as they were on October 15, 2019 just west of the Elkhorn Creek Unit #4 and stationary frontal boundary.

6. The spot forecasts provided by the National Weather Service- Boulder, requested on the evening of October 15 and the morning of October 16 for Day 2 operations underestimated 20-foot wind speed **gusts** by at least 10 mph, and possibly more.

Supporting Climate-Fire Weather Analysis:

Seasonal Severity and Antecedent-Conditions from September 1, through October 14, 2019, Prior to Prescribed Fire Operations.

The intent of this section is to provide antecedent conditions leading up to prescribed fire operations of Elkhorn Creek Unit #4 Prescribed Fire on October 15 and16, 2019. This analysis will provide large- and small-scale climatology, analysis of weather patterns and observations, and evaluate the fire weather variables and breakpoints contained in the Elkhorn #4 Rx Fire Plan.

Heavy winter snowpack in 2019 delayed the onset of wildfire season across Colorado, allowing prescribed fire activities to continue into mid-summer. Weather patterns supported below average temperatures and above average precipitation (both rain and snow) through much of June 2019, as shown in Figures 1 and 2 (Mean Temperature Anomaly and Percent of Average. Precipitation for June of 2019, respectively). A stronger than average northern stream jet, and related extended cold and wet period into the late spring and early summer of 2019, likely impacted the timing and strength of the North American Monsoon; a weather pattern that develops over the Desert Southwest and promotes an increase in humidity and beneficial precipitation from thunderstorm activity for much of Colorado from early July into late August or early September. Only 1.09 inches of rainfall was recorded at the Red Feather Remote Automated Weather Station (RAWS) from August 1, 2019 to October 14, 2019.

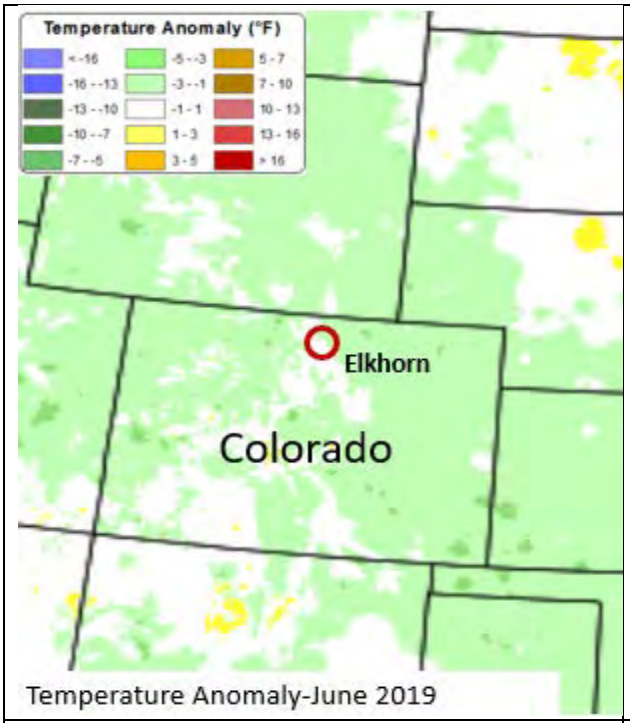

Figure 1. Mean Temperature Anomaly (PRISM Data-Oregon State University) for June 2019. Warm colors (orange and reds) indicate above average temperatures and cool coolers (greens and blues) indicate below average temperatures.

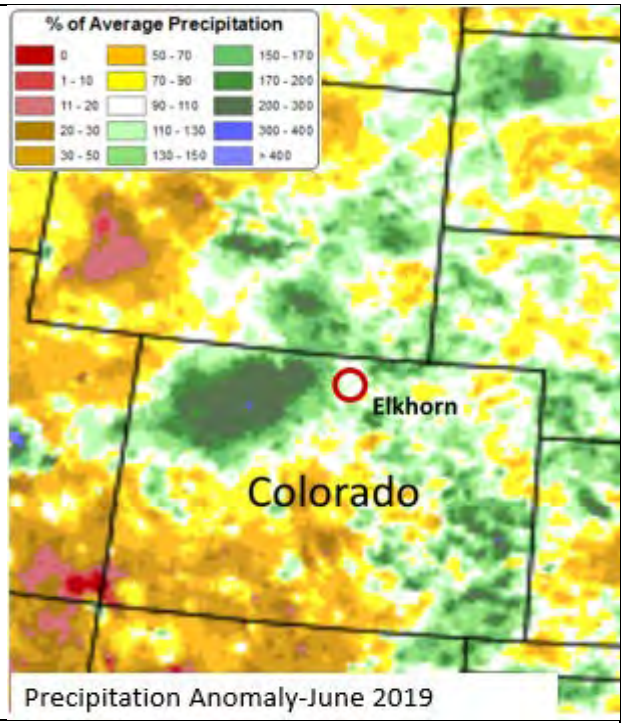

Figure 2. Percent of Ave. Precipitation (PRISM Data-Oregon State University) for June 2019. Yellow and red colors indicate below average precipitation with greens and blues indicative of above average precipitation.

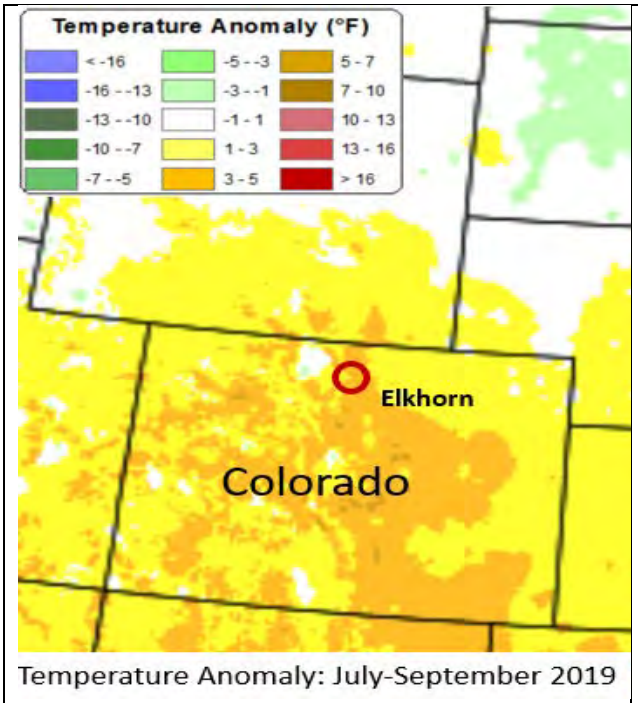

Figure 3. Mean Temperature Anomaly (PRISM Data-Oregon State University) for July-September 2019. Warm colors (orange and reds) indicate above average temperatures and cool coolers (greens and blues) indicate below average temperatures.

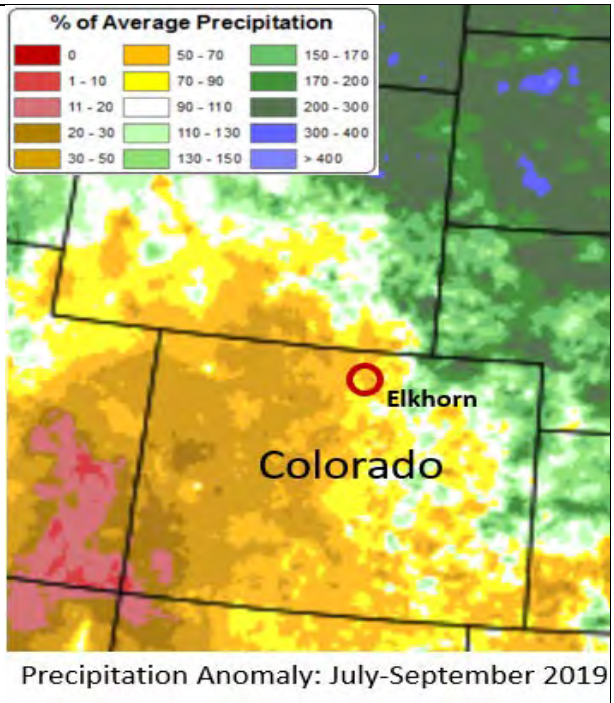

Figure 4. Percent of Ave. Precipitation (PRISM Data-Oregon State University) for July-September 2019. Yellow and red colors indicate below average precipitation with greens and blues indicative of above average precipitation.

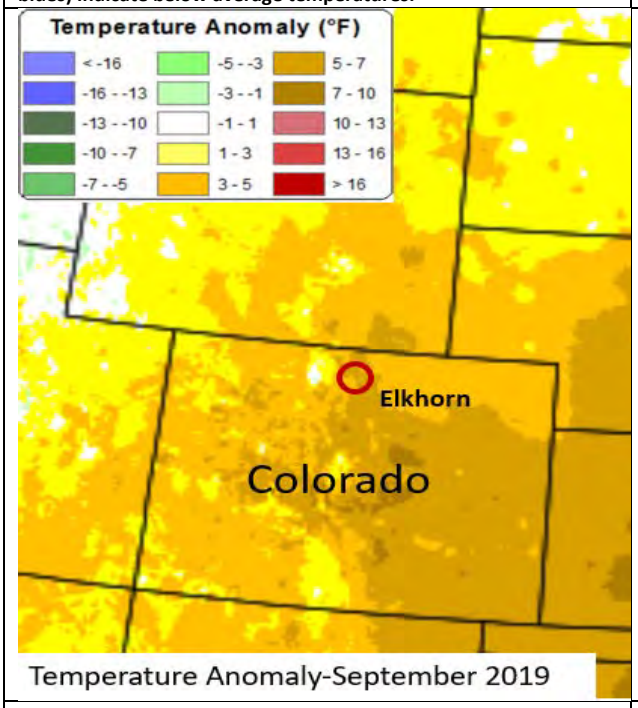

Figure 5. Mean Temperature Anomaly (PRISM Data-Oregon State University) for September 2019. Warm colors (orange and reds) indicate above average temperatures and cool coolers (greens and blues) indicate below average temperatures.

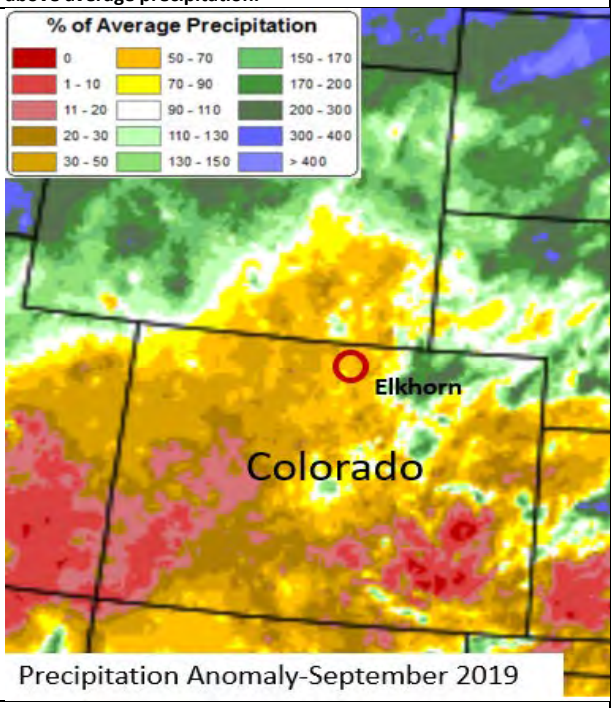

Figure 6. Percent of Ave. Precipitation (PRISM Data-Oregon State University) for September 2019. Yellow and red colors indicate below average precipitation with greens and blues indicative of above average precipitation.

U.S. Drought Index- Colorado Drought Index for August 6 and October 15, 2019

These long-term temperature and precipitation trends, especially during the second half of the summer (August and September) resulted a slight intensification of drought conditions across Colorado, with *D0- Abnormally Dry* across Larimer County and the Elkhorn Creek Unit #4 (Figures 7 and 8).

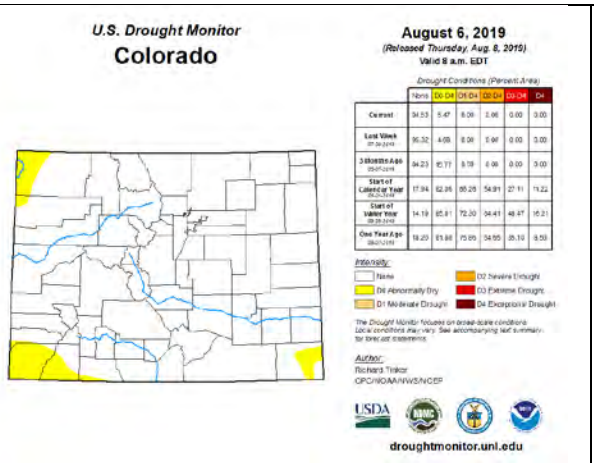

Figure 7. U.S. Drought Monitor- Colorado August 6, 2019. Map shows no drought category for Larimer County or the Elkhorn Unit.

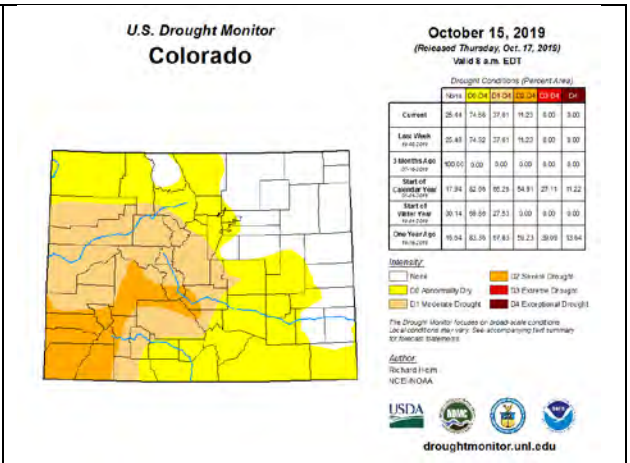

Figure 8. U.S. Drought Monitor- Colorado October 15, 2019. Abnormally Dry (D0) indices for Larimer County and Elkhorn Unit.

Evaporative Demand Drought Index (EDDI)-

The Evaporative Demand Drought Index (EDDI) is calculated from temperature, humidity, wind speed and solar radiation and can be utilized for early warning and flash drought detection (conditions that may not be represented in the standard U.S. Drought Monitor). EDDI is not a drought prediction, but does illustrate evaporative demand, impacts on vegetation, and potential for drought emergence. EDDI values (Figure 9) based on a 4-week period ending October 9, 2019, range from the 90th – 95th percentile (ED2-ED3) meaning evaporative demand was elevated for the period, a result of warm, dry, and windy conditions that frequented the area in September and early October.

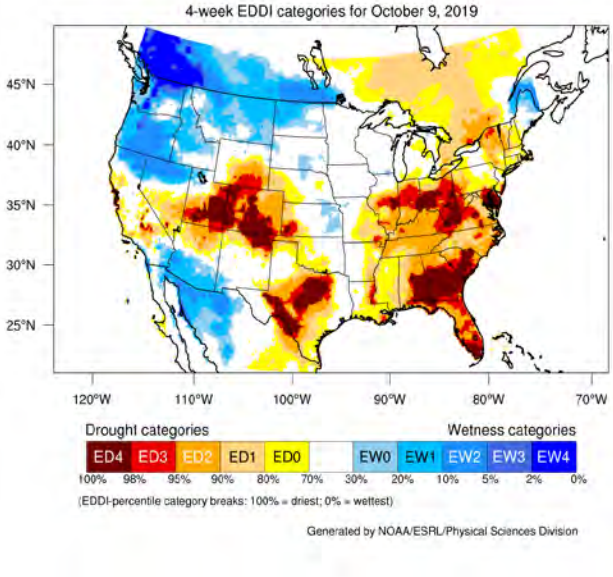

Figure 9. Evaporative Demand Drought Index for a 4-week period ending October 9, 2019.

October 10-11, 2019 Precipitation Event-

On October 10-11, 2019, a low pressure system moved across the Northern Rockies and into the Upper Mid-West (depicted in Figures 10 and 11). The path of the storm supported a very cold airmass for the time of year across northern Colorado, with maximum daytime temperature readings only reaching the mid-20s on the 10th and around 40 degrees on the 11th near the Elkhorn Creek Unit #4. Precipitation fell in the form of snow, with local observations ranging from 2 to 3 inches of snowfall and water equivalency values ranging from 0.10”-0.12” (shown in Figures 12 and 13) Additionally, 0.11” of rain had fallen about 9 day prior.

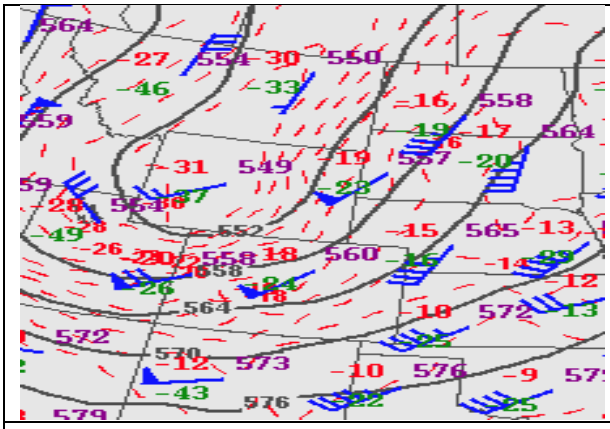

Figure 10. 500-mb Chart for October 10, 2019- 0600 hrs.

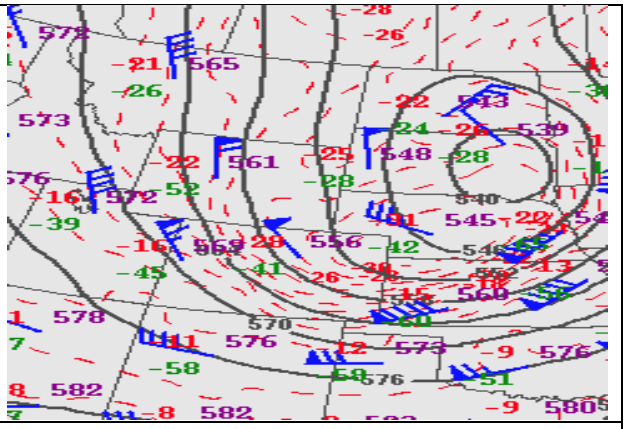

Figure 11. 500-mb Chart for October 11, 2019- 0600 hrs.

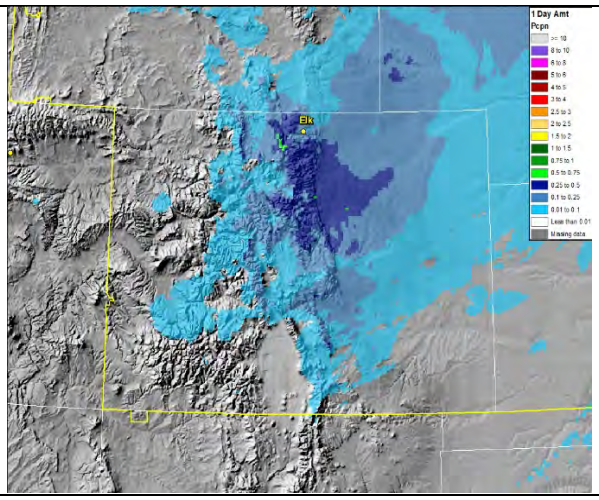

Figure 12. Precipitation Analysis for 10/10-11/2019- 5-6 Day Prior to Burn

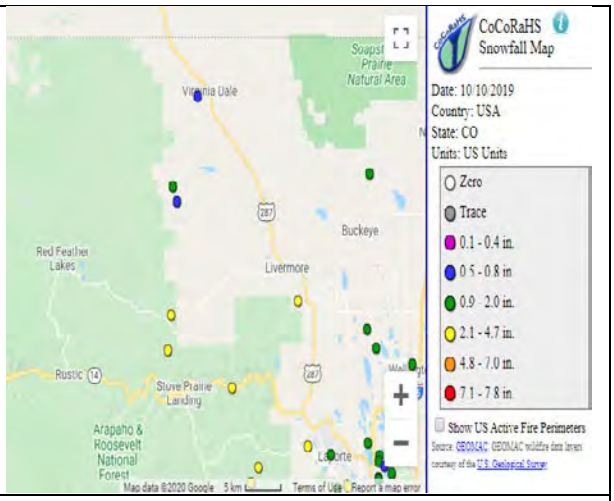

Figure 13. CoCoRaHS Snowfall Map for 10/10/2019- 5-6 Day Prior to Burn

In the wake of the storm system in the afternoon of October 11, much drier air began filtering into the area. Despite the precipitation and cooler temperatures the night before, minimum RH values managed to drop into the upper teens during the afternoon. This occurrence marked the first day of several where minimum RH values dropped at or below critical thresholds (15% or less). Importantly, poor to moderate RH recovery during the overnight hours was also noted during this time (22%-35%), despite precipitation that was received on the 10th and 11th.

Warming trends were also noted during this time with daytime maximum temperature readings rising into the mid to upper 50s, which is near the seasonal averages for the area.

Long-term Humidity and Wind Trends Prior to Prescribed Fire Operations-

Humidity and wind are critical factors in the fire environment, with both playing a major role in fuel dryness, rates-of-spread (ROS), and spotting. Local observations help establish recent weather trends including impacts from recent weather patterns. This insight provides baseline information on weather patterns or climatology for a prescribed fire unit prior to operations, while also considering other critical factors such as aspect, elevation, vegetation type, exposure, sheltering, and seasonality (to name a few). Remote Automated Weather Stations (RAWS) deliver valuable standardized information for local, state and federal fire organizations for the sole purpose of estimating fire environment conditions and potential fire behavior. According to the National Interagency Fire Center (NIFC), there's approximately 2,200 RAWS strategically located throughout the United States, with approximately 84 in Colorado and 4 in Larimer County, Colorado (Figure 14).

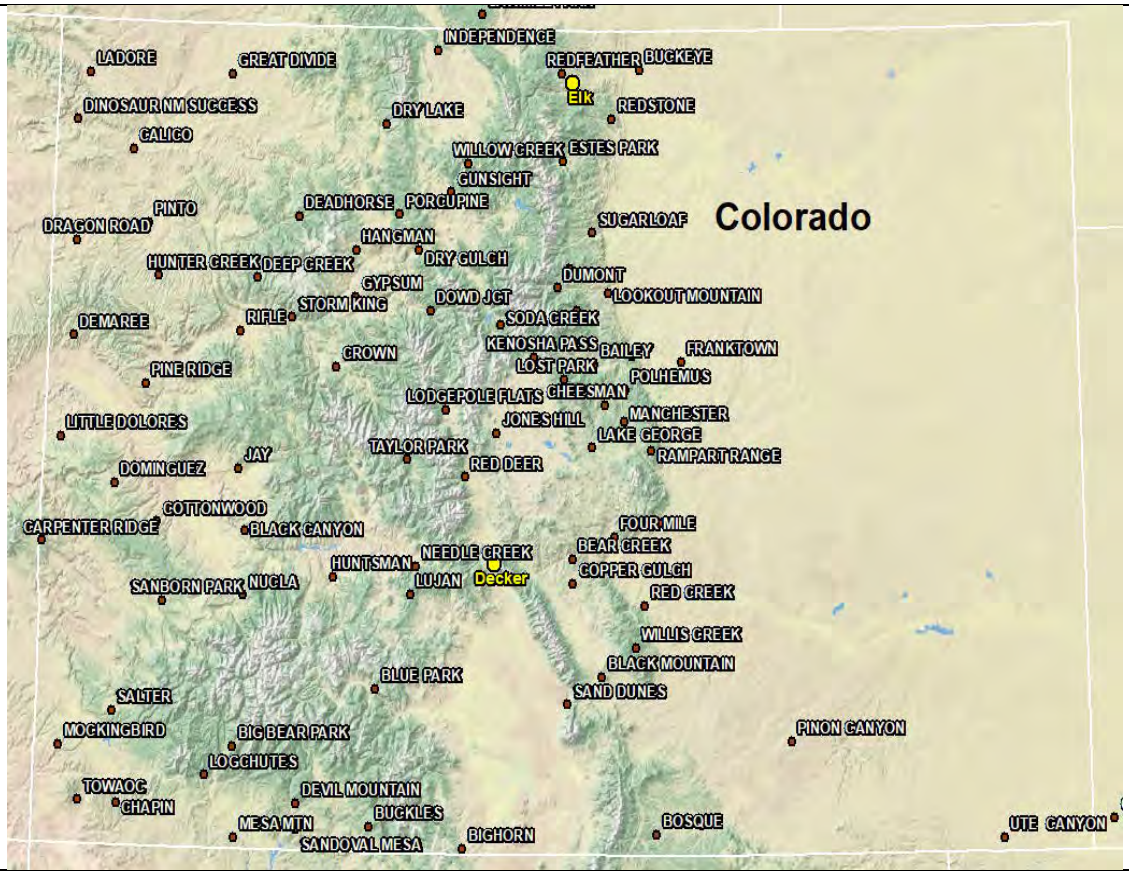

Figure 14. Map of Remote Automated Weather Station (RAWS) network across the state of Colorado.

Nationally, these stations are owned by a variety of land management agencies, but primarily by federal and state agencies, and are required to meet National Wildfire Coordinating Group standards outlined in *PMS 426-3 October 2014 Interagency Wildland Fire Weather Station*

Standards & Guidelines, which include 1) National Fire Danger Rating System (NFDRS) Weather Station Standards & Guidelines, and 2) Fire Remote Automatic Weather Station (RAWS) Standards & Guidelines. Additionally, PMS 426-3 outlines instrumentation and sampling standards that support fire behavior calculations. Importantly, the data from the RAWS has a variety of applications including NFDRS, fire behavior, burned area fire rehabilitation, planned ignitions for prescribed fire, and other land management operations and activities. Local weather stations or websites that support weather station platforms, other than RAWS, *do not* meet NWCG standards for a variety of reasons. The reasons include, but are not limited to, nonstandard station maintenance, quality control of observations, quality of sensor equipment, accuracy and different data sampling methods. For example, fixed RAWS measure "surface" wind at 20 feet above the ground in a clearing, or 20 feet above the average vegetation cover. The 20-ft wind is a standard used in the wildland fire community, at least for federal and state agencies that are using NFDRS and performing fire behavior calculations as part of their suppression or prescribed fire planning and operations. However, there are instances where area RAWS are not representative of a specific site or prescribed fire unit. As a result, for purposes of prescribed fire planning and implementation, other weather station networks or web platforms should not be used or used with caution. These include the weather underground, weather bug, Department of Transportation (DOT) weather networks, or private weather stations where sampling and quality control are uncertain.

The Red Feather RAWS is located approximately 5.5 miles northwest of the Elkhorn Unit (Figure 15 and 16) and has an extensive climate record dating back to 1985 (34 years of record), and other supporting climate data extending back to 1970.

Figure 15. Google Map showing proximity of the Red Feather Remote Automated Weather Station (RAWS) to Elkhorn.

Figure 16. Photo of Red Feather Remote Automated Weather Station (RAWS).

Though 5.5 miles to the northwest and 400-500 ft higher in elevation, Red Feather RAWS is an excellent proxy for the Elkhorn Creek Unit #4 in terms of climate record, observations, and planning prescribed fire implementation. The Maximum Temperature (MaxT) record (Figure 17) shows well above average temperatures during the first 5 days of September, with the MaxT rising to 86 degrees on September 2, 2019, which is 11 degrees above the seasonal average. Beyond September 2nd, more significant swings in temperature were noted through October 14th, which is typical for September and early October as cold fronts frequent the region. Despite maximum temperatures trending near or below seasonal averages for much of the period, minimum relative humidity (RH) records for the corresponding period (Figure 18) indicate episodes (consecutive days) of very dry atmospheric conditions. Figure 18 shows several periods where minimum RH (pink line) values drop near or set new record minimums (blue line) for the season. One period in the record that stands out is October 4-9, 2019, when minimum RH values ranged from 4%-15%. Values bottomed out in the 4% and 9% range (in the top 5% of the data record) from October 5-8, 2019. Overnight relative humidity recovering (not shown) for October 7th and 8th were 22% and 29%, respectively. Poor overnight relative humidity recoveries further exacerbate fuel drying and expand burn windows (the period of the day when environmental factors support independent spread of fire).

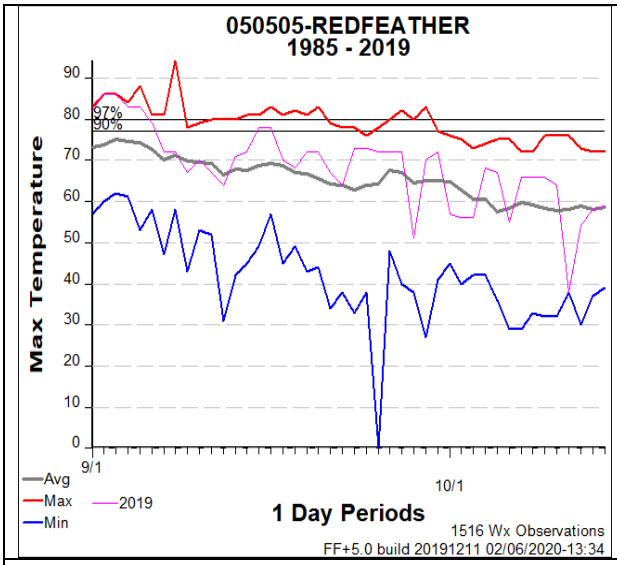

Figure 17. Maximum Temperature (pink line) for the Red Feather RAWS from September 1-October 14, 2019. The red line represents the highest MaxT, grey line is the average, and blue line lowest MaxT for the time period and dataset dating back to 1985.

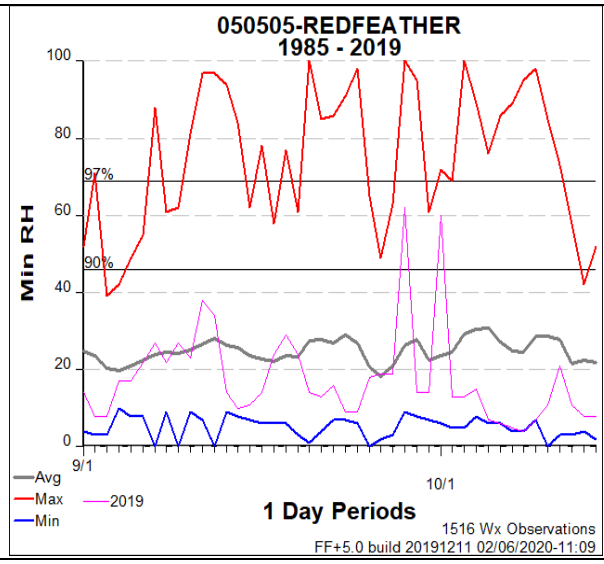

Figure 18. Minimum Relative Humidity (RH) (pink line) for the Red Feather RAWS from September 1-October 14, 2019. The red line represents the highest Minimum RH value, grey line is the average, and blue line lowest Minimum RH value for the time period and dataset dating back to 1985.

Importantly, sustained wind speed and gust speed records (Figures 19 and 20) from September 1- October 14, 2019 depict multiple days of windier than average conditions, and in some cases, in conjunction with minimum RH values near record low values. Wind gust records during the

approximately 6-week period shows 23 days out of 44 days with gusts near or over the 90th percentile of 28 mph. The combination of higher than average wind speeds, periods of low minimum RH, and poor relative humidity recoveries at night are characteristic of conditions that promote high-end fire behavior. Finally, these conditions are consistent with indices revealed in the Evaporative Demand Drought Index (EDDI).

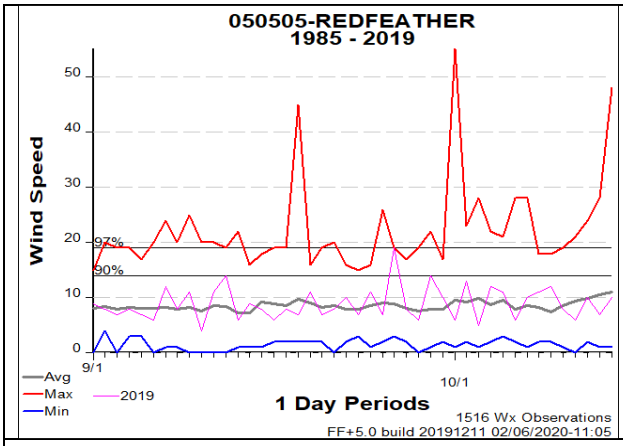

Figure 19. Sustained Wind Speed (mph) (pink line) for the Red Feather RAWS from September 1-October 14, 2019. The red line represents the Average Sustained Wind Speed value, grey line is the average, and blue line lowest Average Sustained Wind Speed value for the time period and dataset dating back to 1985.

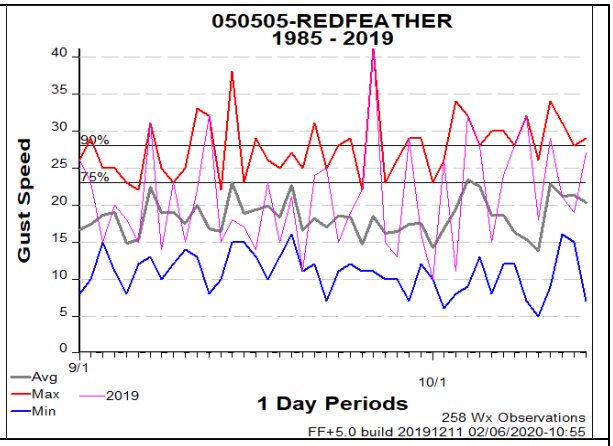

Figure 20. Max Wind Gust Speed (mph) (pink line) for the Red Feather RAWS from September 1-October 14, 2019. The red line represents the Max Wind Gust value, grey line is the average, and blue line lowest Max Wind Gust value for the time period and dataset dating back to 1985.

Local Climatology Compared to Elkhorn #4 Rx Fire Plan Weather Parameters: September 1-October 14, 2019

This section evaluates weather variables listed in **Element 7: Prescription** and seasonality in **Element 9: Pre-Burn Considerations and Scheduling** of the Elkhorn #4 Rx Fire Plan against known climatology from the nearest RAWS site, Red Feather.

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Element 7: Prescription
(Fuels, Weather, Fire Behavior, Smoke)

Fuel Parameters:	LOW	PREFERRED	HIGH	OUT*
1-Hour Fuel Moisture (%)	13	6-8	4	Sustained 20' winds > 24 without blackening or other mitigating factors** or high Fuel Parameters + more than one of the following Weather parameters
10-Hour Fuel Moisture (%)	15	8-10	6	
100-Hour Fuel Moisture (%)	17	12	8	
Live Fuel Moisture (%) (Herb/Woody%)	60/90	40/70	30/60	
Weather Parameters:				
Air Temperature (F)	40	70	85	--
Probability of Ignition	17	40-60	80	--
20 ft wind speed (mph)	10	18	24	25
Wind Direction(s)	*Refer to smoke permit. Southwesterly component would be preferred from a tactical perspective.			--

BOLD numbers indicate values used in Behave runs when a range of variables existed but all were not modeled.
**Other parameters could include: environmental or fuels conditions that moderate fire behavior, black lines are in place, natural barriers/sparse fuels that would limit fire spread

Figure 21. Element 7: Prescription for Fuels, Weather, Fire Behavior and Smoke.

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*Element 8: (*Scheduling – See Element 9)*

Element 9: Pre-Burn Considerations

SCHEDULING			
SEASON(S) OF BURN:	Fall, Winter or Spring	TIME OF DAY:	Any
EARLIEST DATE:	Check with Camp for Camper Conflicts Each Year	BLACKLINE PHASE LENGTH:	1-2 Days
LATEST DATE:	N/A	BURNOUT PHASE LENGTH:	2-3 Days

Figure 22. Element 9: Pre-Burn Considerations Including Season(s) of Burn.

Table 1. depicts weather parameters and breakpoints used in the Elkhorn #4 Rx Fire Plan, compared to the climate record retrieved from the Red Feather RAWS. The Maximum Temperature (MaxT) breakpoints in the Plan range from 40°F (Low), to 70°F (Moderate) to 85°F (High). Climate records from the Red Feather RAWS show that the percentile values for these MaxT breakpoints ranging from 2.51st percentile to 99th percentile, a range that is exceptionally broad based on Red Feather RAWS climate record. Moreover, MaxT as low as 40°F and as high as 85°F are extremely rare events for this area. The Plan's 20-ft sustained wind speed breakpoints ranged from 10 mph (Low), to 18 mph (Moderate), to 24 mph (High), to 25 mph or greater (Out of Prescription). Again, considering climate data record for the area, the percentile for 10 mph is the 72nd, for 18 mph 97th, for 24 mph 99th, and for 25 mph or greater, 99thpercentile. The sustained wind speed breakpoints in the Plan for *Moderate, High*, and *Out*, are of rare occurrence (less than 3%) for the area when considering the climate record of sustained 10-minute average 20-ft wind speed.

Table 1. Weather Parameters Included in the Burn Plan Compared to the Percentiles Calculated at Red Feather RAWS

Weather Parameters	Low	Percentile	Moderate	Percentile	High	Percentile	Out*	Percentile
MaxT (°F)	40	2.51	70	65%	85	99.74	N/A	N/A
20-ft Wind (Sustained mph)	10	72	18	97%	24	99	25	99.27%

Table 2. depicts other weather parameters that were not included in the Elkhorn #4 Rx Fire Plan but are equally as important when considering resultant fire behavior and possible outcomes: Minimum Relative Humidity (Min RH) and 20-ft Wind *Gusts*. These variables are routinely measured on both prescribed fires and wildfires, and are included in spot weather forecasts. Importantly, measurements of Min RH and 20-ft wind gusts (among other weather parameters) were discussed by fireline personnel during their interviews. Like Table 1., data in Table 2. applies a percentile to a value based on climate record obtained from the Red Feather RAWS. For Min. RH, 20%, 15%, 9% and 6% were selected based on known values that support fire activity in Colorado and climate record of percentiles including the 50th , 70th, 90th, and 97th. The 20-ft Wind Gusts of 16 mph, 21 mph, 28 mph and 31 mph were selected based on 50th, 70th, 90th, and 97th percentile from the climate record, respectively. As already mentioned, and depicted in Figure 15., September 1-October 14, 2019 represented a windy period with 23 of 44 days near or over the 90th percentile for wind gust.

Table 2. Weather Parameters Not Included in the Burn Plan and Percentiles

Weather Parameters	Value	Percentile	Value	Percentile	Value	Percentile	Value	Percentile
Min. RH (%)	20	50th	15	70th	9	90th	6	97th
20-ft Wind Gusts (mph)	16	50th	21	70th	28	90th	31	97th

Fire Weather Analysis for October 15-16, 2019- Firing Operations.

This section provides meteorological conditions that occurred during Elkhorn Creek Unit #4 operations on October 15 and 16, 2019. Datasets used include archived fix station observations from the Red Feather and Redstone RAWS, on-site field observations, archived upper air and surface weather charts, ArcGIS analysis, and National Weather Service Spot forecasts that supported prescribed fire operations.

Meteorologist look at a variety of meteorological fields that provide valuable information of both current and forecast weather patterns related to low pressure and high pressure systems, atmospheric moisture, temperature, and wind (among many other variables). It is common practice for meteorologists to analyze upper air (above the surface) and surface charts to identify weather features that will impact an area. The weather pattern for the two days of operations can be characterized as intricate. A series of weather charts analyzed for the 2-day period depicts a changing weather pattern from October 15th to 16th. 500 mb (~18,000-ft MSL) weather charts valid 10/15/2019 at 12Z (Figure 23) and 10/16/2019 at 12Z (Figure 24) shows a trough extending from the northern plains through eastern Colorado, giving way to a weak ridge of high pressure on October 16th.

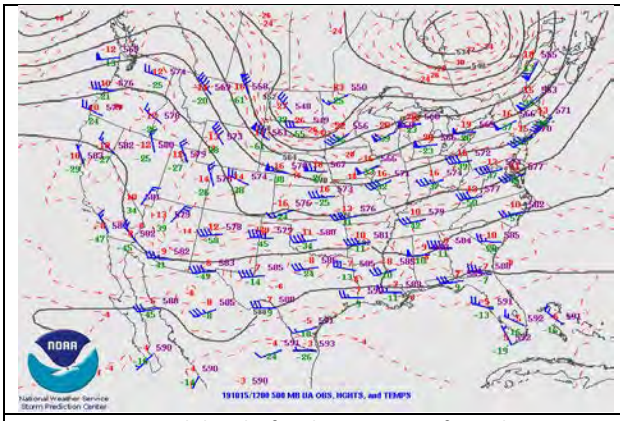

Figure 23. 500-mb height for the morning of October 15, 2019. The upper air weather chart depicts a trough over the Northern Plains extending south into eastern Colorado.

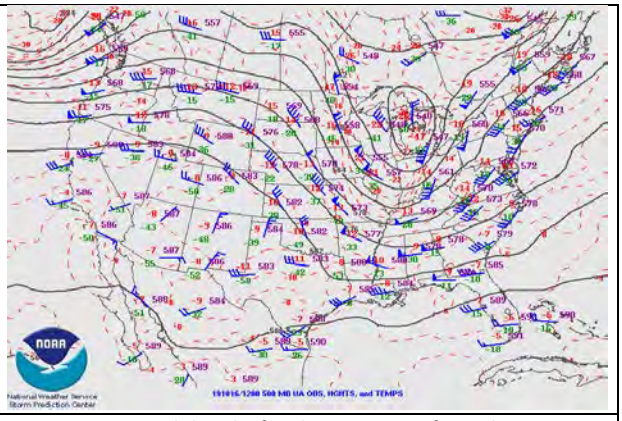

Figure 24. 500-mb height for the morning of October 16, 2019. The upper air weather chart depicts a trough over the Northern Plains extending south into eastern Colorado.

Additionally, corresponding surface wind charts (Figure 25) valid for 0600 hrs MDT time, indicate a stationary front along the Front Range on October 15, 2019, associated with the upper air trough extending south into eastern Colorado. The surface chart for the morning of October 16, 2019 (Figure 26) indicates a warm front boundary (the leading edge of warm air) extending across the plains of eastern Montana, eastern Wyoming and eastern Colorado.

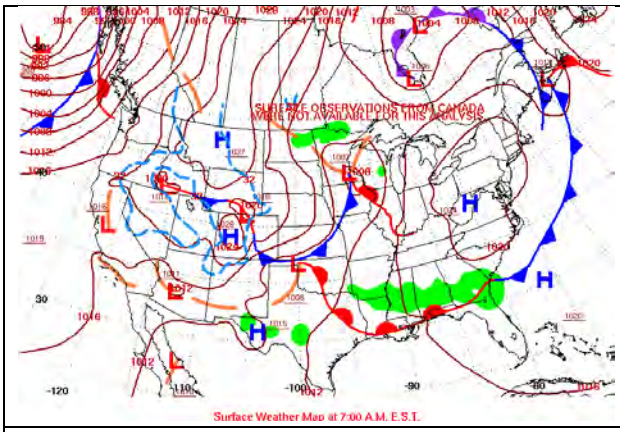

Figure 25. Surface analysis valid for the morning of October 15, 2019. The analysis depicts a stationary front along the Front Range of Colorado.

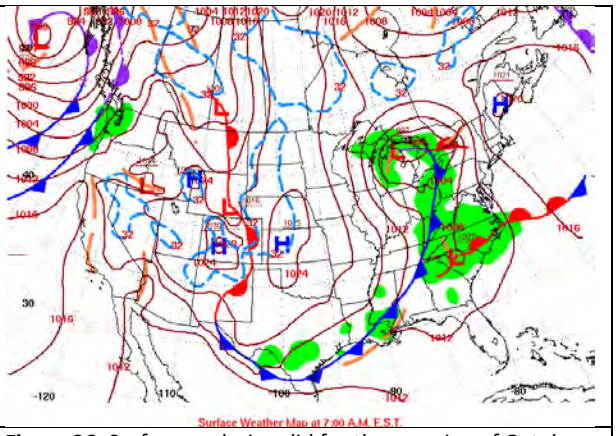

Figure 26. Surface analysis valid for the morning of October 16, 2019. The analysis depicts a warm front over eastern Colorado.

A more detailed surface wind analysis supported by local RAWS (Red Feather and Redstone), on-site observations, and frontal analysis utilizing ArcGIS-ArcMap for October 15-16, 2019 provides a higher resolution depiction of the stationary front near or over the Elkhorn Creek Unit #4 on October 15th. Area observations from fixed stations and on-site measurements confirm a meandering frontal boundary in the area (illustrated in Figures 27-30). Moreover, significant changes in RH and wind direction (and to a lesser extent, wind speed) were documented by the FEMO, with RH starting at 43% at 1045 hrs, dropping to 18% at 1140 hrs, 11% at 1300 hrs, and increasing again to 39% at 1350 hrs. There were corresponding wind shifts associated with the changes in RH as well (See Table 3 For Observations). Fixed RAWS stations (Red Feather and Redstone) identified the differing airmasses and boundary as well, with cool and moist measurements at Redstone (18 miles SE of Elkhorn) for the entire operational period and warm, but dry and windy conditions at Red Feather RAWS for the same time.

Figure 27. Frontal analysis and station plot for 0900-1100 hrs, October 15, 2019. The stationary front (red and blue line) represents a boundary between two differing airmass, with cool and moist conditions east of boundary, and warmer and drier conditions west.

Figure 28. Frontal Analysis and station plot for 1200 hrs, October 15, 2019. On-site observations indicate a significant drop in RH at 1140 hrs, when the test fire commenced. The change in RH indicated a slight eastward propagation of the stationary front.

Figure 29. Frontal Analysis for 1400 hrs, October 15, 2019. Corresponding surface observations indicate the boundary pushing back into the Elkhorn Unit, indicative of the increase in RH and wind shift.

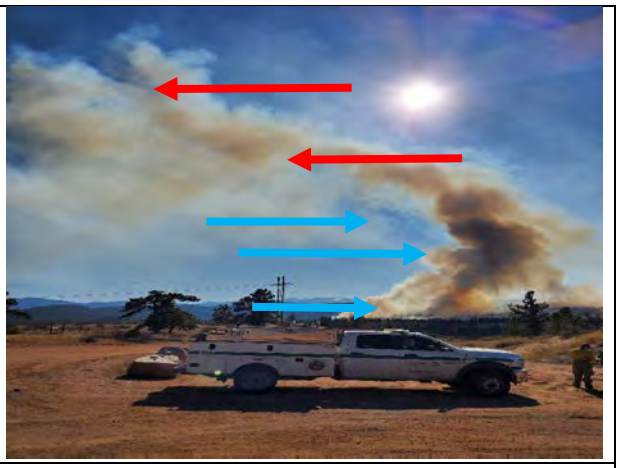

Figure 30. Smoke column behavior looking south. Smoke column behavior indicative of a wind shear profile associated with shallow frontal boundary in the area. Photo taken on October 15, 2019 at 1441 hrs.

Table 3. compares observations between the Red Feather RAWS, the Redstone RAWS, and on-site observations taken by the FEMO. These observations aided in the surface analysis in Figures 27-29, and in determining airmass conditions that impacted the Elkhorn Creek Unit #4 on October 15, 2019.

Table 3. October 15, 2019 Observations for Red Feather RAWS, Redstone RAWS, and On-Site.

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	0900	Red Feather	8233	45	21%	3G8 mph	NE
10/15/2019	0900	Redstone	6160	43	59%	2G6 mph	N

Note: No onsite observation

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	1100	Red Feather	8233	49	15%	10G26mph	W
10/15/2019	1100	Redstone	6160	47	50%	10G15 mph	SSE
10/15/2019	**1045**	**On-Site Ob**		**46**	**43%**	**3G5 mph**	**NE**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	1200	Red Feather	8233	52	16%	8G23mph	W
10/15/2019	1200	Redstone	6160	50	46%	10G16 mph	SSE
10/15/2019	**1140**	**On-Site Ob**		**54**	**18%**	**7G13 mph**	**SSW**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	1300	Red Feather	8233	54	16%	10G26mph	W
10/15/2019	1300	Redstone	6160	52	41%	9G15 mph	SSE
10/15/2019	**1300**	**On-Site Ob**		**60**	**11%**	**5G10 mph**	**Var (W)**

Note: On-site observation is measured at eye-level

Table 3. Continued-

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	1400	Red Feather	8233	56	16%	11G26mph	W
10/15/2019	1400	Redstone	6160	53	38%	9G16 mph	SSE
10/15/2019	**1350**	**On-Site Ob**		**54**	**39%**	**4G7 mph**	**Var (SE)**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	1500	Red Feather	8233	57	16%	9G33mph	W
10/15/2019	1500	Redstone	6160	55	35%	8G14 mph	SSE
10/15/2019	**1500**	**On-Site Ob**		**54**	**38%**	**3G8 mph**	**Var (ENE)**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/15/2019	1600	Red Feather	8233	57	16%	10G21mph	NW
10/15/2019	1600	Redstone	6160	55	34%	9G14 mph	SSE
10/15/2019	**1600**	**On-Site Ob**		**50**	**40%**	**3G6 mph**	**E**

Note: On-site observation is measured at eye-level

Using identical methodology from the October 15th analysis, surface observations and ArcGIS-ArcMAP provided a more refined depiction of surface conditions and a timeline for October 16, 2019 (shown in Figure 31 and 32). Area observations for the early morning hours of the 16th revealed a mild and very dry airmass over the Elkhorn Creek Unit #4 (as shown in Table 4). The Red Feather RAWS recorded a sharp drop in RH values just after midnight local time, along with an increased wind speed (gusts to 21 mph). The FEMO Summary Report also mentions *"consistently strong winds beginning around 0430 that calmed by 0930".* Given on-site observations for the morning of October 16th, and analysis of the synoptic scale pattern and surface observations, this was likely a result of the upper air high pressure and low-level warm front migrating into the Elkhorn Creek Unit #4. The 0945 on-site observation yielded a dry-bulb temperature of 56 °F and RH of 20%, which was approximately 10 degrees warmer and 23% drier that the previous day for around the same time. (The first on-site measurement was at 1045 on October 15 versus 0945 on the 16th, therefore the differences could have been more.)

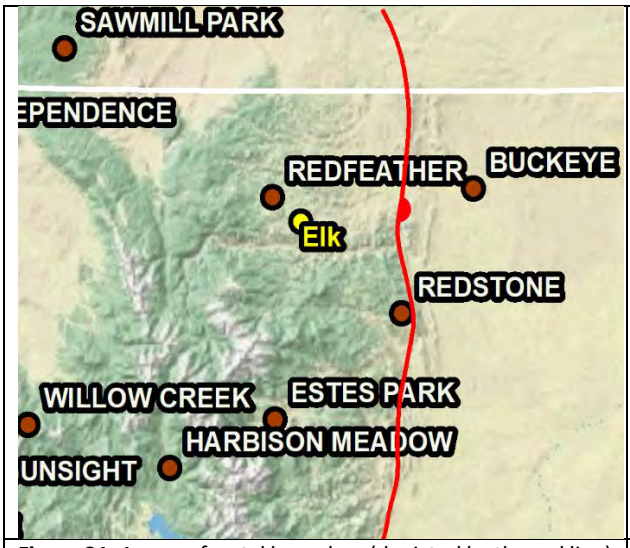

Figure 31. A warm frontal boundary (depicted by the red line) had moved east of the Elkhorn Unit during the early morning hours of October 16, 2019. FEMO observation at 0945 measured and RH of 20%.

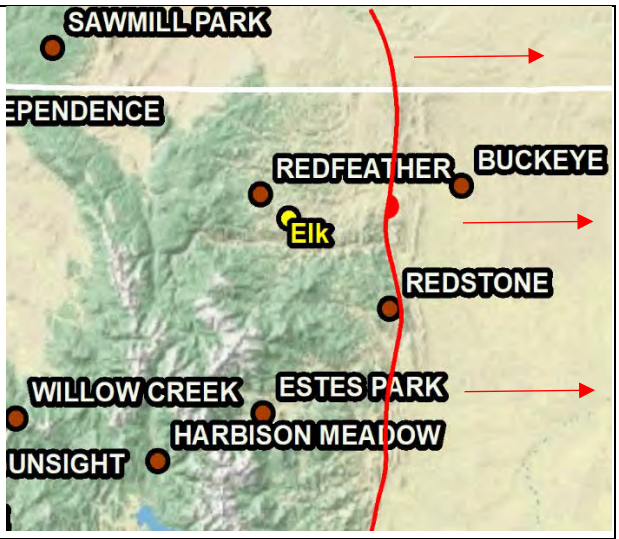

Figure 32. Warm front shift east abruptly on October 16, 2019. Behind the warm front, warm, dry and windy conditions developed.

Table 4. October 16, 2019 Observations for Red Feather RAWS, Redstone RAWS, and On-Site.

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1000	Red Feather	8233	51	20%	4G15mph	WSW
10/16/2019	1000	Redstone	6160	54	33%	3G6 mph	N
10/16/2019	**0945**	**On-Site Ob**		**56**	**20%**	**Light**	**W**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1100	Red Feather	8233	55	17%	8G18mph	W
10/16/2019	1100	Redstone	6160	61	27%	1G5 mph	NNW
10/16/2019	**1050**	**On-Site Ob**		**62**	**17%**	**2G8 mph**	**Terrain Driven**

Note: On-site observation is measured at eye-level. RH 14% at test fire time of 1120.

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1200	Red Feather	8233	58	15%	11G25mph	WSW
10/16/2019	1200	Redstone	6160	65	19%	2G5 mph	S
10/16/2019	**1200**	**On-Site Ob**		**62**	**14%**	**2G6 mph**	**WSW**

Note: On-site observation is measured at eye-level

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1330	Red Feather	8233	61	14%	13G29mph	WSW
10/16/2019	1330	Redstone	6160	71	13%	5G7 mph	SSE
10/16/2019	**1330**	**On-Site Ob**		**65**	**14%**	**2G8 mph**	**W**

***Note: On-site observation is measured at eye-level,* Cloud cover decreased at 1350**

Table 4. Continued-

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1430	Red Feather	8233	65	12%	11G27mph	WSW
10/16/2019	1430	Redstone	6160	67	16%	6G9 mph	SE
10/16/2019	**1430**	**On-Site Ob**		**70**	**13%**	**4G10 mph**	**W**

***Note: On-site observation is measured at eye-level,* Gust at eye-level of 23 mph on ridgetop**

Date	Time	Station	Elevation	DB	RH	WS	WD
10/16/2019	1530	Red Feather	8233	65	11%	13G31mph	WSW
10/16/2019	1530	Redstone	6160	74	14%	6G12 mph	SE

Note: No on-site observation measured. Wildfire declared at 1545-1600

Importantly, complementary upper air radiosonde data (SkewT Log-P Diagram) information for October 15 and16, 2019 from Denver (KDNR) provides a profile of temperature, dewpoint temperature (atmospheric moisture), and wind. Radiosonde data from October 15 and16, 2019 supports the large- and small-scale meteorology discussed above. Analysis of the data from the morning of October 15, 2019 at 12Z (Figure 33) provides vertical detail on the depth and significance of the frontal boundary/inversion at low levels that was in place along the Front Range foothills (generally below 700 mb ~ below 10,000-ft MSL). The radiosonde data for the afternoon of October 15th (dated October 16, 2019 00Z) (Figure 34) indicated a slight weakening of the stationary front (frontolysis), most likely a result of upper trough exiting the area, approaching upper air ridge, and surface heating. Subsequent soundings for October 16th confirm changing airmass conditions. The sounding for October 16, 2019 at 12Z (Figure 35) denotes a low-level radiation/nighttime inversion present, with some influence possible from the weakening stationary front from the previous day. Importantly, given the early morning observations (warmer and drier with increasing wind) and elevation difference (approximately 2500 feet) between the Elkhorn Creek Unit #4 and Denver (KDNR) where the upper air measurements are taken twice a day, the Elkhorn Creek Unit #4 likely started the day above the inversion layer or with weak inversion conditions present, and experienced further warming and drying conditions into the afternoon of October 16, 2019 (Figure 36, Dated October 17, 2019 00Z) .

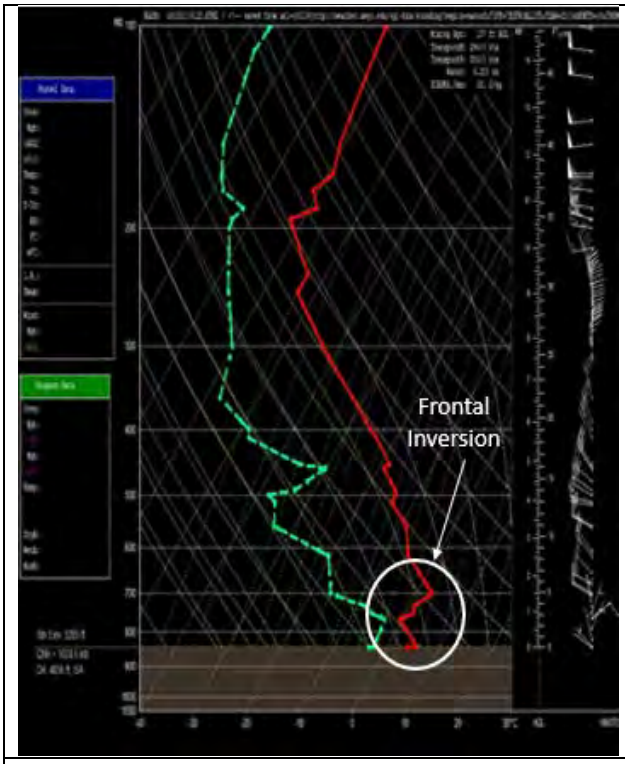

Figure 33. KDNR (Denver) for October 15, 2019 (12Z). The temperature (red line), dewpoint temperature (green line) and wind profile (wind barbs) are displayed.

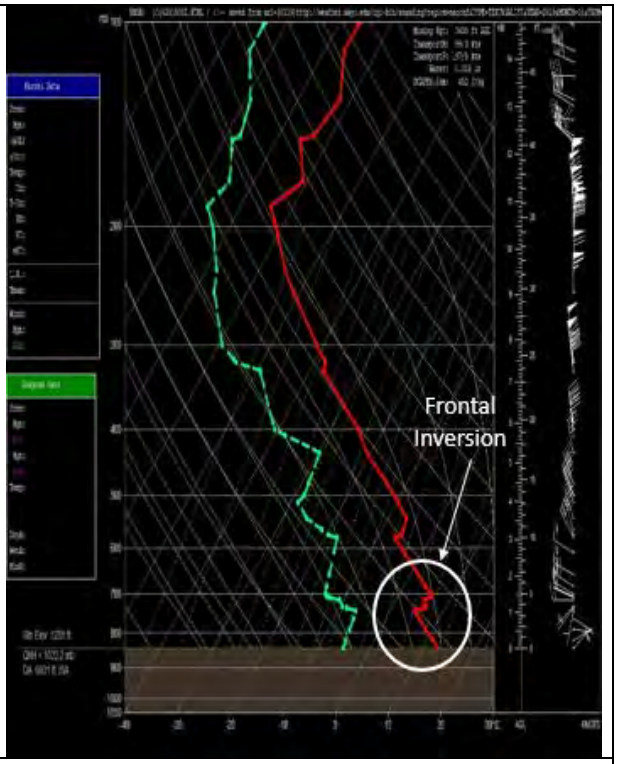

Figure 34. KDNR (Denver) for October 16, 2019 (00Z). The temperature (red line), dewpoint temperature (green line) and wind profile (wind barbs) are displayed.

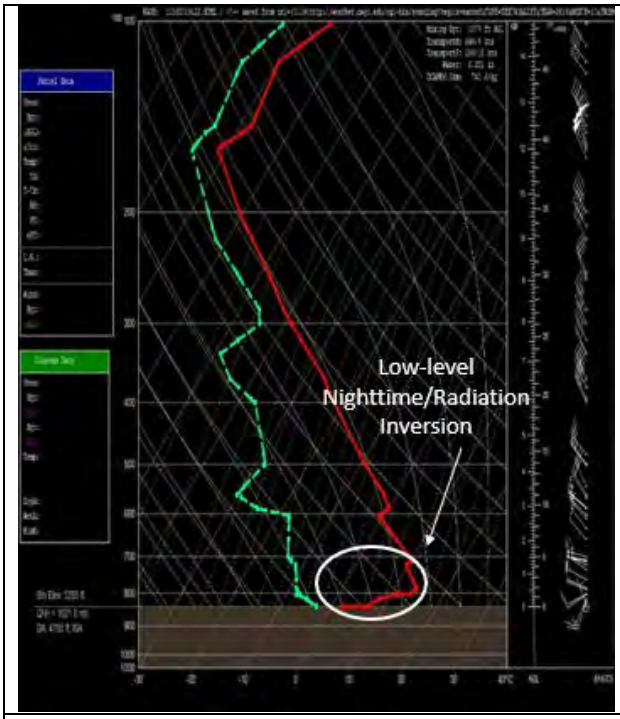

Figure 35. KDNR (Denver) for October 16, 2019 (12Z). The temperature (red line), dewpoint temperature (green line) and wind profile (wind barbs) are displayed.

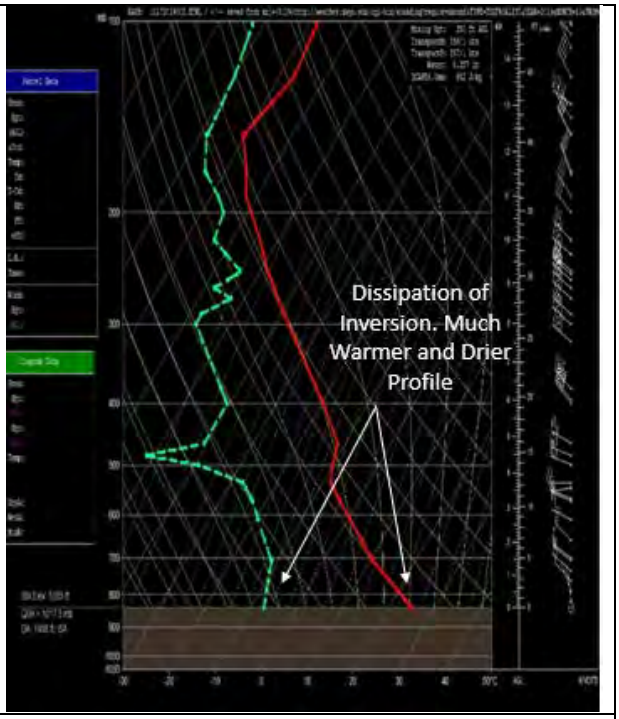

Figure 36. KDNR (Denver) for October 17, 2019 00Z. The temperature (red line), dewpoint temperature (green line) and wind profile (wind barbs) are displayed.

Figure 37, provides further insight in the vertical structure of temperature, dewpoint temperature (atmospheric moisture), and wind, and the changes that ensued from the afternoon of Day 1- October 15th (dated October 16, 2019 00z) in cyan vs. Day 2- October 16th (dated October 17, 2019 00z) in Red. Specifically, the afternoon sounding on October 16th shows approximately 20°F increase in temperature and 3-5°F decrease in dewpoint temperature below 700mb (approximately 10,000-ft MSL) compared to airmass conditions on October 15th. Finally, low-level wind profile comparisons correspond well to changes conveyed in on-site observations with a variable or easterly component wind flow on Day 1, giving way to westerly flow on Day 2. Bottomline, airmass and wind changes were considerable in the 36-hour window from the Day 1 operational period to the Day 2 operational period.

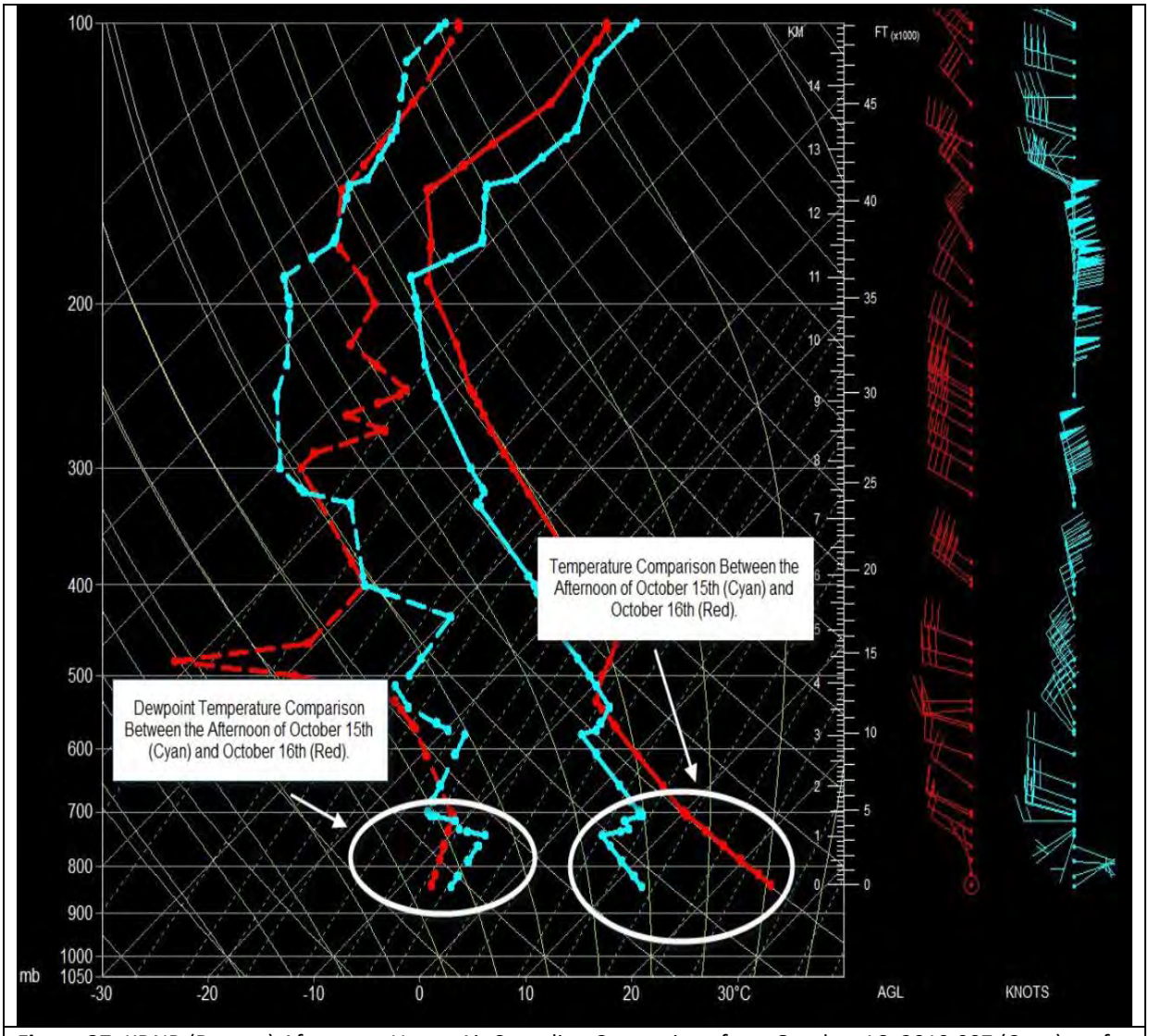

Figure 37. KDNR (Denver) Afternoon Upper Air Sounding Comparison from October 16, 2019 00Z (Cyan) vs. for October 17, 2019 00Z (Red).

Wind: 20-ft Wind vs. Mid-Flame Wind Speed

Wind is one of the most critical components of the fire environment and can have the most significant impact on fire behavior. Wind can: 1) exacerbate the drying of fuels, 2) provide oxygen rich air to aide in combustion, 3) bend flames towards unburned fuels (pre-heating), 4) promote spotting, and 5) have the greatest impact on direction of fire spread. The standard surface wind speed and direction for fire behavior calculations are measured 20-feet above a clearing or 20-feet above the average vegetation (Figures 41 and 42). Standardized 20-ft winds are typically measured by permanent or fixed local RAWS, like the station pictured in Figure 41 and located at Red Feather. These types of stations are usually sited and maintained by fire agencies, usually federal or state, and must meet NWCG standards and guidelines as outlined in *PMS-426-3 NWCG Standards for Fire Weather Stations*. Importantly, forecast 20-ft winds are provided in spot forecasts generated by local NWS offices in support of fire operations.

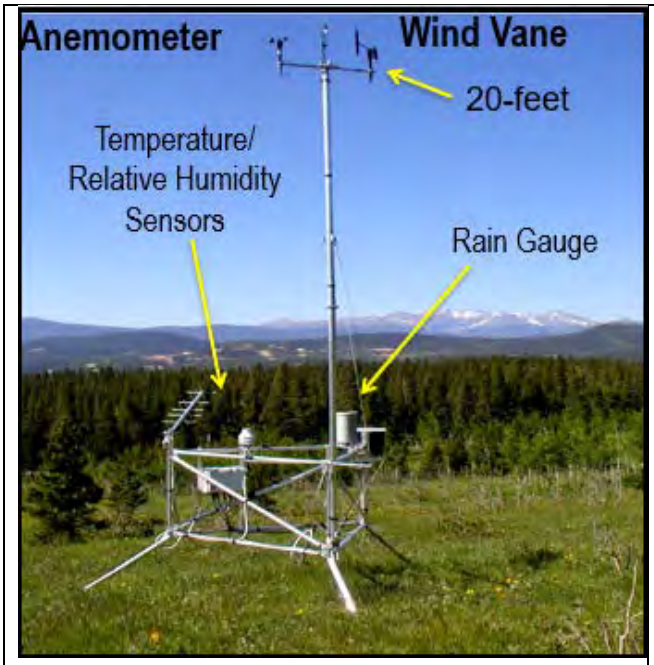

Figure 41. Electronic components of a Remote Automated Weather Station (RAWS). The anemometer and wind vane are located 20-ft above the ground.

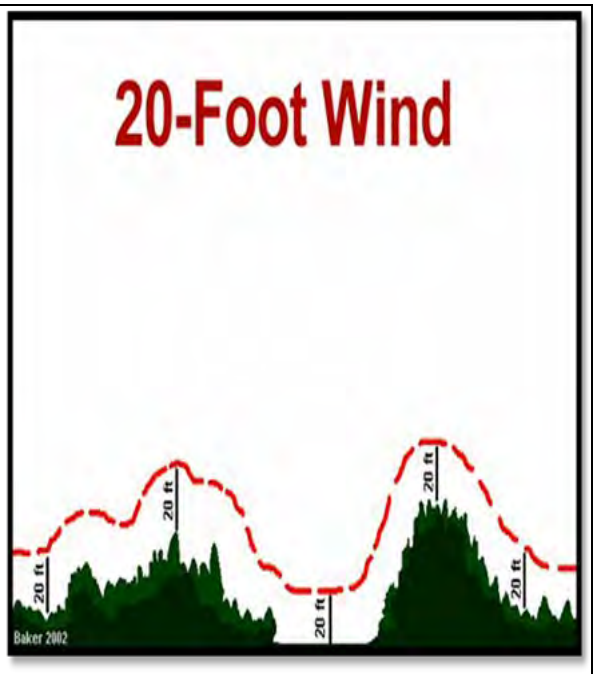

Figure 42. This diagram illustrates the measurement of the 20-ft wind. 20-ft wind (surface wind) is measured 20-ft above the ground in a clearing, or 20 feet above the average vegetation cover.

Whether from a RAWS or Spot Forecast, a 20-ft wind speed can then be reduced using a *Wind Adjustment Factor* (WAF) (Figure 43 and 44), based on sheltering and fuel type, to calculate a *Midflame Wind Speed* (MWS). Midflame Wind is the wind that acts directly on the flaming fire front at the level of ½ the flame height and is required to determine fire behavior calculations such as rates of spread (ROS). The WAF is typically part of a prescribed fire plan. Eye-level wind, that is manually measured on-site in the field using hand-held wind meters, is a customary surrogate for midflame wind.

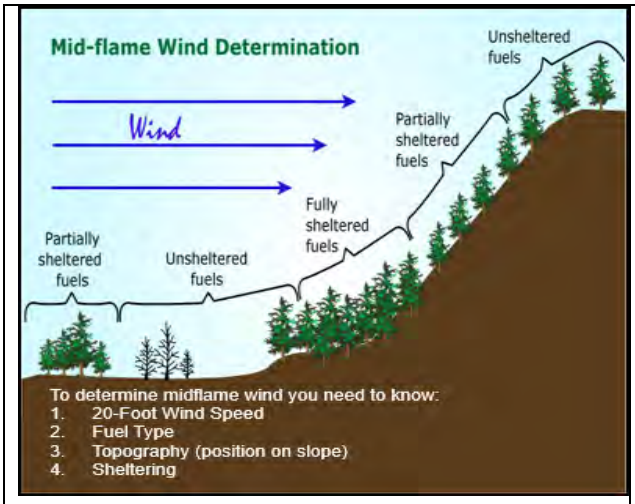

Figure 43. Midflame Wind Determination diagram. The diagram provides a list of "you need to know" elements when determining midflame wind speed.

Degree of Sheltering	Fuel Model	Adjustment Factor
Unsheltered	4, 13	0.5
	8, 9	0.3
	All Others	0.4
Partially Sheltered	All Models	0.3
Fully Sheltered	All Models	
	Open Stand	0.2
	Dense Stand	0.1

Figure 43. Midflame Wind Adjustment Factor (WAF) table. This table contains the adjustment factor for the 20-ft wind speed reduction.

Figure 44. This illustration shows how vegetation and friction can impact 20-ft wind speed.

Figure 45. This image illustrates a midflame wind, which is calculated as half the flame height OR estimated by eye-level wind measurements.

When comparing 20-ft wind vs. midflame wind (eye-level) speeds, the 20-ft wind speed will always be higher than the midflame wind due to vegetation and sheltering. Moreover, fuel type and sheltering result in varying degrees of friction and can lead to a ***significant*** decrease in 20-ft wind speed, 50% to 90% reduction depending on fuel type and sheltering.

For Example: A 20-ft wind at 20 mph in a fully sheltered dense stand can result in a midflame wind (eye-level) speed of 2 mph. 20 mph x WAF (0.1) = 2 mph.

In the case of the Elkhorn Creek Unit #4 Prescribed Fire, an eye-level wind of 23 mph was recorded on a ridgetop and documented around at 1430 hrs FEMO observation. A 23 mph eye-level wind is considerable and represents a calculated 20-ft wind (using 0.4 WAF as used in the prescribed fire plan) of 57 mph. Though 57 mph is possible when considering terrain influences (channeling, constriction or narrowing of terrain), occurrence is unlikely. However, area observations from other stations support gusts over 30 mph during the afternoon of October 16th, which would easily correspond to 23 mph at eye-level and result in high likelihood of fire spotting and high rates of spread (ROS).

Review of National Weather Service (NWS) Spot Forecasts for October 15-16, 2019

Most, if not all, local, state, and federal fire organizations are required by applicable policy to request a *Spot Weather Forecast* prior to initiating prescribed fire operations. Spot forecasts are generated by the National Weather Service (NWS) upon request and provide forecast weather variables that are site specific to fit the time, topography, and weather for the particular project or incident. Though dependent on the project, common weather variables that are requested include, but are not limited, a Discussion, Sky/Weather, Chance of Wetting Rain (CWR), Lightning Activity Level (LAL), MaxT, MinRH, 20-ft Wind Speed and Direction, Smoke Dispersal and Haines Index.

The Elkhorn Creek Unit #4 is located within the jurisdiction of the National Weather Service Forecast Office- Boulder. Spot forecasts were requested from the Boulder forecast office several hours prior to operations on Day 1 and Day 2. In support of Day 1 operations, a spot forecast was transmitted to fireline personnel by the NWS Forecast Office-Boulder at 0715 hrs on October 15, 2019 (Figure 38), several hours prior to briefing and ignition. The spot forecast for Day 1 forecasted a MaxT of 56, Min RH of 21%, variable and shifting 20-ft wind throughout the operational period.

Elkhorn 4

National Weather Service Denver/Boulder

2019-10-15 7:15 AM MDT

```
Spot Forecast for Elkhorn 4...NATURE CONSERVANCY
National Weather Service Denver/Boulder CO
714 AM MDT Tue Oct 15 2019

If conditions become unrepresentative...contact the National Weather
Service.

.DISCUSSION...A dry environment will persist through Thursday.
Today will feature lighter winds aloft, and thus fairly normal
diurnal wind patterns should prevail. Smoke dispersion will
become good this afternoon given full sunshine and sufficient
heating, and a shallow inversion to start the day.

On Wednesday, winds will begin to increase a little, temperatures
will warm, and humidities will drop. Good to very good smoke
dispersion is expected during the afternoon.

Thursday will likely feature higher fire danger due to a further
strengthening of winds. Critical fire danger conditions will be
possible with wind gusts potentially reaching 30 mph and
humidities dropping into the 10 to 15 percent range.

.REST OF TODAY...

Sky/weather.........Sunny.
CWR.................0 percent.
LAL.................1.
Max temperature.....Around 56.
Min humidity........21%.
Wind (20 ft)........Variable up to 5 mph until 0800, then northwest
                    6-7 mph until 1100, then southeast 4-8 mph until
                    1600, then southwest 4-8 mph.
Mixing height.......Below 1000 FT AGL until 1000, then 5400 ft AGL
                    until 1700, then 2600 ft AGL.
Transport winds.....Northwest 15-25 mph until 1700, then west 10-15
                    mph.
Smoke dispersal.....Poor until 1100, then fair until 1200, then
                    good until 1400, then very good until 1600,
                    then fair until 1700, then poor.
Haines Index........3 or very low potential for large plume
                    dominated fire growth.
```

Figure 38. The spot forecast (October 15, 2019 @ 0714) for Elkhorn 4 provided the National Weather Service Office in Boulder, Colorado.

Spot forecasts were requested for Day 2 operations the evening of October 15, 2019 (Figure 39) and again on the morning of October 16, 2019 (Figure 40). Both forecasts highlighted warmer and drier airmass conditions (MaxT 67, MinRH 12%-14%), along with west wind ranging from 8 to 15 mph with gusts up to around 20 mph. Additionally, both forecasts emphasized a Fire Weather Watch valid October 17, 2019 for increasing fire danger, a result of increasing wind and low humidity that was forecast ahead of an approaching trough and associated cold front.

Elkhorn4 RX

National Weather Service Denver/Boulder

2019-10-15 6:42 PM MDT

Spot Forecast for Elkhorn4 RX...The Nature Conservancy
National Weather Service Denver/Boulder CO
641 PM MDT Tue Oct 15 2019

If conditions become unrepresentative...contact the National Weather Service.

...FIRE WEATHER WATCH IN EFFECT FROM THURSDAY MORNING THROUGH THURSDAY EVENING...

.DISCUSSION...A ridge of dry high pressure will continue to dominate the northern Colorado region through late Thursday keeping daytime temperatures warm and relative humidity low. Winds will be light this evening initially but some increased downsloping flow should move by late evening and overnight. Humidities will only recover partially through early morning Wednesday. The same daytime pattern will persist for Wednesday and Thursday afternoons with strengthening winds each day. By Thursday, with gusts expected around 30 mph, the combination of low relative humidity and gusty erratic winds will create critical fire weather conditions for both days with a Fire Weather Watch in effect for Thursday.

.REST OF TONIGHT...

Sky/weather.....Mostly clear.
CWR.....0 percent.
LAL..... 1.
Min temperature.....Around 34.
Max humidity.....52%.
Wind (20 ft).....Northwest winds 4-5 mph until 2100, then west 5-11 mph with gusts of 15 to 20 mph.
Mixing height.....Below 1000 FT AGL.
Transport winds.....North 8-10 mph until 2000, then west 12-22 mph.
Smoke dispersal.....Poor.
Haines Index.....3 or very low potential for large plume dominated fire growth.

TIME (MDT)	7PM	8PM	9PM	10P	11P	MID	1AM	2AM	3AM	4AM	5AM
Sky (%).....	5	9	12	13	12	12	14	17	19	22	29
Weather cov.....											
Weather type....											
Tstm cov.....											
CWR.....	0	0	0	0	0	0	0	0	0	0	0
LAL.....	1	1	1	1	1	1	1	1	1	1	1
Temp.....	44	40	36	35	34	34	35	36	36	37	38
RH.....	38	44	52	52	51	49	45	42	40	37	35
20 FT wind dir..	N	W	W	SW	W	W	W	W	W	W	W
20 FT wind spd..	5	4	4	4	4	5	6	7	7	12	11
20 FT wind gust.							8	8	12		16
Mix hgt (kft)...	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8
Transp wind dir.	N	W	SW	SW	W	W	W	W	W	W	W
Transp wind spd.	10	10	10	10	11	12	15	18	20	21	24
Haines index. .	3	3	3	3	3	3	3	3	3	3	3
SDspl kt-ft/1000	5	4	4	4	5	6	8	10	12	13	14
SmokeDispersion.	P	P	P	P	P	P	P	P	P	P	P

.WEDNESDAY...

Sky/weather.....Mostly sunny until 0700, then partly cloudy(30-40%) until 1700, then mostly sunny.
CWR.....0 percent.
LAL..... 1.
Max temperature.....Around 67.
Min humidity.....14%.
Wind (20 ft).....West winds 8-14 mph with gusts to around 20 mph.
Mixing height.....Below 1000 FT AGL until 1000, then 3700 ft AGL.
Transport winds.....West 18-28 mph until 1700, then 13-18 mph.
Smoke dispersal.....Poor until 1100, then fair until 1200, then good until 1600, then fair until 1700, then poor.
Haines Index.....4 or low potential for large plume dominated fire growth.

TIME (MDT)	6AM	7AM	8AM	9AM	10A	11A	12P	1PM	2PM	3PM	4PM	5PM
Sky (%).....	28	30	34	37	39	41	42	40	38	35	30	25
Weather cov.....	M	M	M	M	M	M	M	M	M	M	M	M
Weather type....	M	M	M	M	M	M	M	M	M	M	M	M
Tstm cov.....	M	M	M	M	M	M	M	M	M	M	M	M
CWR.....	0	0	0	0	0	0	0	0	0	0	0	0
LAL.....	1	1	1	1	1	1	1	1	1	1	1	1
Temp.....	41	44	47	51	55	59	63	66	67	67	65	62
RH.....	33	28	26	23	21	18	16	14	14	14	15	16
20 FT wind dir..	W	W	W	W	W	W	W	W	W	W	W	W
20 FT wind spd..	12	12	13	13	14	14	14	14	15	15	13	11
20 FT wind gust.	16	16	16	16	20	20	20	20	20	20	16	16
Mix hgt (kft)...	0.8	0.8	0.8	0.7	1.5	2.4	3.2	3.7	4.2	4.6	3.4	2.2
Transp wind dir.	W	W	W	W	W	W	W	W	W	W	W	W
Transp wind spd.	25	25	26	26	27	28	29	28	26	25	21	18
Haines index....	4	4	4	4	4	4	4	4	4	4	4	4
SDspl kt-ft/1000	16	15	15	14	32	52	73	80	85	89	54	28
SmokeDispersion.	P	P	P	P	P	F	G	G	G	G	F	P

Figure 39. The spot forecast (October 15, 2019 @ 1841 hrs) for Elkhorn 4 provided the National Weather Service Office in Boulder, Colorado.

Elkhorn4 RX

National Weather Service Denver/Boulder

2019-10-16 7:11 AM MDT

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Spot Forecast for Elkhorn4 RX...The Nature Conservancy
National Weather Service Denver/Boulder CO
711 AM MDT Wed Oct 16 2019

If conditions become unrepresentative...contact the National Weather
Service.

...FIRE WEATHER WATCH IN EFFECT FROM THURSDAY MORNING THROUGH
THURSDAY EVENING...

.DISCUSSION....A dry northwesterly flow today will bring breezy
conditions with very low humidity. Temperatures will be warmer
today, despite the high clouds that will be present. Smoke
dispersion will become good by 11 AM to Noon.

Fire danger is expected to increase on Thursday as southwest flow
aloft increases. At this time, it appears the stronger winds won't
arrive until mid to late afternoon. However, humidities will be
very low so a Fire Weather Watch is in effect for Thursday. Friday
will likely feature windy conditions but cooler temperatures and
higher humidity.


.REST OF TODAY...

Sky/weather.........Mostly cloudy(60-65%) until 1100, then partly
                    cloudy(40-50%).
CWR.................0 percent.
LAL.................1.
Max temperature.....Around 67.
Min humidity........12%.
Wind (20 ft)........West winds 9-15 mph with gusts to around 20
                    mph.
Mixing height.......3800 ft AGL.
Transport winds.....West 22-32 mph until 1700, then 16-21 mph.
Smoke dispersal.....Poor until 1100, then fair until 1200, then
                    good until 1400, then very good until 1600,
                    then good until 1700, then poor.
Haines Index........4 or low potential for large plume dominated
                    fire growth.
```

Figure 40. The spot forecast (October 16, 2019 @ 0711 hrs) for Elkhorn 4 provided the National Weather Service Office in Boulder, Colorado.

COLORADO
Department of Public Safety
Executive Director's Office

Compliance & Professional Standards Office

Elkhorn Creek Unit #4 Prescribed Fire Review

Appendix D

Fuels and Fire Behavior Review Report

Appendix D - Fuels and Fire Behavior Review Report

Submitted by Brad Pietruszka, LTAN/FBAN, USFS

1. Site Characteristics

The Elkhorn 4 prescribed fire units are in Larimer County, Colorado, approximately 5.5 miles Southeast of Red Feather Lakes within the northern Front Range. Elevation ranges from 7,300 ft to 7,900 ft within the two units, encompassing the east to west oriented Elkhorn Creek at the lowest area and scattered rock outcroppings to the north. Slopes range in the prescribed fire units from nearly flat to in excess of 40% on rock outcroppings in unit 4a and on ridgelines within unit 4b.

The project area is heavily influenced by the east to west running Elkhorn Creek drainage, with a ridgeline to the south dominated by Pingree Hill (8,770') separating Elkhorn Creek from the Cache La Poudre River. West of Red Feather Lakes, the terrain lifts towards the continental divide.

Vegetation immediately adjacent to the project area is dominated at the lower elevations by montane grasslands with some sagebrush, transitioning to ponderosa pine woodlands at higher elevations and on rockier sites. On north aspects, Douglas fir intermixes with ponderosa pine, and on drier south and west aspects there is some juniper present. Understory in the ponderosa pine is a mixture of grasses and shrubs. Ponderosa pine woodlands of the northern Front Range are recognized as having higher stocking levels than pre-European settlement conditions due to land use pattern changes, leading to an increased hazard of crown fire. On wetter sites and some drainages, aspen is present, as well as willows adjacent to streams that carry water much of the year.

Grasses at lower areas are grazed, resulting in lower fuel loadings in flatter areas. Cheat grass (*Bromus tectorum)* is present in many areas, favoring disturbed sites and drier aspects. From 2009-2011, a widespread outbreak of Mountain Pine Beetle occurred on the northern Front Range, resulting in mortality of upwards of 1,000 ponderosa pine trees on the Ben Delatour Scout Ranch. While many of these trees were removed, steep slopes and difficult terrain resulted in some pockets of heavy downed fuels (up to an acre in size) within and adjacent to the prescribed fire units.

2. Prescribed Fire Plan Prescription

The Elkhorn 4 Prescribed Fire Plan used two fuel models to characterize fire behavior within and outside of the units. GR2 – Low Load, Dry Climate Grass was used to model fire behavior within montane grasslands, and TU1 – Low Load Dry Climate Timber-Grass-Shrub was used for timbered areas. The burn plan estimates 15% of the prescribed fire area is non-burnable (NB9) due to rock and other barren areas. The prescription narrative states, "In areas with mixed conifers, heavier pockets of fuel loading exist, and an increase in fire behavior and single-tree torching can be expected."

The prescription for the Elkhorn #4 prescribed fire is shown below in red text.

Fuel Parameters:	**LOW**	**PREFERRED**	**HIGH**	**OUT***
1-Hour Fuel Moisture (%)	**13**	**6-8**	**4**	

10-Hour Fuel Moisture (%)	**15**	**8-10**	**6**	Sustained 20' winds >24 without blacklining or other mitigating factors** or high Fuel Parameters + more than one of the following weather parameters
100-Hour Fuel Moisture (%)	**17**	**12**	**8**	
Live Fuel Moisture (%) (Herb/Woody%)	**60/90**	**40/70**	**30/60**	
Weather Parameters:				
Air Temperature (F)	40	70	85	--
Probability of Ignition	17	40-60	80	--
20 ft wind speed (mph)	**10**	**18**	**24**	25
Wind Direction(s)	*Refer to smoke permit. Southwesterly component would be preferred from a tactical perspective.			--
BOLD numbers indicate values used in Behave runs when a range of variables existed but all were not modeled. **Other parameters could include: environmental or fuels conditions that moderate fire behavior, black lines are in place, natural barriers/sparse fuels that would limit fire spread.				

Fire Behavior			
Fuel Model – GR2, TU1	**Acceptable Fire Behavior Range**		
	LOW	**PREFERRED**	**HIGH**
Rate of spread (ch/hr)	15.8/.8	78.5/6.3	153.9/11.3
Headfire flame length (feet)	2.5/.2	6.5/2.6	9.0/3.6
Backfire (*sic)* flame length (feet)	.7/.2	1.3/.5	1.5/.6
Scorch height (feet)	5/0	29/4	58/7
Spotting distance (mi)	.2	.4	.5
Probability of ignition (%)	17	40	76

Narrative

A low to moderate intensity burn will be needed to meet the resource objectives of reducing conifer seedlings and saplings (<6") by 20% and removing 30% of 1-hour, 10-hour, and 100-hour fuels from the burn unit. The desired fire intensity will also support the Forest Management Objective of creating and supporting the maintenance of forest stand structures that will be consistent with low and mixed-severity fires.

In the areas with mixed conifers, heavier pockets of fuel loading exist and an increase in fire behavior and single-tree torching can be expected. Fire intensities in these areas will likely lead to isolated pockets of mortality due to higher flame lengths and increased residence time in larger diameter fuels.

Surface fire behavior fuel models used for surface fire behavior calculations were GR2 – Low Load, Dry Climate Grass (Dynamic), and TU1 – Low Load Dry Climate Timber-Grass-Shrub (Dynamic). In general, these selections were adequate to assess surface fire behavior characteristics, with GR2 generally overpredicting spread rates and fire intensities and TU1 underpredicting these characteristics. But since

the objectives of the prescribed fire were to both reduce conifer regeneration and maintain the majority of the larger diameter overstory, we have to assess TU1's ability to predict small diameter mortality in order to gauge its utility as a fuel model. By running BEHAVE Plus with the same inputs as the ECU4 RXBP "High" prescription parameters, but instead finding only values that would achieve this singular objective, it becomes apparent that TU1 as a surface fuel model selection is not capable of reducing over 20% of small diameter trees under any realistic wind scenario. Since TU1 is one of the least reactive surface fuel models that users can select, this is not surprising.

In prescription development, utilizing objectives that identify minimum and maximum limits on a fire effect, such as mortality of different size classes, is done to identify fuel moisture and environmental conditions in which objectives can be met while control of the fire is maintained. A maximum limit objective is one that should not be exceeded. In the case of ECU4, the objective, "Limit mortality of trees greater than 10" DBH to 20% or less" is a maximum limit objective. The objective, "Reduce conifer regeneration (<6" DBH) by at least 20% within 1 year of the burn" is a minimum limit objective. Within the BEHAVE Plus software utilized to model fire behavior parameters, both of these scenarios need to be run to identify what conditions can be present to both cause over 20% mortality in conifer regeneration and limit mortality of overstory trees below 20%. There is a desirable fire intensity level that will meet both objectives simultaneously that is both above a very low intensity fire and below a very high intensity fire. Unfortunately, TU1 is a difficult surface fuel model to assess these objectives with, as it will only show low intensity surface fire behavior characteristics under all fuel moisture and wind scenarios.

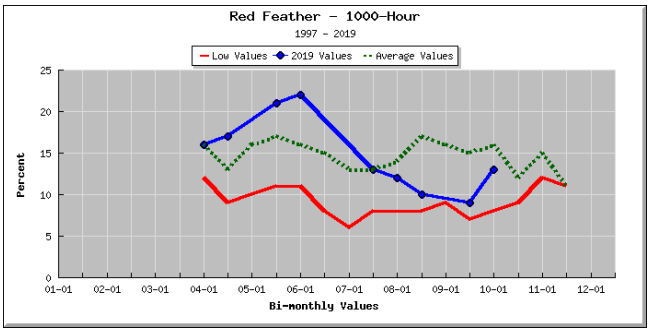
Since a dynamic fuel model was selected, it is apparent that the plan preparer felt that live fuel moistures, both woody and herbaceous, were important influences on fire behavior. Based on observed fire behavior and the knowledge that both live and dead moistures were important to predicting fire behavior, fuel models that may have helped identify potential mortality constraints were GS1 – Low Load, Dry Climate Grass-Shrub (Dynamic) or GS2 – Moderate Load, Dry Climate Grass-Shrub. Both of these surface fuel models are significantly more reactive than TU1, and would have shown that 20-foot wind speeds above 18 miles per hour in GS1 and above 4 miles per hour in GS2 would have exceeded the limiting objective of the burn plan while at the same time reducing the rate of spread of the adjacent grass fuels.

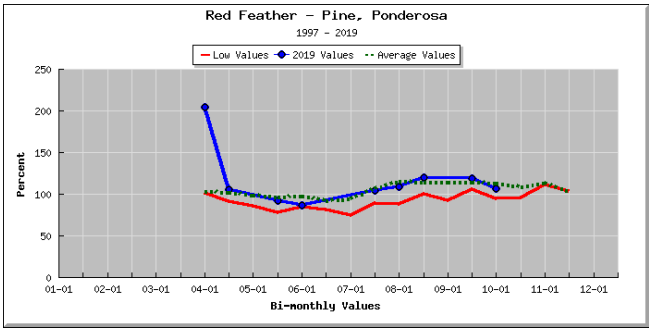
Element 11, Organization & Equipment, states that, "As modeled, fire behavior shows that spot/slop containment will be unobtainable with resources on scene under Moderate and High conditions in fuel model GR2. Black lines will be developed at a minimum of 100 feet utilizing backing fire before main ignitions begin."

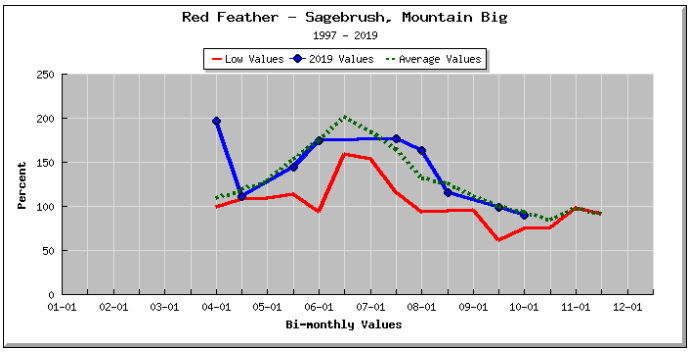
As shown above, moderate (Preferred) conditions in the prescribed fire plan prescription indicate spotting distances of up to 0.4 miles (2,112 ft), with up to 0.5 miles (2,640 ft) possible at high end conditions.

3. Fuel Moisture Conditions

While there was a stated desire to have on-site fuel moistures taken prior to ignition, numerous issues transpired that did not allow for this to occur. A light snow fell on October 11, prohibiting fuel moisture samples on successive days. A series of logistical issues and the need to prioritize other parts of the prescribed fire plan led to not having fuel moisture sampling completed prior to ignition. Numerous interviewees mentioned that fuel moistures taken by the Arapahoe-Roosevelt National Forest at the Red Feather fuel moisture monitoring site were used as a proxy. Relevant information available at the time of October 15th is shown below from Red Feather fuel moisture sampling site on the National Fuel Moisture Database.







On October 1, the observed dead fuel moisture of 1000-hour timelag fuels was reported at 13%, while ponderosa pine live foliar moisture was 107%, and Mountain Big Sagebrush was 90%.

Within fire behavior fuel models, 1000-hour timelag fuels are not incorporated, as the Rothermel spread equation does not account for their influence. While Ponderosa pine live foliar moistures are near average, they are not incorporated into surface fire behavior modeling. Sagebrush live foliar moistures are near average, but trending downwards towards seasonal lows. While grasses were not sampled at Red Feather, minimum temperatures were below 32°F on 9/22, and from 10/2-10/7, with hard freezes below 15°F occurring on 10/10 and 10/11. These successive freezing events completely cured herbaceous fuels in the area (30% live herbaceous moisture content), which is evident from photographs of the prescribed fire.

While 30% implies there is some moisture left in the live herbaceous fuels, in surface fire behavior calculations this implies that the fuel is to be treated as a dead fuel. In many surface fire behavior fuel

models (including the prescribed fire plan selected GR2 and TU1) the entire live herbaceous load is transferred to a dead fuel loading category and treated the same as a dead fuel.

October 15th photograph showing cured grasses (live herbaceous fuel moisture of 30%) and dormancy of woody shrub species (live woody fuel moisture of 60%) under ponderosa pine.

Given the mid-October implementation of the prescribed fire, seasonal senescence had occurred on many woody shrub species, resulting in leaf fall and dormancy, also evident through visual evidence. Live woody fuel moistures can be represented as 60% during the implementation of the Elkhorn 4 prescribed fire.

While 1-hour, 10-hour, and 100-hour dead fuel moistures were not sampled prior to implementation, Fort Collins Dispatch provides daily WIMS indices for numerous Remote Automated Weather Stations (RAWS) on their website during fire season, which were available on October 15th and 16th, 2019. While these values are not measured, they are interpolated from National Fire Danger Rating System models.

October 15th and 16th, WIMS forecast fuel moistures are shown below. WIMS Forecast data is shown rather than observed values because that would have been available to the prescribed fire at the time of implementation.

WIMS Forecast Fuel Moisture Values at Red Feather RAWS, fuel model 7G2P2					
	1-hour dead fuel moisture	10-hour dead fuel moisture	100-hour dead fuel moisture	Live herbaceous moisture	Live woody moisture
October 15, 2019	3.91	4.26	6.98	30.7	92.2

October 16, 2019	3.36	5.1	6.88	3.4*	89
*WIMS processing allows live herbaceous moistures to drop below 30%, while fire behavior processors treat 30% and lower live herbaceous moistures as a fully cured dead fuel.					

While WIMS values are available throughout the year on Fort Collins Interagency Dispatch Center's website, a more common method to determine 1-hour fuel moisture in the field is to reference site-specific weather forecasts or observations to lookup tables to determine fine dead fuel moisture and probability of ignition. Fire Effects Monitors (FEMOs) were responsible for reporting the hourly fine dead fuel moisture and probability of ignition, and their observations are shown below.

Date	Time	Dry Bulb	RH (%)	Winds (MPH)	% Cloud Cover	Fine Dead Fuel (unshaded / shaded %)	Prob. Of Ignition (unshaded / shaded %)	Notes
10/15	1045	46	43	3 (5), NE	1	9/12	30/20	
10/15	1140	54	18	7 (13), SSW	1	5/7	60/40	
10/15	1300	60	11	5 (10), var W	1	3/6	80/50	
10/15	1350	54	39	4 (7), var SE	1	7/10	40/30	
10/15	1500	54	38	3 (8), ENE	1	7/10	40/30	
10/15	1600	50	40	3 (6), E	1	8/11	40/20	
10/15	1700	48	43	2 (6), SSE	0	9/11	30/20	
10/16	0945	56	20	Light, W	80	6/8	50/40	
10/16	1050	62	17	2 (8), terrain-driven	70	5/7	60/40	RH of 14% recorded at 1120 at test fire location
10/16	1200	62	14	2 (6), WSW	80	3/6	80/50	
10/16	1330	65	14	2 (8), W	70	3/6	80/50	Cloud cover reduced at 1350
10/16	1430	70	13	4 (10), W	40	3/6	80/50	Gusts of 23 MPH recorded on ridgetop

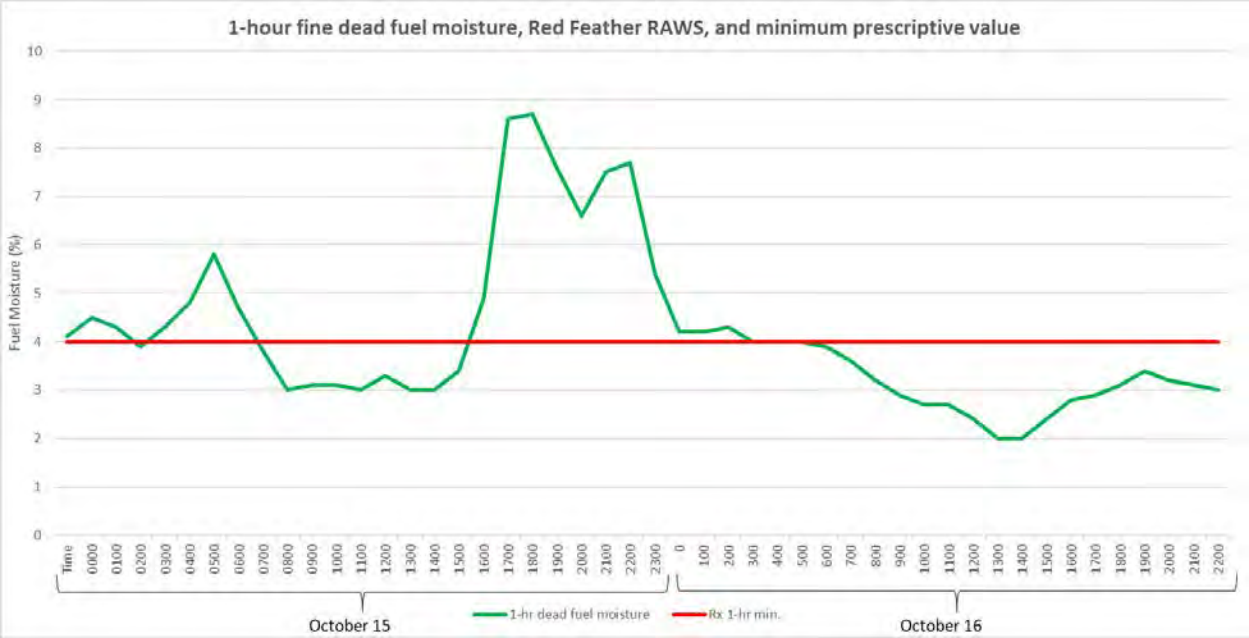
Spot weather forecasts were provided by the National Weather Service's Boulder Weather Forecast Office from October 14th through October 16th for the Elkhorn #4 prescribed fire. Using the spot forecast maximum temperature and minimum relative humidity and field lookup tables, fine dead fuel moisture can be determined from these spot weather forecasts as 5% on October 15th, and 3% on October 16th.

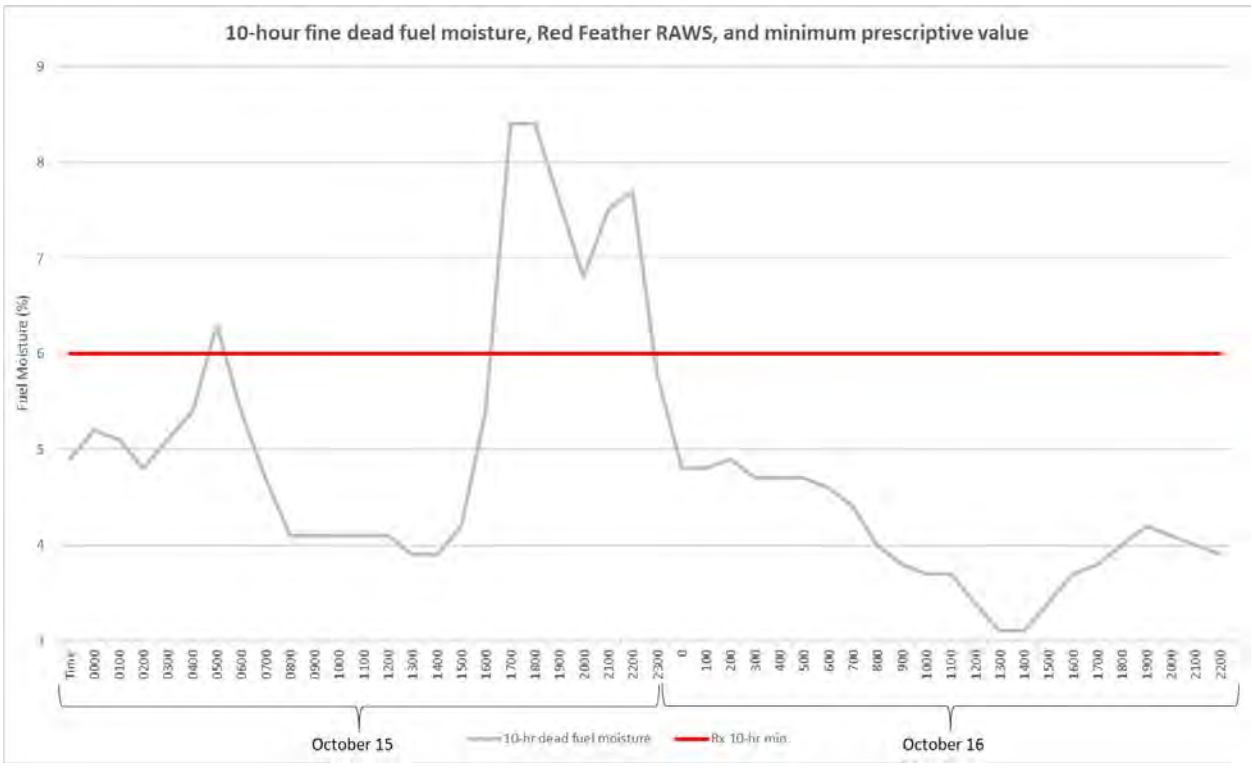
4. National Fire Danger Rating System

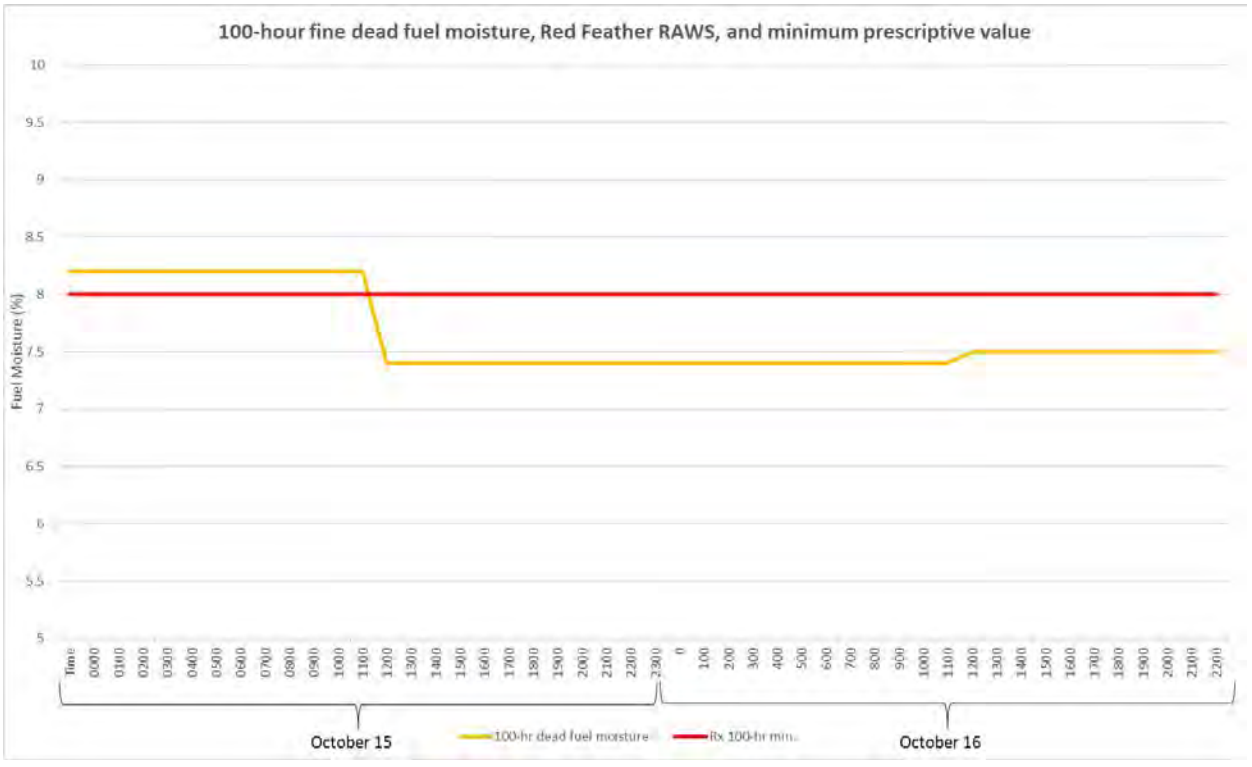
The National Fire Danger Rating System is a system that has been in place since 1978 that provides a consistent system to process weather information from Remote Automated Weather Stations (RAWS) into predictive metrics related to fire danger for the United States. The closest and most representative RAWS site is the Red Feather RAWS (050505), located approximately 6 miles NW of the Elkhorn 4 prescribed fire at 8,216'.

NFDRS 1978 is updating to NFDRS 2016, with improvements to live and dead fuel moisture calculations, but at the time of the Elkhorn #4 prescribed fire only NFDRS 1978 outputs would have been available to personnel associated with the project. For this reason, NFDRS 1978 outputs were used for the fire danger analysis.

NFDRS hourly fuel moisture data for fuel model G were analyzed through FireFamily Plus to produce the charts below of hourly fuel moistures of the 1, 10, and 100-hour timelag categories.

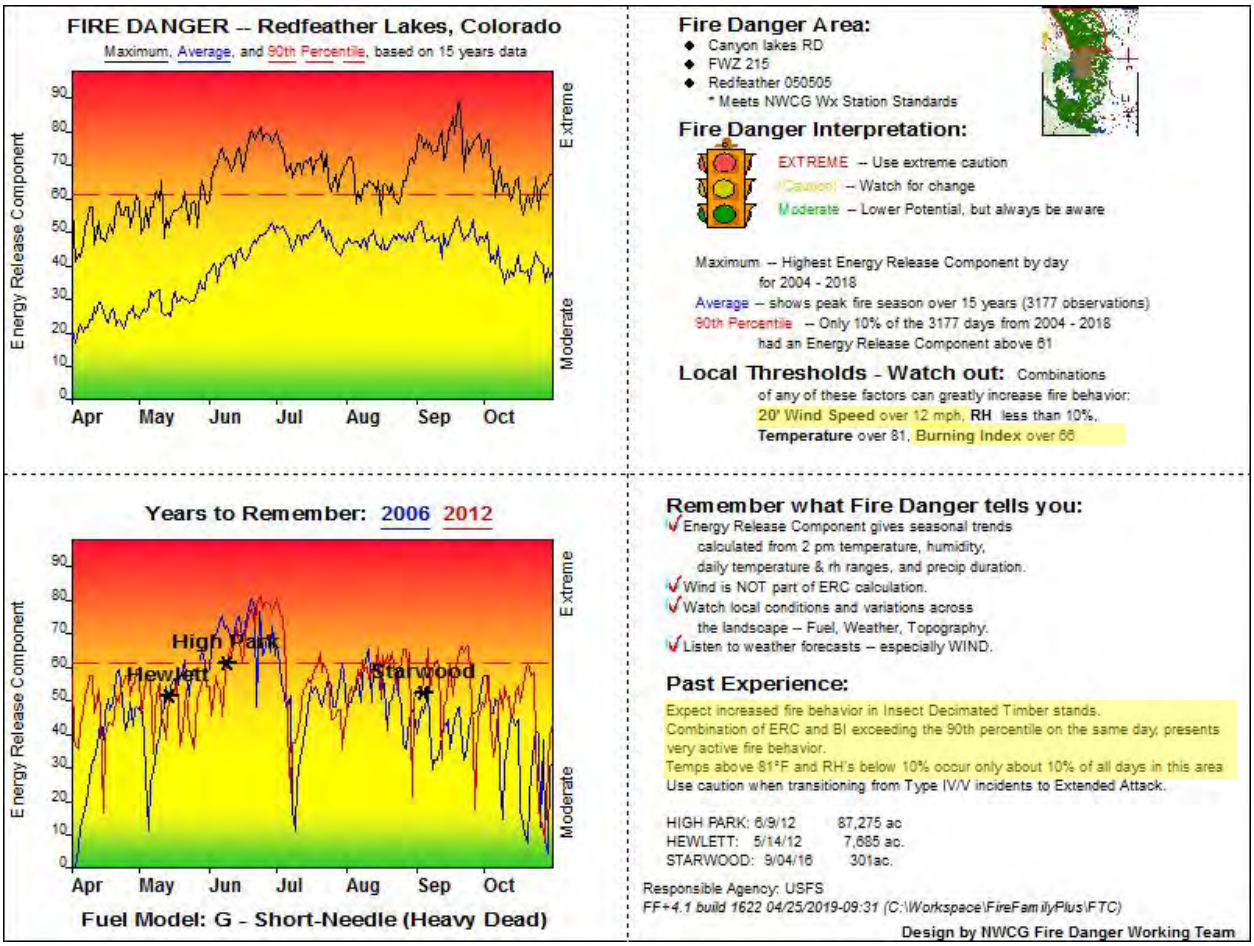






Locally relevant indices from NFDRS are analyzed and communicated to the field in a format called Fire Danger Pocket Cards. Fort Collins Dispatch provides Fire Danger Pocket Cards for the Redfeather Lakes area using data from Red Feather RAWS from 2004-2018. This information shows Energy Release

Component (ERC), a cumulative index of seasonal live and dead fuel dryness, as the index to reference for the area. The pocket card is shown below, with notations added.

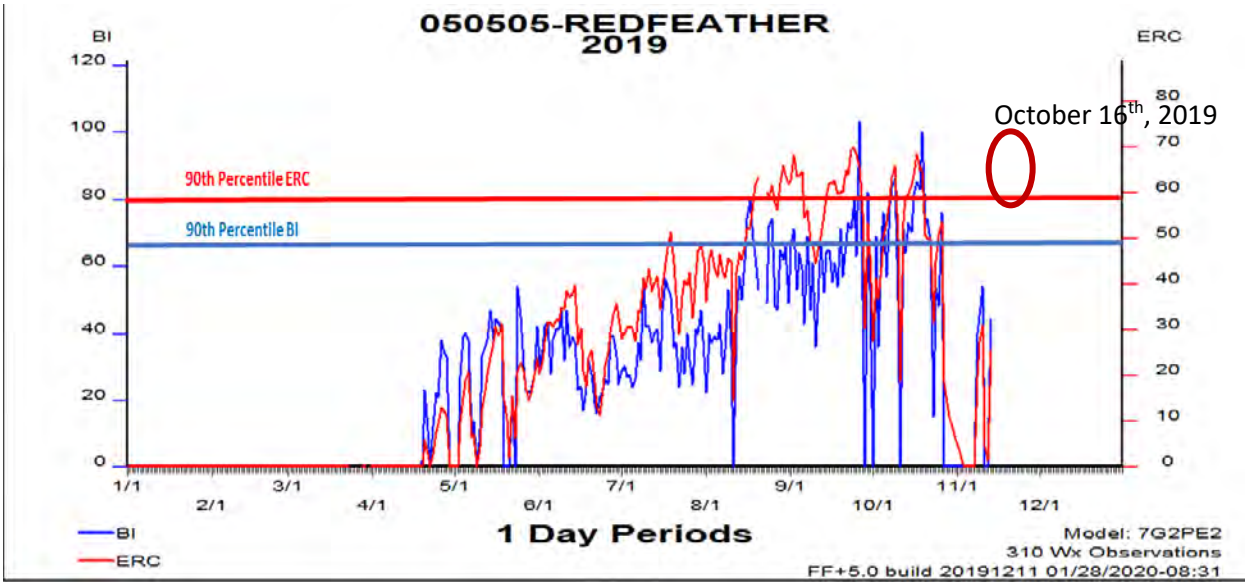


The Red Feather pocket card indicates that 20-ft wind speeds over 12mph and Burning Index above 66 are both local watch out thresholds. Burning Index is another NFDRS output that combines Energy Release Component with Spread Component, essentially adding the influence of windspeed to ERC. The pocket card also points out that, "…ERC and BI exceeding the 90th percentile on the same day presents very active fire behavior." For reference, the 90th percentile ERC value is 59, and the 90th percentile BI value is 66 at Red Feather RAWS from 2000-2019.

WIMS forecast and observed ERC and BI values were posted on Fort Collins Dispatch website on October 15th and 16th and are summarized below. Forecast values are simply predicted weather information for the day in question processed through NFDRS, and observed values are NFDRS processed values on observed weather data at the RAWS in question.

Date	ERC Forecast	BI Forecast	ERC Observed	BI Observed
October 15, 2019	62.2	64.7	63.4	66.8
October 16, 2019	63.7	77.4	65.3	77.9

The WIMS forecast values were very similar to the observed values on both the 15th and 16th of October. On October 16th, both forecast and observed ERC and BI were above the 90th percentile, indicative of a local watch out situation.



Shown above is a chart of both daily ERCg and BIg values from Red Feather RAWS for 2019, with the 90th percentile ERC and BI levels shown as a steady line in the corresponding color. October 16th is circled in red.

Cross-referencing ERC and BI percentiles is commonly done to identify critical fire business thresholds, and can incorporate prescribed fires as well as wildfires. The Elkhorn #4 prescribed fire is compared to northern Front Range notable wildfires since 2000 in the table below, in terms of ERC and BI percentiles.

Fire Name	Date	Acres Spread	ERC Percentile	BI Percentile
Bobcat	6/12/2000	10,599	97	97
Weaver Ranch	10/31/2001	1,600	80	97
Rennels	8/22/2010	327	80	80
Four Mile	9/6/2010	6,194	90	97
Reservoir Road	9/13/2010	652	97	90
Hewlett	5/15/2012	982	80	90
Hewlett	5/16/2012	4,112	80	90
High Park	6/9/2012	7,467	90	97
High Park	6/10/2012	29,492	90	97
Fern Lake	12/1/2012	1,590	90	90
Starwood	9/4/2016	301	70	80
Elk*	***10/16/2019***	***150***	***95***	***97***

**The Elkhorn 4b prescribed fire was renamed the Elk fire after a wildfire declaration was made on October 16th. Only fire spread outside of the prescribed fire units is shown above.*

The Elkhorn #4b prescribed fire was ignited under 95th percentile ERC's and 97th percentile BI's, well above the local watch out thresholds identified on the Red Feather pocket card, and under similar conditions as two of the largest fire spread days in recent history, June 9th and 10th, 2012, when the High Park Fire spread a combined 36,959 acres.

5. Observed Fire Behavior

Elkhorn #4 prescribed fire had one qualified FEMO and one FEMO trainee on October 15th, and one qualified FEMO on the 16th who took numerous photographs and observations of fire behavior during implementation. These observations are summarized below.

On October 15th, a test fire of unit 4a was initiated at 1204 in the northeast corner of the unit at DP-10. (See main report for map showing drop point locations.) Initial flame lengths in grass were 1-3', head fire and flanking, and around 1 ft backing fire flame lengths. In dormant brush, flame lengths were 4-6'.

Backing fire behavior in heavy grass at 1222, October 15th.

After main ignitions began, flame lengths were not observed to be over 6 ft in any vegetation type, and fire would only climb into mature ponderosa pine canopies when heavy brush or other ladder fuels were adjacent to the canopy.

Head fire in brush at 1340, October 15th.

Given the dry and continuous nature of surface fuels, fire carried through the interior of unit 4a on its own, making short upslope runs where wind and slope aligned. Winds and terrain generally pushed fire from east to west and south to north through the unit. There was some single tree torching observed but it was not extensive throughout the unit, and it was at levels consistent with prescribed fire plan objectives. At 1350, relative humidity increased from 11% to 39%, moderating fire behavior. There was very little spotting on October 15th, with only two detected and suppressed at very small sizes. By 1700, fuels were less receptive and difficult to carry fire through. By 1730 ignitions were completed in unit 4a.

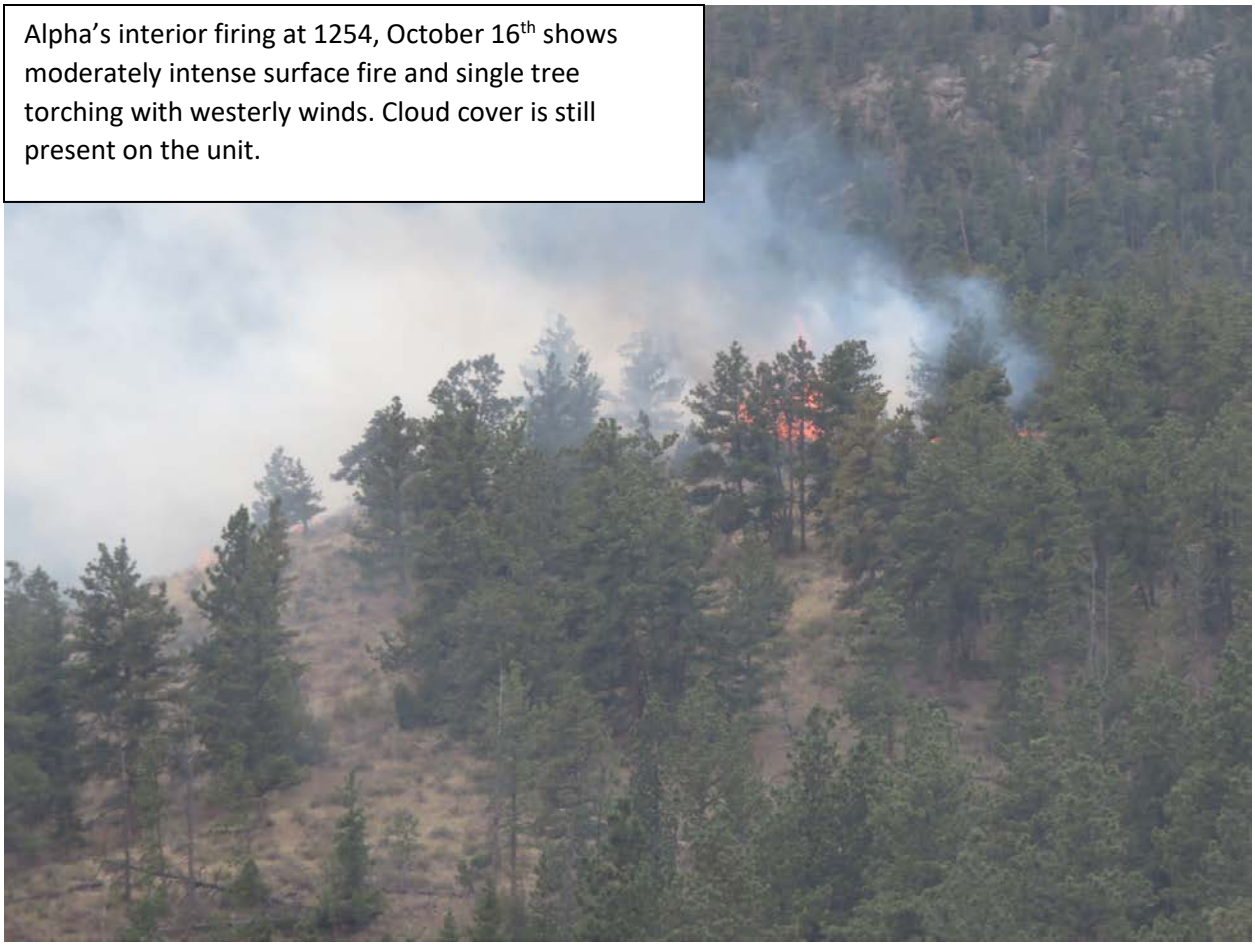
Higher humidity and loss of solar heating effectively ended the burn period around 1700. Fire behavior at 1728 on October 15th is shown here.

On October 16th, the same qualified FEMO from the previous day was again observing fire behavior and making notes. In the morning, there was heavy cloud cover and strong winds from 0430 to 0930. At 1121 a test fire was initiated southwest of DP-30, producing flame lengths from 1-3 ft with rates of spread of 14 chains per hour (~.2 mph) in grass. In brush, flame lengths of 3-6 ft were observed with single tree torching of junipers.

Test fire behavior at 1129, October 16th. Increased cloud cover is evident.

By 1215, blackline operations were moving from north to south towards DP-40 slowly, and Alpha firing initiated an interior test fire on a ridgeline northwest of DP-40. Fire was observed to back very slowly from the ridgetop in all directions with flamelengths from 1-2 ft and occasional torching of junipers and ponderosa.

Alpha's interior firing at 1254, October 16th shows moderately intense surface fire and single tree torching with westerly winds. Cloud cover is still present on the unit.

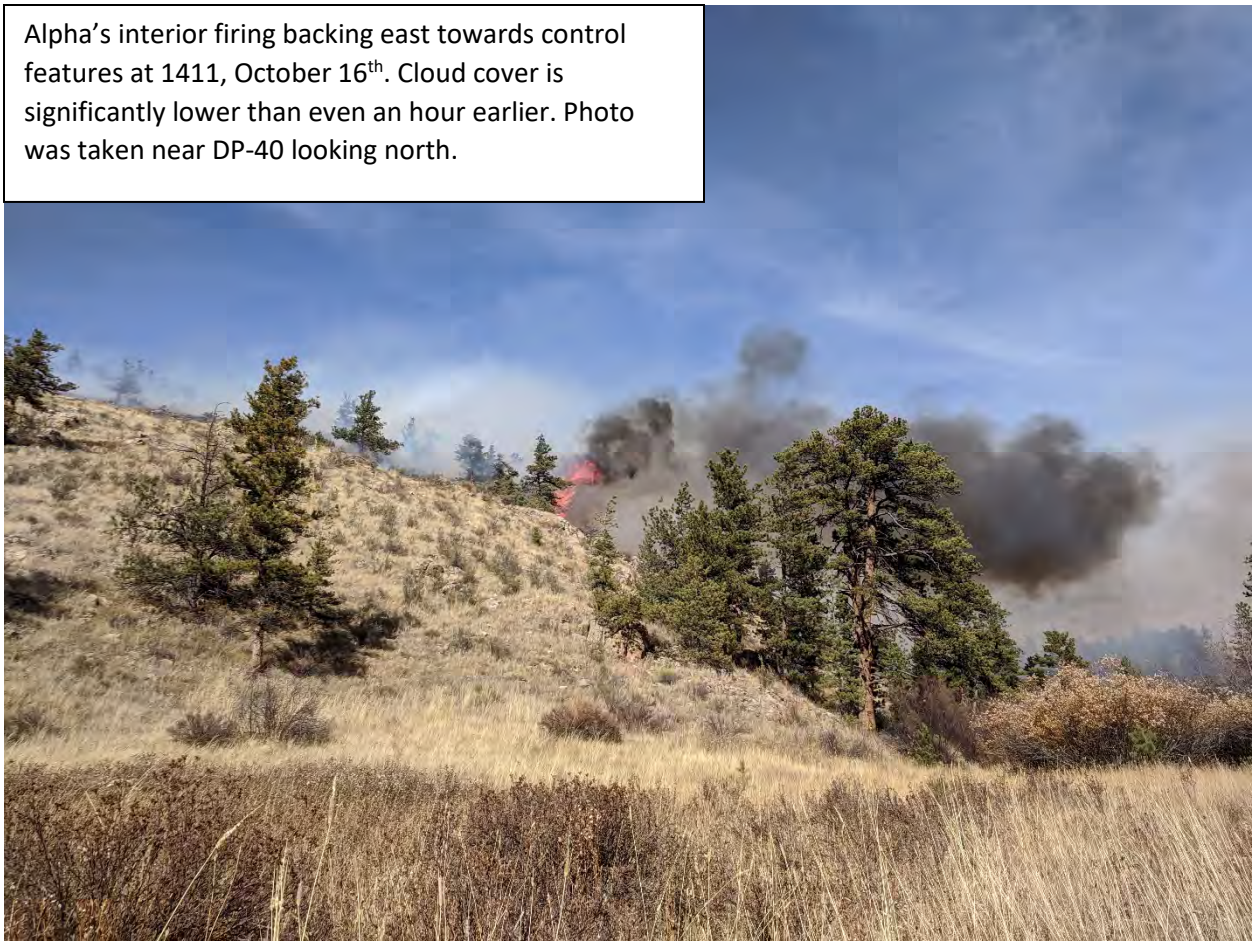


By 1345, the Zulu firing team (see main report for explanation of Zulu and Alpha) had completed their blackline from DP-30 to DP-40 of approximately 8 acres and repositioned to a knob north of Alpha firing's position to begin interior ignitions. Zulu firing team carried fire from the knob north of Alpha's firing team slightly west, then dot fired underneath their own fire. Around 1400, a third firing team initiated fire around a large machine pile that was to be excluded from ignitions. Fuels on the north aspect were less receptive to fire spread, and several interviewees observed residual snow patches in sheltered areas.

Zulu firing squad personnel dot fire beneath their ridgetop ignitions at 1421. Cloud cover has dissipated.

Zulu's firing at 1457 moving upslope.

Alpha's interior firing backing east towards control features at 1411, October 16th. Cloud cover is significantly lower than even an hour earlier. Photo was taken near DP-40 looking north.

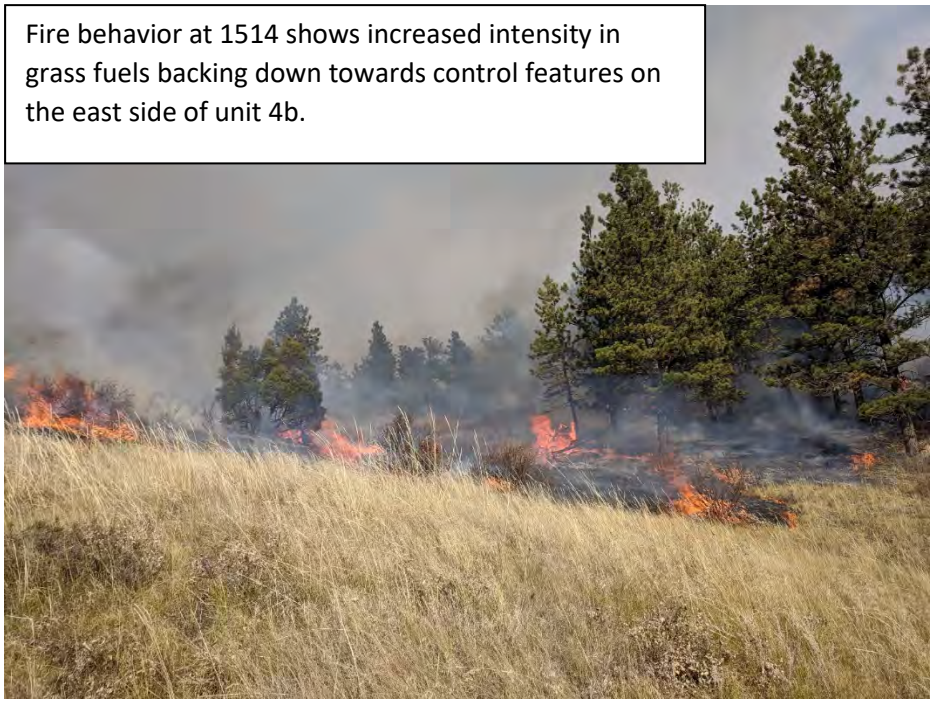


By 1430, the FEMO joined Alpha's interior firing team on top of a ridge north of DP-40, where winds were observed to be much stronger with an eye-level gust to 23 mph recorded. Fire intensity had increased, with flame lengths from 6-8 ft in brush, with rates of spread above 20 chains per hour (.25 mph) observed in grass. Backing fire intensity and rate of spread had increased downhill from Alpha firing's ignitions, and fire would back down in grasses, then flank to the east with strong west winds. Torching was observed in mature ponderosa pine around this time.

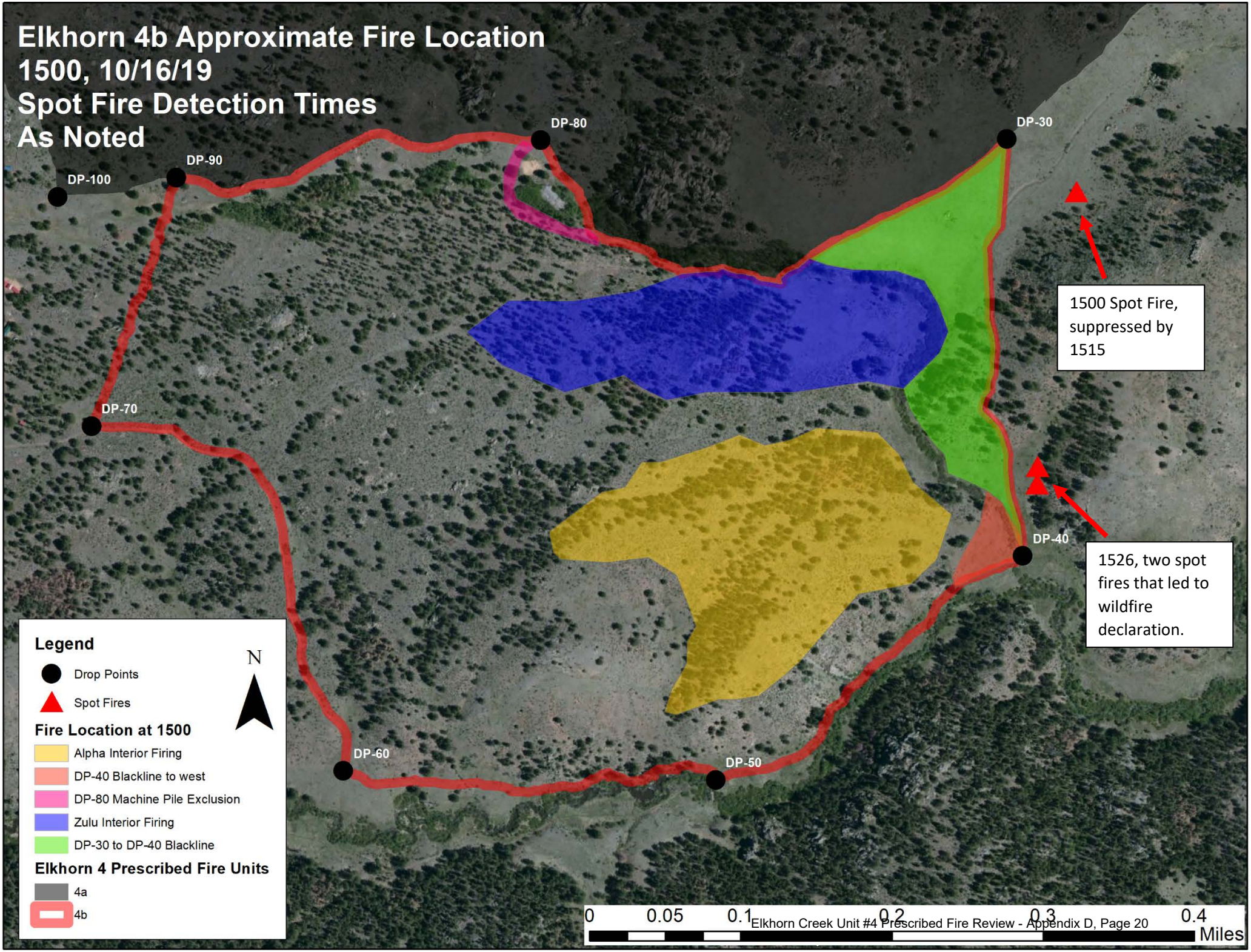
Back near DP-40, another small firing team initiated a blackline operation from DP-40 a very short distance west (less than 100 yards). This firing team was later pulled to suppress the eventual spot fires, but very little fire was applied near DP-40, and Alpha's ignitions had nearly backed to the control line near DP-40 by 1500.

Fire behavior at 1514 was significantly increased from the morning.

Fire behavior at 1514 shows increased intensity in grass fuels backing down towards control features on the east side of unit 4b.



At 1500 the burn boss detected a spot over the line near DP-30 in a punky log. The fire was smoldering and resources extinguished it by 1515. Around this time, the Alpha holding boss took a UTV from DP-30 to DP-40 along a rough road and at 1526 hrs, detected two separate spots at least 50 ft east of the road which was the eastern control feature for unit 4b. These spot fires rapidly grew upslope, aided by strong west winds on a southwest aspect in cured cheatgrass. By 1545, prescribed fire overhead recognized that these spot fires posed significantly difficulties to suppress, and at 1559 the Elkhorn #4b Prescribed Fire was declared a wildfire.


Elkhorn 4b Approximate Fire Location
1500, 10/16/19
Spot Fire Detection Times
As Noted
DP-80
DP-30
DP-90
DP-100
DP-70
DP-40
DP-60
DP-50
1500 Spot Fire, suppressed by 1515
1526, two spot fires that led to wildfire declaration.
Legend
Drop Points
Spot Fires
Fire Location at 1500
Alpha Interior Firing
DP-40 Blackline to west
DP-80 Machine Pile Exclusion
Zulu Interior Firing
DP-30 to DP-40 Blackline
Elkhorn 4 Prescribed Fire Units
4a
4b
N
0
0.05
0.1
0.2
0.3
0.4
Miles

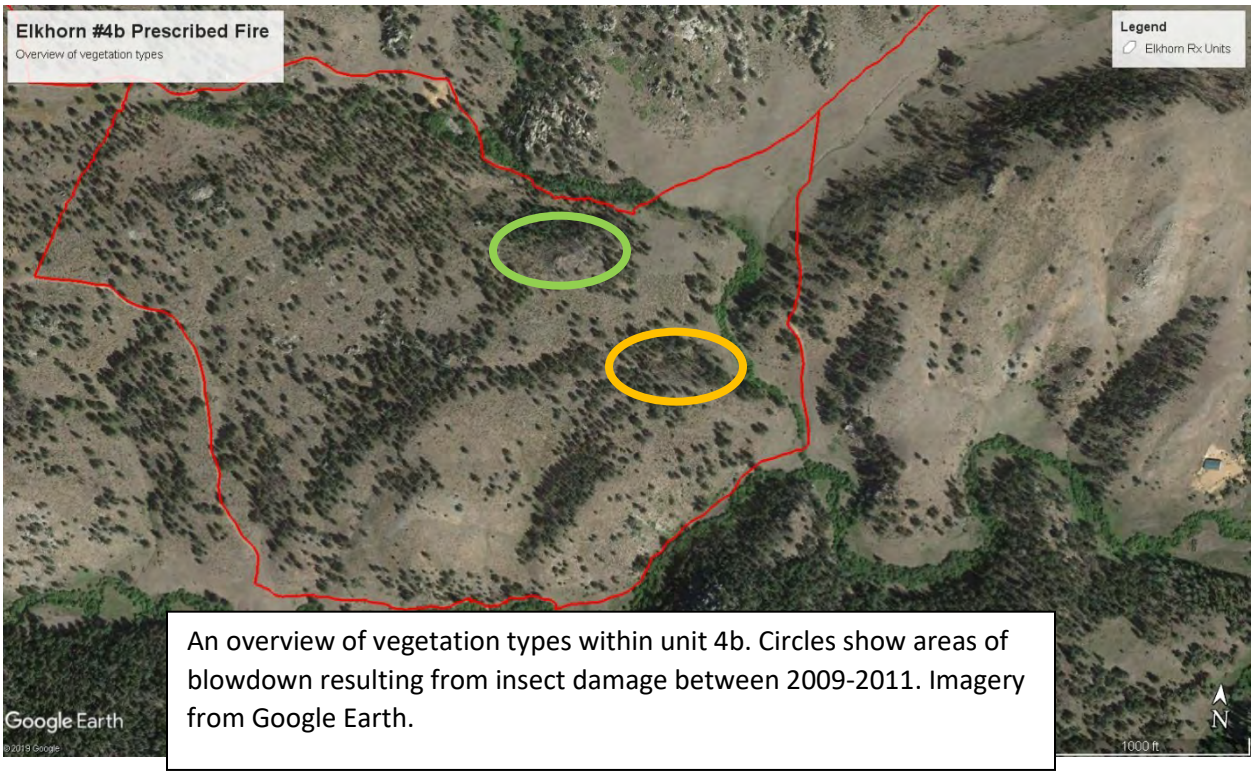
6. Post-hoc Fire Behavior Modeling

Fuels within the area are mixed but can generally be described by Scott & Burgan surface fire behavior fuel models based on site settings, informed by photographic evidence of fire behavior on October 15th and 16th.

Site Setting	Surface Fire Behavior Fuel Model
Montane grassland/sagebrush	GR1 – Short, Sparse Dry Climate Grass
Aspen/Willow	TU1 – Low Load Dry Climate Timber-Grass-Shrub
Ponderosa Pine Woodland	GS2 – Moderate Load, Dry Climate Grass-Shrub
Ponderosa Pine Woodland, Insect mortality, heavy dead and down fuel loading	SB1 – Low Load Activity Fuel

Canopy characteristics, where present, are generally 30-50% canopy cover of conifers that rarely exceed 70 feet.

Evident from Google Earth imagery as well as from interviews with key personnel is the existence of pockets of blowdown both along the ridgeline of unit 4b as well as in a sheltered bowl on the east side of the unit.



An overview of vegetation types within unit 4b. Circles show areas of blowdown resulting from insect damage between 2009-2011. Imagery from Google Earth.

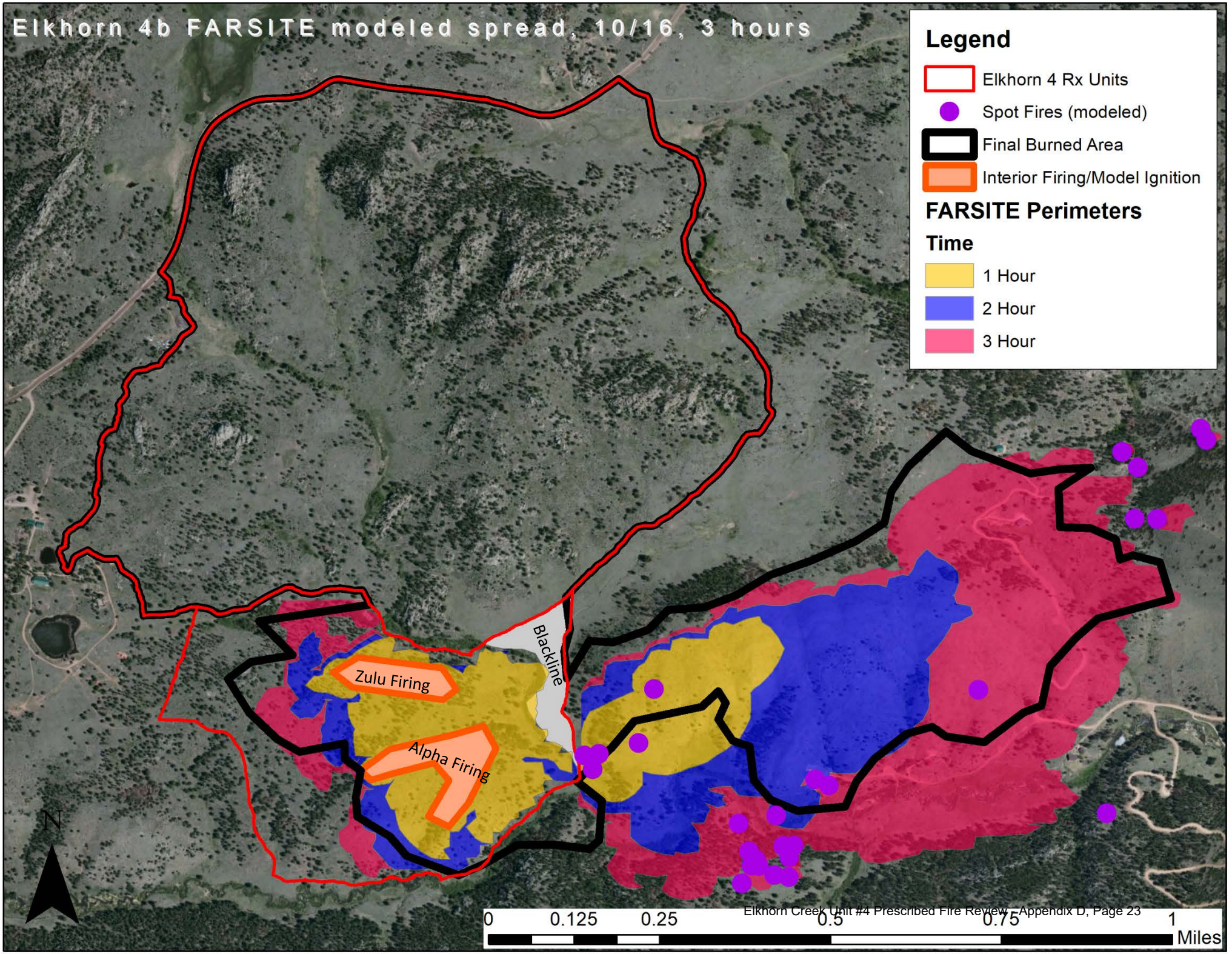
A closer view of blowdown circled in orange in the overview image. This area of blowdown is 1 acre in size and less than 600 ft from control features on the east perimeter. Imagery from Google Earth.

Fuel models used for the post-hoc fire behavior analysis of the Elkhorn Creek Unit #4 Prescribed Fire are similar to those used in the prescribed fire plan, with the exception of the fuel models GS2 and SB1 to represent ponderosa pine and areas of insect mortality and blowdown, respectively.

FLAMMAP6's implementation of FARSITE was used to model fire spread from Alpha Firing between 1400 and 1700 hrs. The landscape was edited to more accurately reflect current conditions, and to change surface fuel models to representative ones for the area. Visible areas of blowdown were incorporated into the landscape file, changing both the surface fuel model and removing canopy characteristics. Landscape masks were applied to make unit 4a non-burnable, as well as blackline from DP-30 to DP-40. Very little additional fire was applied along the perimeter of unit 4b after 1400 hrs during implementation and was not incorporated as an ignition to the model.

FARSITE modeled fire growth is shown on the next page, with yellow, blue, and red polygons representing modeled 1 hour fire growth, and purple circles representing modeled spot fire ignitions.

Modeled results do a reasonable job capturing overall fire spread as well as spot fire locations that led to the eventual wildfire declaration. Suppression action (which cannot be captured by a model) on the south flank of the Elk Fire likely limited spread south of Elkhorn Creek, explaining the difference between the observed and modeled fire perimeters.


Elkhorn 4b FARSITE modeled spread, 10/16, 3 hours
Legend
Elkhorn 4 Rx Units
Spot Fires (modeled)
Final Burned Area
Interior Firing/Model Ignition
FARSITE Perimeters
Time
1 Hour
2 Hour
3 Hour
Zulu Firing
Alpha Firing
Blackline
N
0
0.125
0.25
0.5
0.75
1
Miles

7. Spotting Source Locations

There were two locations where fire spotted on October 16th, one near DP-30 at 1500, and the second, and eventually the problem spot fire, in a small subdrainage east of the control features between DP-30 and DP-40 at 1529.

The spot fire near DP-30 was generated from ignitions by the Zulu firing team. The Zulu firing team began to ignite below their fire on the ridge around 1421 to speed fire's progression from the ridgetop to the control features on the north back to the test fire site at DP-30. This fire was un-anchored and allowed to move freely as a headfire back to the test fire and blackline area, which was approximately 350 ft in depth near DP-30. BEHAVE plus shows that a wind driven surface fire could have spotted up to 0.3 miles under observed conditions, or a small shrub or tree could have torched and generated this spot. This spot fire was rapidly detected and extinguished.

Zulu firing begins carrying fire west at 1421, October 16th. Unit 4a visible in foreground. Circled in black are Zulu firing squad personnel. Single tree torching is evident on ridgetop.

Based on interviews and modeled fire spread, there are three possible areas that generated the embers that led to the eventual wildfire declaration of Elkhorn 4b. All are possible but described below from more likely to less likely.

In the first scenario, interior ignitions from Alpha firing was able to back to the south, then flank east when exposed to westerly winds and curl back north until it entered the bowl of blowdown near the eastern perimeter. Fire was observed to be picking up in that bowl between 1400-1430 by Zulu Firing Boss Trainee until smoke obscured the view. While this fire was predominantly backing downslope through the heavy fuels, the intensity it created could have easily lofted embers over the relatively close by control feature (550 ft west) onto a southwest aspect at its ft peak flammability for the day in light, flashy fuels. Very little lofting would have been necessary for this to occur, as the blowdown and the spot locations are at the same elevation, with a small drainage between them.

In the second scenario, interior firing by Alpha caused individual or small group torching, launching embers high enough to be exposed to strong 20-ft winds which could have easily moved the 1,000-1,200 feet required to breach the unit boundaries. Given that interior ignitions had moved west by 1400, overall spotting distance would have to be closer to 2,000 feet but is still possible given the windspeeds on October 16. While winds would have likely been eddying in the tributary creek, embers generated on the ridge would have had to descend 150 vertical feet to ignite spots in the area they were observed. While this is certainly possible, the limited torching observed on the ridgeline proper along with high windspeeds makes it less likely than the first scenario.

And in the third scenario, as fire backed downhill from Alpha and Zulu's interior firing, it would have encountered unburned willows along a north/south tributary of Elkhorn Creek. These willows were purposely excluded from blackline operations between DP-30 and DP-40 and available to burn. As the willows caught fire, there is an area roughly halfway between DP-30 and DP-40 that contains several ponderosa pines that had been underburned but had the canopy intact. The direct flame contact from the willows to unburned canopy could have generated single tree torching, or embers from the willows could have spotted over the control line. The drainage scenario would have needed to spot the least horizontal distance, but also would have been the most sheltered from the winds and would have needed to loft a minimum of 50 vertical feet for this to have occurred. Additionally, the eventual spot fires that led to the wildfire declaration were slightly south of where the willows and pine met. However, eddying winds could have certainly transported embers in any direction from a torching tree in a drainage bottom.

BEHAVE Plus SPOT modules from a wind driven surface fire in a valley bottom, a burning pile at the same elevation on the leeward side of the ridge, and a single tree torching on a ridgetop as well as a valley bottom show that maximum spotting distances are all within the realm of possibilities for the three scenarios above. FARSITE identifies scenario number one is the most likely spotting source. Given that all interior firing was un-anchored (firing was not initiated next to control features or previously burned areas), the fire could have burned in any number of ways that are difficult to determine without direct observational evidence.

Regardless of the spotting source, after the problem spot fire ignitions occurred they were detected within 1-2 minutes of ignition. Upon sizeup, the spots were described as rapidly growing and approximately 10x20 feet. Rates of spread in the cured cheat grass on the southwest aspect were around 30-40 feet per minute, with flame lengths of 3-5 feet. The rate of spread and fire intensity made direct attack difficult, and within an hour the fire was over 50 acres outside of the unit boundaries and fully exposed to strong westerly winds.