South Beaver Prescribed Fire

Little Twist Wildfire

June 13, 2024

DECLARED WILDFIRE REVIEW

Beaver Ranger District
Fishlake National Forest

Forest Supervisor Delegation
Report Date: March 6, 2025

Abstract: South Beaver is a landscape-scale prescribed fire project designed to improve forest health and vegetation diversity, reduce fuel buildup, and enhance wildlife habitat. Several units were ignited in May 2024 utilizing snow lines. Over the ensuing weeks, as expected, fire continued to spread within those units as the snow melted. Eventually management and resource needs were greater than could be handled by the prescribed fire organization. Even though it remained entirely within the project boundary, 42 days after initial ignitions, the South Beaver prescribed fire was declared a wildfire.

Table of Contents

Introduction

Prescribed fire is a key tool on the Fishlake National Forest; by the numbers it is one of the top Forest Service programs in the western United States. The forest averaged 56,000 acres of fuels treatments accomplished annually in the last five fiscal years, of which over 10,000 acres annually is prescribed fire. The philosophy of the Fishlake dovetails with the agency-wide Wildfire Crisis Strategy: active management with the goals of resilient ecosystems, improved wildlife habitat, and reduced fuel loads. The forest fuels program is well integrated with internal and external partners.

During the spring of 2024 the forest planned and implemented three mixed-conifer prescribed fires across three different ranger districts. With similar vegetation, these all came into prescription about the same time, each requiring an individual organization. As expected for the mixed-conifer fuel type, there was visible smoke, as well as fire moving around in the interior of the units over the days and weeks following ignitions. The forest anticipated, planned for, and took actions to manage fire containment.

South Beaver Prescribed Fire May 2024

The South Beaver prescribed fire conducted ignitions May 2nd – 4th, and 16th – 18th. The plan for holding included burning into snow at the upper elevations of the target units. By late May and into early June, with snow receding and conditions drying out, Beaver District fire resources were engaged in securing and holding actions daily. Personnel from other districts, the Supervisor's Office, and other forests were involved both on the ground and for advice/expertise.

Additional ignitions conducted June 5th – 7th to limit fire spread went according to plan, but despite these efforts there was significant fire movement to the east in Unit 4 on June 12th and 13th. Though the fire was still well within the project area, a portion of the prescribed fire was declared a wildfire on the afternoon of June 13th as the complexity of containment actions was expected to exceed the current level of management. Resource availability, fire behavior, terrain, and the larger organization needed for containment drove this decision. The wildfire was called Little Twist and was under a Type 3 management organization and reached 5,367 acres.

Background

Prescribed Fire in the USFS Intermountain Region

The Intermountain Region stewards about 34 million acres of National Forest System (NFS) lands, more than any other region. Approximately 50% of these NFS lands are moderately to highly departed from historic conditions leading to significant wildfire risk[1]. The U.S. Forest Service has recognized that solving the problem is complex and requires a common vision and strategy, as well as highly motivated employees on individual forests. To manage the wildfire crisis, the agency utilizes all fuel treatment options available, along with a focus in those areas that will make the greatest impact to enhance decision space when managing the inevitable unplanned ignitions.

Prescribed fire is one treatment option (often the most effective one)[2] to reduce wildfire risk, and the Intermountain Region is working to increase the use of safe and effective prescribed fire. Some examples include providing training opportunities in prescribed fire project development and design and facilitating burn plan writing workshops. These efforts lay the groundwork for alignment between leadership, specialists, and prescribed fire practitioners to implement objective-based prescribed fire treatments. Actions include greater resource coordination during prescribed fire season which develops a common operating picture, aligns priorities, and streamlines the sharing of limited resources. The end goal is to create efficiency and competence leading to increased prescribed fire accomplishments.

[1] LANDFIRE Fire Regime Groups - Catalog (data.gov)

[2] Davis, Kimberley T.; Peeler, Jamie; Fargione, Joseph; Haugo, Ryan D.; Metlen, Kerry L.; Robles, Marcos D.; Woolley, Travis. 2024. Tamm review: A meta-analysis of thinning, prescribed fire, and wildfire effects on subsequent wildfire severity in conifer dominated forests of the Western US. Forest Ecology and Management. 561: 121885.

NWCG Glossary of Wildland Fire, PMS 205

Prescribed Fire over the last 5-years within the Intermountain Region

While the South Beaver prescribed fire was in progress, similar landscape-scale projects of long duration were being implemented on four forests within the region. From May through June, region-wide, an average of 3,300 acres were accomplished per week, and during peak implementation there were as many as 16 different ignition units on seven different forests. Historically, up to two-thirds of prescribed fire acres in the Intermountain Region are implemented in spring (March-June).

South Beaver Project Area

The Beaver Ranger District of the Fishlake National Forest is a single contiguous block of land surrounding the Tushar Mountain range. Water from these mountains provides the municipal supply for the rural communities on both sides of the range in Beaver and Piute counties, and it is essential for agriculture in the region.

The Tushars rise higher than other nearby ranges (12,169 ft), with steep slopes and intermittent cliff bands. The vegetation and topography are typical of Central Utah with mixed conifer and aspen being the main forest types at the moister, higher elevations. In the South Beaver project area, treatment units range from 7,700 feet elevation near the Birch Creek trailhead, up to 10,700 feet along Birch Creek ridge. Douglas-fir, Engelmann spruce, and subalpine fir are the most common conifer species. Aspen stands range from stable to seral and conifer-encroached depending on competition from other forest types. Lower elevations receiving less rainfall include large patches of shrubland and woodland.

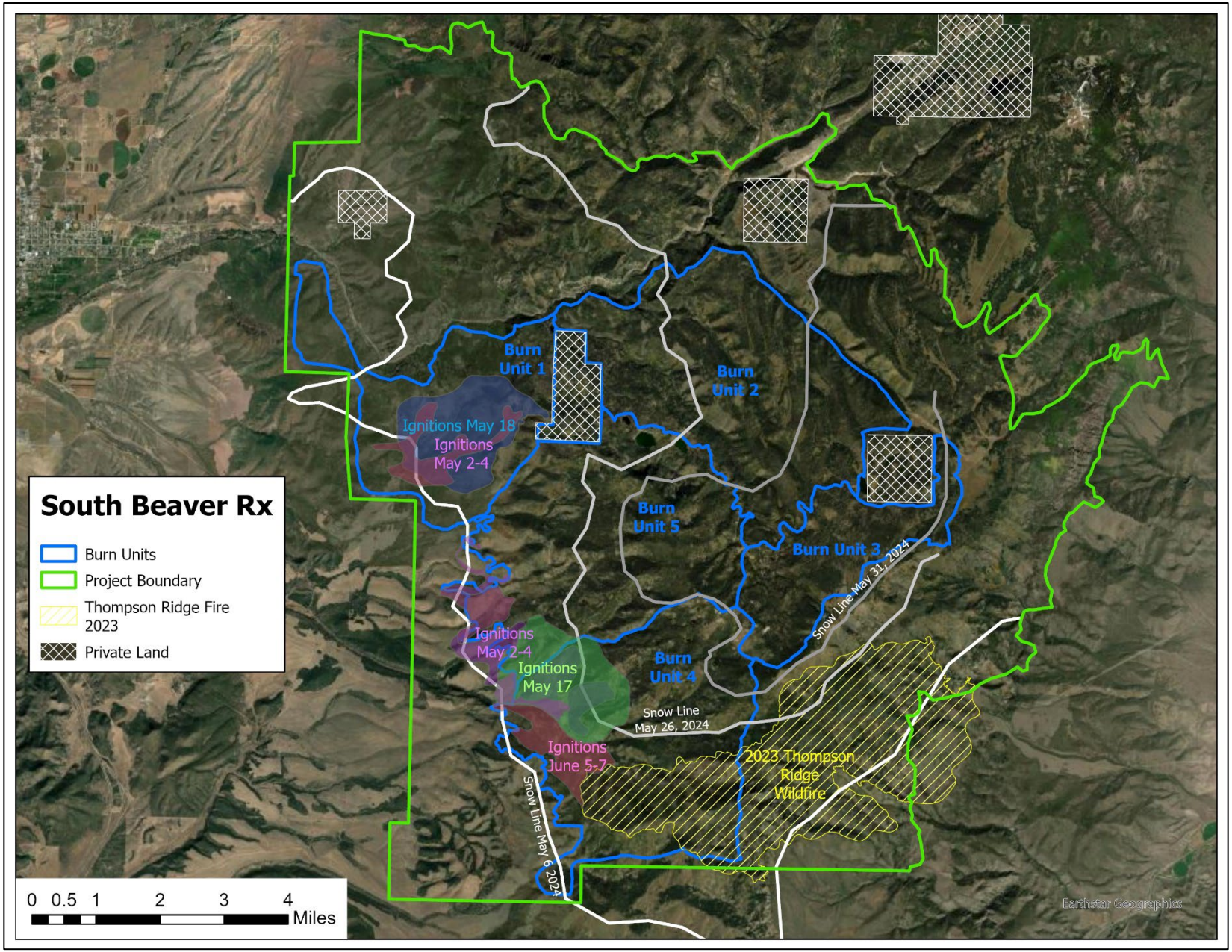
Significant wildfires on the district since the year 2000 have included at least eight incidents over 300 acres for a total of 70,000 acres[3]. The 2010 Twitchell fire (44,000 ac) is noted in the South Beaver Vegetation Management EA (signed in 2018)[4] as a trigger for management to consider landscape-scale vegetation management treatments over the rest of the district.

The Beaver district fuels program is known for having experienced fire practitioners (the District Fuels Specialist has over 140 shifts acting as RXB2 and the District AFMO has 90) and are familiar with and have experience burning in this vegetation type. The surrounding community and cooperating partners (various state and local government entities, plus NGOs) are engaged on wildland fire issues and generally supportive of fuels projects, due to the longstanding high-trust relationships in place.

During implementation of the South Beaver prescribed burn, the fire environment followed typical seasonal patterns. In May and June of 2024, the Energy Release Component (ERC) indices from the area tracked the 10-year average. Conditions progressed from cool and moist days with occasional windows for burning in early May, to hot and dry days approaching pocket card thresholds in June. No significant wind events occurred. There was not an unusually rapid transition from spring into summer conditions. Daily high temperatures increased from the 40's to the 80's as snow receded. This transition season provides opportunities for prescribed fire even as wildfire season begins.

[3] Risk_Management_Assistance_Dashboard

[4] USDA: https://www.fs.usda.gov/project/fishlake/?project=52632


South Beaver Rx
Burn Units
Project Boundary
Thompson Ridge Fire 2023
Private Land
0 0.5 1 2 3 4 Miles
Burn Unit 1
Burn Unit 2
Burn Unit 3
Burn Unit 4
Burn Unit 5
Ignitions May 18
Ignitions May 2-4
Ignitions May 2-4
Ignitions May 17
Ignitions June 5-7
Snow Line May 31, 2024
Snow Line May 26, 2024
Snow Line May 6 2024
2023 Thompson Ridge Wildfire
Earthstar Geographics

Narrative

The South Beaver prescribed fire was planned to occur between **April 24th-May 31st** in Units 1, 2 and 5 for about 1,000 acres with snow as the holding feature at high elevations. Hand and aerial ignitions were planned, targeting mixed conifer stands, pinyon-juniper, oak brush and mountain mahogany on south aspects. An Uncrewed Aircraft System (UAS) recon flight was conducted on **April 29th** and the decision was made to start implementing **May 2nd -May 5th** with hand ignitions and UAS.

On **May 2nd**, district and forest employees, along with an out-of-area Wildland Fire Module (WFM), initiated the test fire with UAS. The fire carried in the oak litter and pinyon-juniper, but the UAS was unable to build enough heat in the mixed conifer to meet objectives, accomplishing 527 acres. On **May 4th** cloud cover moderated fire behavior and by the end of the operational period the WFM and UAS were released having accomplished 1,089 acres.

From **May 6th – 10th**, local resources continued to patrol the units. During this timeframe, limited to no smoke was visible and moisture was received on the unit. In the lead-up to the second ignition phase the planned helitorch base location had to be adjusted because the previous location had become unavailable. The new helitorch base was located further south and in proximity to Unit 4.

The forest had substantial discussions related to the fire behavior required to meet objectives in this vegetation type, associated risks, resource needs, and the potential for long duration fire on the landscape. On **May 14th** a forest-wide prescribed fire planning call was held to discuss implementation plans on three of the four districts during the same burn window. The Beaver Ranger District was selected to be first to utilize the helicopter and helitorch platform and then the ship would move to other districts. Ignitions would target the mixed conifer and other available fuels for an additional 1,000 acres. Snow was present on upper slopes, and the burn was to be implemented under the low prescription parameters.

District personnel gathered on the morning of **May 16th**, and after a successful test fire, continued with hand ignitions in Unit 4. On **May 17th**, two Type 3 helicopters arrived at the helitorch base. After a recon flight, a test fire by helitorch occurred, and with objectives being met, ignitions continued until late afternoon. Repeated calls were made from the public to the county fire warden and Richfield Interagency Fire Center (RIFC) about the prescribed fire due to its visibility from I-15.

Aerial ignitions with the helitorch continued **May 18th** and went well throughout the afternoon with rain occurring around but not directly on the unit. Aerial ignitions ceased late that afternoon due to weather and an additional 1,705 acres were claimed. The total acreage of the South Beaver prescribed fire was set to 4,754 since beginning on **May 2nd**.

From **May 19th - June 3rd**, district fire personnel were engaged in patrolling and securing portions of the burn. Access was difficult due to the snow. Calls about fire and smoke continued to come into RIFC and Color Country Dispatch and increased as the Memorial Day weekend approached. The prescribed fire continued to exhibit spread within Units 1 and 4. Fire behavior was meeting burn objectives, however, efforts at this point focused on eliminating or at least reducing spread potential in undesirable directions. Based on difficult access to the interior of Unit 4, concentrations of snags, and a heavy dead and down fuel load, the decision was made to implement an indirect firing operation to tie a portion of the burn into an old fire scar.

An Interagency Hotshot Crew (IHC) based in the region arrived the morning of **June 4th** and the firing plan was fleshed out to halt potential fire spread to the south and east within Unit 4. Hand ignitions

South Beaver Prescribed Fire, May 17

were initiated on **June 5th** and helitorch operations followed on **June 6th – 7th**. An additional 500 acres were accomplished for a total of 5,254 acres.

A UAS platform was utilized on **June 7th** to recon the previous days' ignition with infrared. No spots or slop overs were noted outside of the ignition units, but isolated single and group tree torching was observed. The IHC was released at the end of shift on **June 9th** and moved to another forest within the region to assist with prescribed fire implementation. Throughout the next shift, local crews concentrated on areas that might have potential. On **June 11th**, fire activity began to increase, and resources focused efforts to slow the spread towards the east and north within Unit 4. A Type 2 helicopter arrived **June 12th** to assist the ground resources around Senseball Peak, but it experienced bucket malfunctions and no water was delivered. Late in the afternoon the Burn Boss advised dispatch that fire activity had increased on the west side of Senseball Peak with continuous fuel to the northeast. By early evening all the resources were pulled off the fire. That evening, the AA and Burn Boss talked by telephone to discuss fire progression and the need for additional resources, which were limited unless the prescribed fire was declared a wildfire. A plan was made to talk the next morning.

By the morning of **June 13th**, the fire had burned around the Rock Lake and Mud Lake areas with aspen stringers and old burn scars slowing or checking up the fire spread. Resources assigned started scouting possible line locations, and the Burn Boss and Duty Officer took a recon flight. On the same day, the Beaver Ranger District was having their district orientation, with the Forest Supervisor in attendance. The South Beaver prescribed fire was noticeably visible from town. The District Ranger (RXA2, who was also the prescribed fire agency administrator), Forest Supervisor, Forest FMO (by telephone), Forest Fuels Specialist, District Fuels Specialist, and Duty Officer met to discuss the possibility of declaring a wildfire. The Burn Boss briefly joined the group to give an update of current fire conditions but left before the final decision was made due to tactical obligations. By early afternoon the decision was officially made to declare

the active portion of the South Beaver prescribed fire a wildfire, and both the Regional Fire Director and Regional Forester Team were notified. At approximately the same time, the Burn Boss informed RIFC that fire activity had increased, and everyone was pulled off the line.

Lessons Learned Provided by Review Team

1. Spring burning is vital to regional and national success. Spring burning can come with the challenge of long-duration fire on the landscape and prescribed fire plans must guide management through these extended events. Like a long-term strategy plan on a wildfire, a prescribed fire plan must serve in a similar capacity.

2. Burning in mixed conifer is challenging. Sequence of implementation and size of burn units can begin at small scales, providing for holding features in areas of concern. Patience and timing increase the probability of success for burning much larger burn units after areas of concern are mitigated. *[*See: *Findings and Recommendations, Ignition and Containment Issues in Heavy Fuels]*

3. Prescribed fire in mixed conifer is essential. Forests in Region 4 are learning best practices and sharing methods. Practitioners could utilize the same tools and resources (LANDFIRE, Risk Management Dashboard, geospatial fire behavior modeling, etc.) that are available on wildland fires, and we should help facilitate their use.

4. A thorough technical review of the prescribed fire plan is critical to the success of implementation. For large-landscape-scale burns, a reviewer from outside the area, from another agency, or from the Intermountain Region technical review group could provide an unbiased evaluation of the elements and how they relate to the complexity analysis. [See: *Findings and Recommendations, Fuel Models Incomplete]*

5. Large-scale burns have multiple aspects, vegetation types, prescribed objectives, and constraints that may require more complex planning or organization to implement. Having a burn plan with sufficient depth and detail to match the complexity of the burn is necessary. [See: *Findings and Recommendations, Fuel Models Incomplete and Complexity Analysis]*

6. Prescribed fire is not an exact science but rather an art of implementation sequencing. As prescribed fire managers target larger landscapes, a combination of treatments building off each other across years may be needed. These may include burning during different seasons, utilizing vegetation and terrain transitions, fuel breaks, slash treatments or a combination of all.

7. Individuals close to this declaration noted that others, internal and external to the agency, called this declaration an “escaped prescribed fire”. Within the wildfire community we use the term “escape” as a synonym for a wildfire declaration when an escape is one possible criteria for a wildfire declaration. To improve understanding and limit confusion, it is simply a declaration or a declared wildfire.

Lessons Learned Provided by Participants

1. You need to burn stand-replacing mixed conifer on the high end of the prescription in spring to get the consumption you want and to minimize areas that can become active and pose potential holding issues in June. [See: *Findings and Recommendations, Ignition and Containment Issues in Heavy Fuels]*

2. Our partners had resources and were willing to help, but we didn't have the financial mechanism in place to pay for them. [See: *Findings and Recommendations, Functional and Funded Agreements]*

3. As a prescribed fire manager, the fire effects that we were getting from the South Beaver Rx in May were what we wanted and expected. In June, I suspected we didn't have enough resources to manage the growth or movement. [See: *Findings and Recommendations, Resources Commensurate with Predicted ROS]*

4. There is a need to be more strategic in our ignitions planning and implementation. This type of burn may require that you be aggressive in continued management (RXAA engagement, patrol, long-term holding actions, additional burning, etc.).

5. Mixed conifer stand replacement burning in the spring is a long-term commitment of local and regional resources and can/will fatigue your personnel.

6. Ensure that the assigned Burn Boss understands the plan, makes resource adjustments through time/conditions, is aware of the daily documentation requirements, and knows their importance.

Findings and Recommendations

Findings	***Recommendations***
Fuel Models Incomplete Fuel models selected for use in the burn plan in Element 4, and used to formulate the prescription in Element 7, do not adequately represent conditions on the ground within and adjacent to the burn unit. Fire behavior in heavy mixed conifer is underestimated with the use of TL3 instead of TU5. Gambel oak, sagebrush, and pinyon-juniper areas show very slow rates of spread and flame lengths when modelled with SH1. Containment needs in Element 11 reflect low projections of potential fire growth. [*See: Appendix A.2 and A.3. and Appendix B Contributing Factors and Conditions*.]	Use appropriate fuel models that match the expected range of fire behavior throughout the burn unit and surrounding landscape when developing burn plans. Recognize the impacts of model selection on prescription development and organizational needs. Refer to LANDFIRE spatial data and consult fire behavior analysts for assistance if needed. IFTDSS and WFDSS can be used to indicate critical areas and formulate ignition plans. The final fuel model selection must be made by the user based on experience with fire behavior in the fuels under consideration. [See *Appendix E* for a detailed explanation.] Enroll in on-demand, self-paced IFTDSS trainings through the Wildland Fire Learning Portal. Consider hosting on-site or virtual IFTDSS training. A thorough technical review is critical to ensure that the burn plan accurately mitigates the risks associated with implementation. Technical reviewers need to understand their responsibilities as outlined in PMS 484, page 47.
Resources Commensurate with Predicted ROS Fire behavior was underpredicted. The resources and equipment identified in Element 11 did not meet the fire containment needs at the desired and/or high end of the prescription.	Review and revise the prescribed fire plan to reconcile the inconsistencies that exist in proper fuel model identification, fire behavior modeling, and identification of containment needs and resources at the desired and high ends of the prescription. Specific attention is needed when receptive, continuous fuels exist adjacent to the area being burned.

Findings	***Recommendations***
Functional and Funded Agreements The Regional BLM Agreement had expired and the local agreement for state resources was short of funds for ordering equipment and personnel from other jurisdictions and agencies to support the South Beaver prescribed fire. [See: Appendix B Contributing Factors and Conditions]	Funding is a limiting factor. While it is understood there are limitations and tradeoffs, a best-case scenario for a prescribed fire manager is the ability to use interagency resources with the same flexibility and ease that exists in the wildfire suppression realm. If one of the regional strategies is to prioritize the use of partners (in this case, Utah Forestry Fire and State Lands) to accomplish prescribed fire, then regional agreements must be in place prior to implementation. The regional office is then responsible for delivering this product. The establishment of a National DOI agreement would create efficiencies, thereby reducing the administrative burden to the region and forests.
Ignitions and Containment Issues in Heavy Fuels Ignitions in early May focused on the available shrub and grass fuels (GS2 and SH5) as snow melted at the lower elevations of the project area. No residual heat remained in these lighter fuels. In contrast, ignitions in mid-May focused on available mixed conifer fuels (TU5) with heavy dead and down surface fuel loads across a broad area. These areas of mixed conifer had a long residence time and were in the smoldering stage and would eventually become more receptive as fuels dried. This broadly applied ignition without defined barriers allowed fire to move unchecked as snow melted into June.	Use an appropriate implementation sequence when planning to burn on a large scale; identify barriers or containment options that anticipate potential fire movement and long residence time. Focus and anchor into a barrier to work outward. Address long-term holding and management organizational needs in the *Complexity Analysis* and within *Element 16: Holding.* The management organization and tactics described in the burn plan need to accommodate seasonal transitions and multiple ignition windows during the holding, mop-up and patrol phases due to residence time of mixed conifer.
Complexity Analysis The complexity ratings captured the common situations under the rating descriptors. Site-specific information and local insight were limited in the preliminary risk rating and not included for post-plan risk and technical difficulty. Based on implementation, the complexity was too broad in scope and failed to capture specific risks and uncertainties.	Ensure site-specific descriptors are included in the complexity analysis to document local insight, empirical evidence, guidance and policies. The development of constraints or mitigations in the prescribed fire burn plan manages the risk to values.

Findings	***Recommendations***
Limited Access Difficult terrain, lack of roads, and snow limited the ability of resources to access the prescribed fire area. This caused an inability to observe fire behavior, limited medical evacuation options and, at times, hampered suppression tactics.	Identify access, barriers, and containment options through all phases of ignitions and holding so any fire behavior experienced can be managed. Burn when mixed conifer fuels are receptive and burn cleanly to limit holding concerns, especially in difficult terrain and along containment lines. Consider opening snow-covered roads with equipment to improve accessibility prior to implementation. *Element 13: Public and Personnel Safety, Medical* needs to consider remote extraction and inaccessibility.
Good Intelligence Gathering and Dissemination The organization used the RIFC weekly intelligence outlook to maintain awareness and understanding of current conditions.	Find ways to share examples of *Weather, Fuels, and Fire Danger* products or local tools with other programs within the region and continue to integrate into burn implementation.
Weekly Prescribed Fire Coordination The Fishlake NF facilitates a weekly forest-wide Fuels and Fire Management call to coordinate internal prescribed fire activities. Implementation plans are shared upwards during the weekly regional prescribed fire coordination calls.	Continue internal coordination with fire and fuels staff and upwards reporting of proposed prescribed fire activity to the regional office.
Strong Public Acceptance Public support of prescribed fire is inherent in the Beaver community. The Beaver fuels program has brought the community into the planning efforts of the fuels program, and social support is indicative of the track record of the prescribed fire program.	Continue collaborative efforts within the community to maintain, grow and build trust and confidence with partners.
Remote Automated Weather Stations A portable RAWS (pRAWS) was used during the South Beaver prescribed fire. There is a void of permanent RAWS on the Tushar mountains, and a RAWS has been previously proposed within this range. The district has the potential for a large-scale prescribed fire program and has frequent large fires where a permanent RAWS would be beneficial. *[See: Page 17, Season Severity]*	Conduct a site analysis for permanent RAWS locations and take advantage of funding opportunities. Most Forests have pRAWS but additional pRAWS are available for loan from the Boise RAWS Depot. When implementing prescribed fire, coordinate with your local servicing NWS office to determine if existing RAWS are sufficient, if pRAWS are recommended by NWS, and if so where they should be placed, *Post Pause USFS Quality Assurance Checklist, 2022*.

Appendices

Appendix A.1 - Seasonal Trends, Weather, and Conditions

Introduction

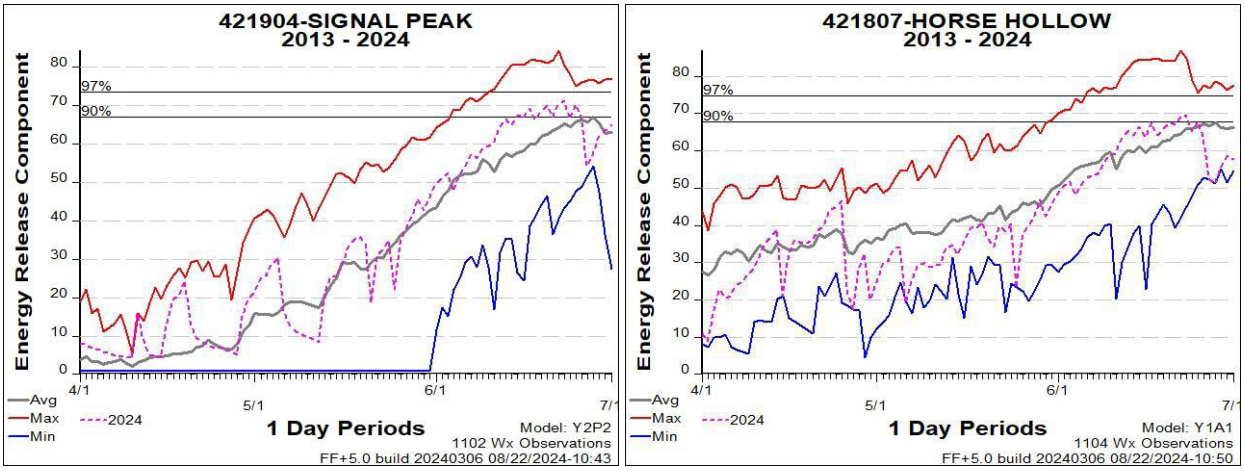
The following is a summary of fire season conditions for the South Beaver prescribed fire project area between May 1 and June 13, 2024. The year's severity indices are compared to seasonal trends from previous years. Predictive services and climate prediction outlooks are included. Observed weather, fuels, and expected fire behavior are summarized.

Seasonal Severity

The South Beaver prescribed fire project area is in the southwest corner of the Utah Central Mountains Fire Danger Rating Area (FDRA). The Fire Danger Operating Plan (FDOP) for the area identifies Fuel Model Y for tracking fire danger indices at Remote Automated Weather Stations (RAWS) within the FDRA.

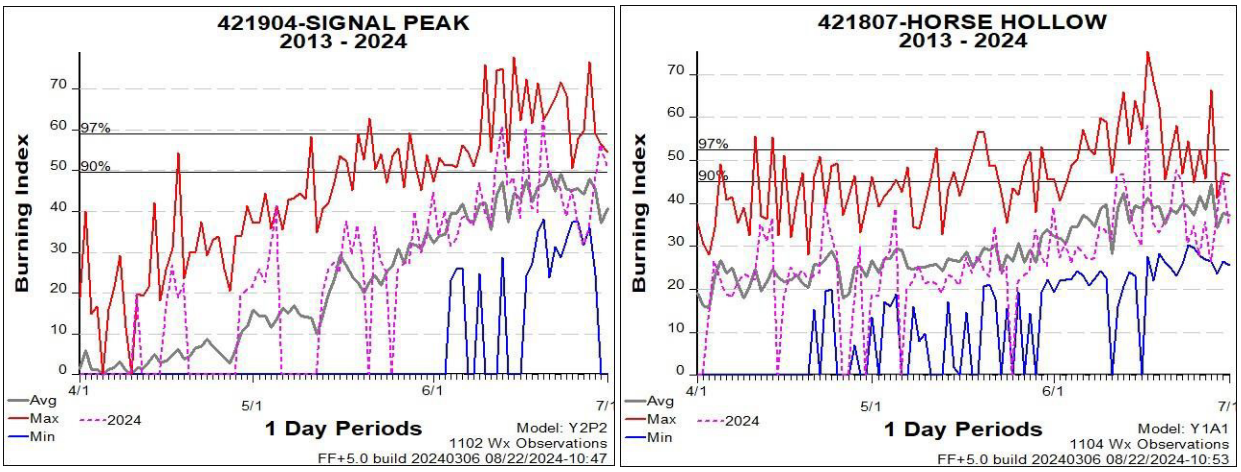
The closest permanent RAWS to the project area are Signal Peak and Horse Hollow. Signal Peak (WIMS ID: 421904) is located at an elevation of 8,767 feet, 31 miles to the northeast of the burn unit. It is representative of higher elevation conditions. The Horse Hollow RAWS (WIMS ID: 421807) represents lower elevations at 6,010 feet and is located 25 miles to the northwest. Both Signal Peak and Horse Hollow RAWS are used here to show how 2024 fire danger indices track with average, maximum, and minimum values from the past 10 years.

The Energy Release Component (ERC) is often used to evaluate the general severity of the fire season. It shows the effects of seasonal drying related to potential fire behavior. An ERC of 30 or greater is a rough indication of fuels being able to burn. In figures A.1 and A.2 below, the 2024 trend lines (dashed pink) indicate near average fire seasons at both high and low elevations.



***Figures A.1 and A.2**. ERC charts for spring 2024.*

The Burning Index (BI) incorporates daily wind speed and relates to the contribution of fire behavior to the effort of containing a fire—in essence, how fast a fire will spread and how much energy will be produced. In figures A.3 and A.4, the above average "spikes" in the BI are when conditions were in prescription and favorable to meet all or some of the burn objectives and correlate to ignition days.



***Figures A.3 and A.4**. Ignition operations were completed during May 2nd – 5th, May 16th – 18th, and June 5th – 7th. The "spikes" in the graphs correlate to these timeframes.*

Within the context of NFDRS, the fire danger adjective rating and preparedness plan components remained "low" from May 2nd – June 7th. June 12th (day before declaration) was the first day the BI reached or exceeded the 90th percentile, resulting in a fire danger adjective rating of "moderate."

Outlooks

National Temperature and precipitation outlooks for May-June 2024 from the Climate Prediction Center indicated warmer than average temperatures for the period. Precipitation was predicted to have equal chances for wetter or drier than normal in May, with a 33-40% chance for drier than average in June and July (Figure A.5). The June 4th 8-14 day outlook (for June 12-18) predicted above normal temperatures and near normal precipitation (Figure A.6).

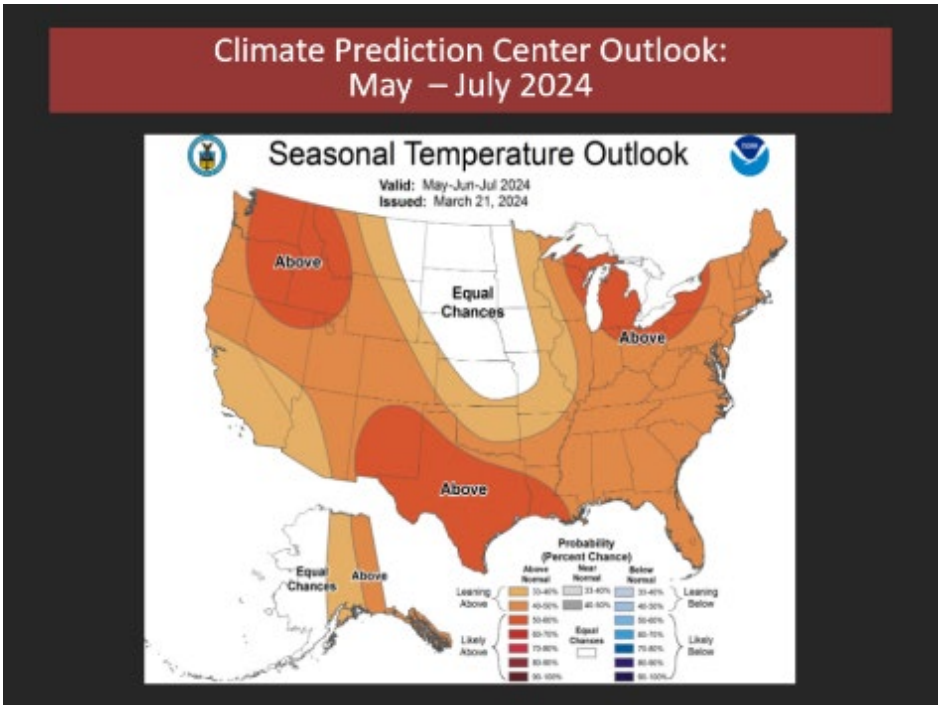


Figure A.5. *Seasonal Temperature Outlook for May – July 2024, issued March 21, 2024.*

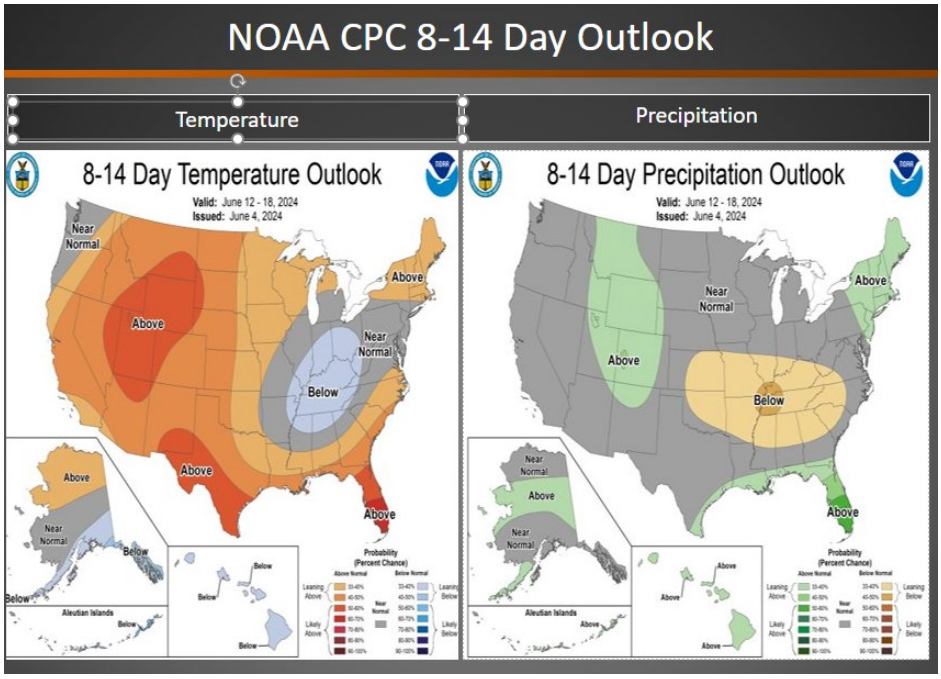


Figure A.6. *CPC 8-14 day temperature and precipitation outlook issued June 4, 2024.*

Drought

During the spring of 2024, Beaver County, Utah was not experiencing drought, according to the U.S. Drought Monitor. Before August 2023 there were periods of "moderate" to "exceptional" drought over the last 10 years with the most intense ("extreme" or "exceptional") conditions experienced from December 2020 until February 2023. In July 2024 indices started to once again elevate into "abnormally dry" conditions (see Figure A.7).

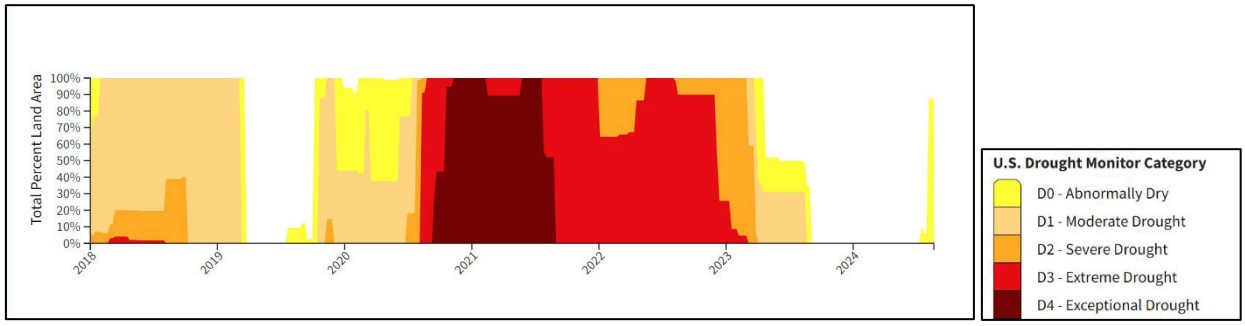


Figure A.7. *Data from the NOAA - National Integrated Drought Information System (NIDIS) for Beaver County, Utah displays drought conditions since 2018.*

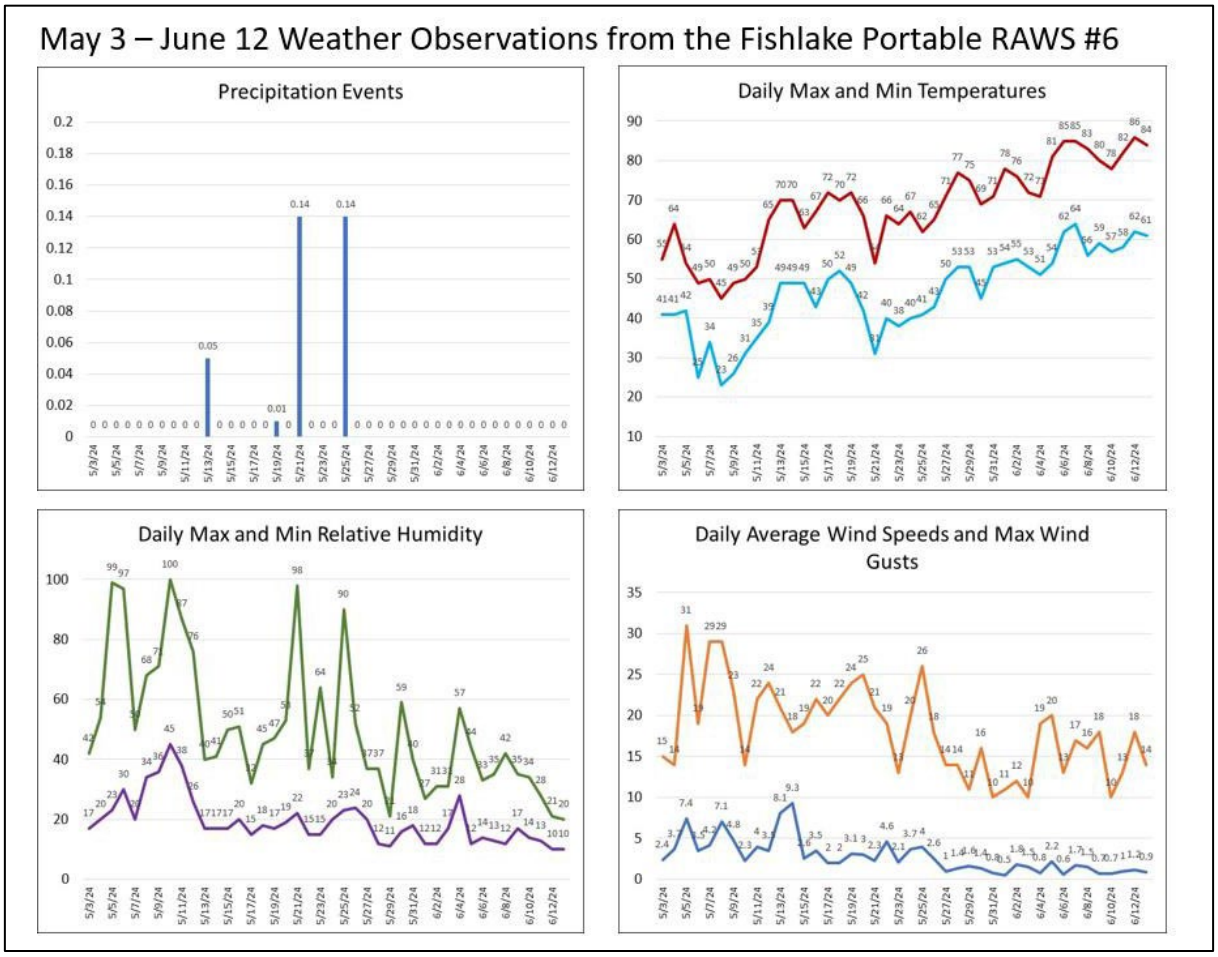
The NRCS Snow Water Equivalent data indicates the South Beaver prescribed fire area received 108% of the median 1991-2020 snowpack by April 28, 2024. By the end of May the snowpack was more than 150% of the median.

Weather

All weather observations from the burn unit are from the Fishlake Portable RAWS #6, which was located at an elevation of 7,730 feet in a saddle on the north side of Big Twist Creek. Between May 3 and June 12, there were four precipitation events, three of which were measurable amounts at the RAWS. After May 25th, no rain had occurred for 19 days when the burn was declared a wildfire on June 13. Note that a 19-day gap in precipitation is not uncommon between May 15 and June 30, according to the Signal Peak RAWS records. This has occurred in 15 of the past 24 years.

Daily minimum relative humidity was in the low teens for most of early June, with poor recovery in the 30% range most nights. Winds consistently averaged below 10 mph with occasional gusts in the teens and 20's, and no substantial wind events occurred.

Spot weather forecasts were obtained daily from the National Weather Service.



Figures A.10, A.11, A.12 and A.13. *Observations from the on-site RAWS*

Fuel Models

Fuel models are used as inputs to fire behavior calculations (such as BehavePlus) along with weather and topography data to predict fire spread rates, flame length, and spotting (and other parameters). They often align with certain vegetation types. Fuel models for the entire U.S. have been mapped by LANDFIRE and are available for use in geospatial fire behavior models such as ITFDSS, WFDSS, and FlamMap. The LANDFIRE fuel models and associated vegetation types for the South Beaver project area are shown in Figure A.14 below. Fuel model selections often need to be adjusted for time of year and calibrated using observed fire behavior.

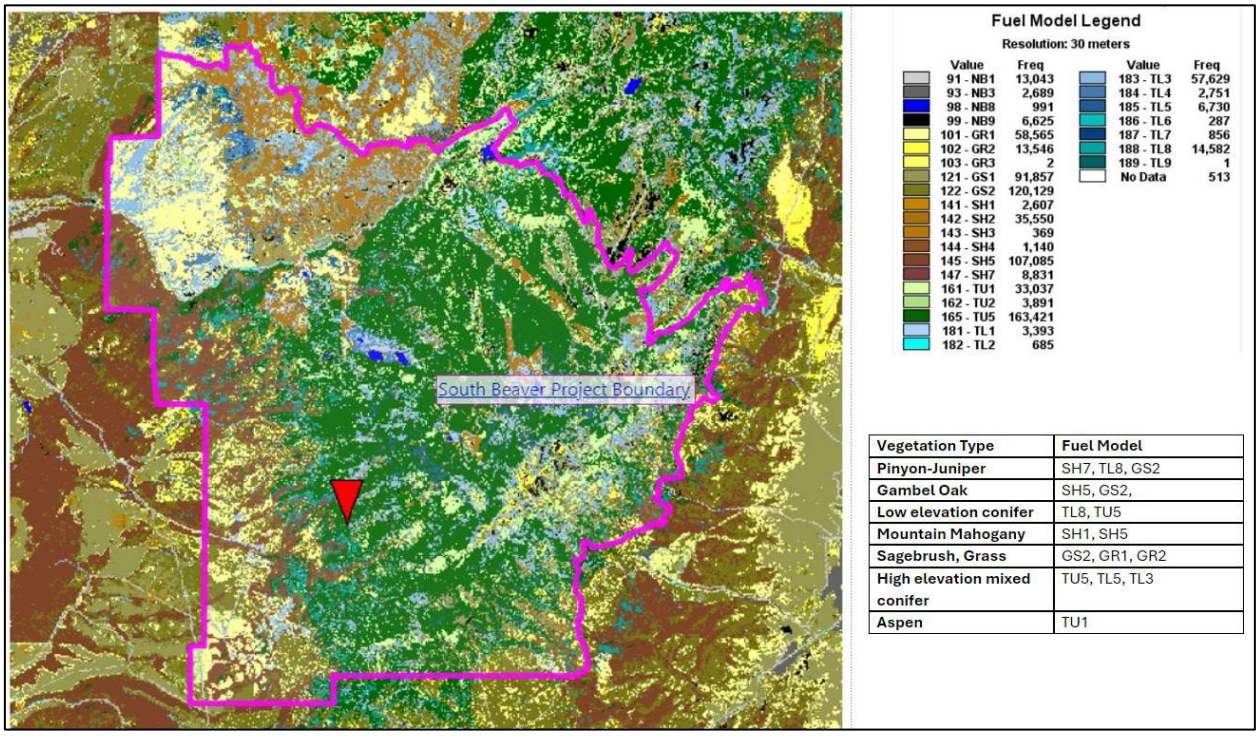


Figure A.14*. Vegetation types and LANDFIRE 2016 suggested fuel models distributed across the South Beaver project area.*

Barriers to Fire Spread

The South Beaver fuels landscape also includes barriers to fire spread and fire-slowing fuel types that play a key role in prescribed fire implementation. Previous prescribed burns and thinning treatments along private property would act like a TL1 fuel model (see map Figure A.14). The 2023 Thompson Ridge Fire would also substantially prevent, or limit, fire spread (NB or TL1). Mountain mahogany (even though LANDFIRE shows it incorrectly as SH5) is a locally recognized barrier to fire spread under most conditions. Aspen (TU1), slows or stops fire spread during the growing season. Topographic transitions, specifically north aspects, will remain moist and slow or serve as a barrier to fire spread because of reduced sun exposure.

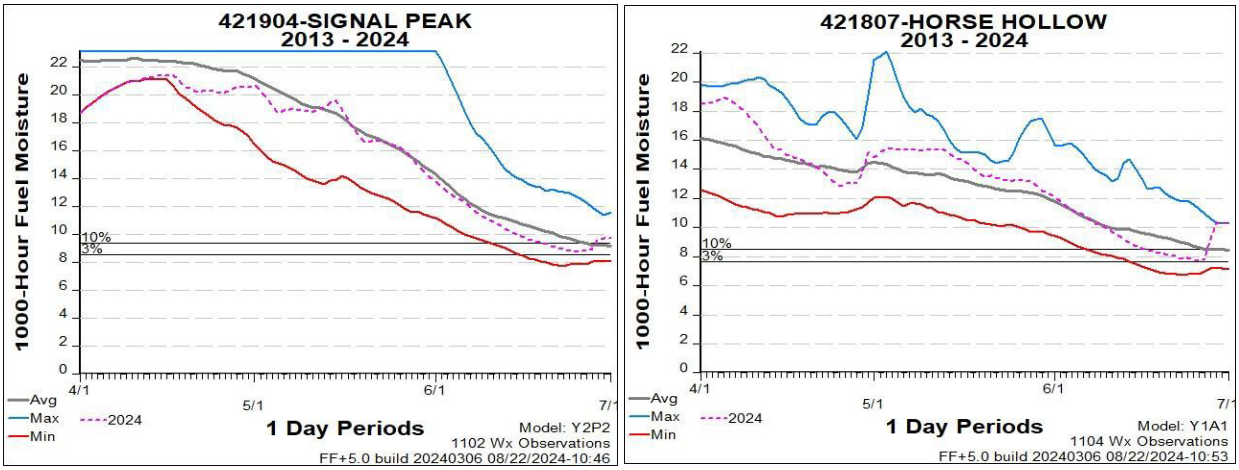
The barrier to fire spread that was used most extensively in the 2024 South Beaver prescribed fire burn implementation was early spring snowpack. Snow can also be used as a control feature in fall under certain conditions.

Fuel Moisture

Live woody fuel moisture for sagebrush, mahogany, and juniper was measured on May 24th and June 6th. Live herbaceous fuel sampling was not included, possibly because cured grasses left over from the previous year were expected to carry the fire.

South Beaver RX Fuel Moisture Sample	5-24-2024	6-6-2024
Sage	224.1	227.8
Mahogany	105.9	91.1
Juni Brush	113.85	133.3

Thousand-hour dead fuels were sampled on May 24, with a percent moisture of 11.1%, indicating that downed logs are very receptive to fire. The Horse Hollow and Signal Peak RAWS recorded 14% and 16% respectively (Figure A.15 and A.16) around the same time. It is noted that there is a discrepancy of 3-5% between the RAWS and 1000-Hour fuels sampled. [*See: Findings and Recommendations, Remote Automated Weather Stations, page 15*.]



***Figures A.15 and A.16**. Ignition 1000-hour fuel moisture for Signal Peak and Horse Hollow RAWS for fuel model Y.*

Appendix A.2 & A.3 – Prescribed Fire Plan, Policy and Implementation

This table includes both ANALYSIS #2 – CONSISTENCY OF PRESCRIBED FIRE PLAN WITH POLICY and ANALYSIS #3 – CONSISTENCY OF IMPLEMENTATION WITH THE APPROVED PLAN

Analysis #2 – Consistency of the Prescribed Fire Plan with Policy				**Analysis #3 – Consistency of Implementation with the Approved Plan**		
Burn Plan Element	**Plan Consistent with Policy**	**Comments**	**Contributing Factor**	**Implementation Consistent with Prescription, actions and procedures**	**Comments**	**Contributing Factor**
1 Signature Page	**No**	The Red Book states *Specific Line Officer Responsibilities for Fire and Aviation at the Field Level* (page 76): *If more than one year has elapsed since a prescribed fire plan was last approved, the plan will be reviewed, updated as necessary, and re-approved before implementation*.	No	**No**	The burn plan was not annually signed by the AA after May 15, 2023. The plan was within one year of last approval date at beginning of ignitions on May 2, 2024. Ignitions continued May 16-18 and June 5-7.	No
2a Agency Administrator Ignition Authorization	Yes	Meets Policy	No	Yes	Meets Plan	No
2b Go/No-Go	Yes	Meets Policy	No	**No**	There was not a signed 2B for ignitions on May 4th, May 16-18, and June 5-7.	**Yes**
3 Complexity Analysis Summary and Final Complexity	Yes	Meets Policy	No	Yes	Meets Plan	No
4 Description of Prescribed Fire Area	Yes	Not all fuel models were identified. Refer to appendices A.1 and F.	**Yes**	Yes	Meets Plan	No
5 Objectives	Yes	Meets Policy	No	Yes	Meets Plan	No
6 Funding	Yes	Meets Policy	No	Yes	Meets Plan	No

Rx Plan Element	Plan Consistent with Policy	Comments	Contributing Factor	Implementation Consistent with Prescription, actions and procedures	Comments	Contributing Factor
7 Prescription	Yes	Not all fuel models were identified within the burn plan, therefore fire behavior was underestimated. The missing fuel models have a higher flame length and rate of spread. This has a cascading effect on Element 11. Using all fuel models would illustrate the need for more personnel and/or equipment for containment.	**Yes**	Yes	Meets Plan	No
8 Scheduling	Yes	Meets Policy	No	Yes	Meets Plan	No
9 Preburn Considerations and Weather	Yes	Meets Policy	No	**No**	Policy (PMS 484): *Reasonable efforts will be made to notify adjacent landowners (or their agents) and other potentially impacted publics. Attempts or actual notifications (or both) will be documented with date and method and placed in the project file.* Notifications in the Rx Plan shows who should be contacted, who is responsible for the contact but not when or how the notification should be made. No documentation was found confirming the dates that the notifications were made and the method by which they were made such as: *Phone call, Email, Voicemail, Text Message, or Direct contact.*	No
10 Briefing	Yes	Meets Policy	No	Yes	Meets Plan	No

Rx Plan Element	Plan Consistent with Policy	Comments	Contributing Factor	Implementation Consistent with Prescription, actions and procedures	Comments	Contributing Factor
11 Minimum Organization and Equipment	Yes	Line production rates and resources were underestimated because not all fuel models were identified in Element 4.	**Yes**	**No**	The Low Intensity Minimum Organization, with snow present, does not include a requirement for a Holding Boss. Element 16 makes repeated reference to a Holding Boss, under "general procedures" but one was never assigned during ignition phases above the low prescription parameters.	**Yes**
12 Communication	Yes	Meets Policy	No	**No**	Key Communication Points: 1. Element 2B Go/No-Go is complete and intent to proceed with test fire or take other actions. No 2B documentation was found for the following ignition dates: May 4, May 16-18, & June 5-7	**Yes**
13 Public and Personnel Safety and Medical	Yes	Meets Policy	No	Yes	Meets Plan	No
14 Test Fire	**No**	Provisions for a test fire are required, PMS 484 (page 23).	No	**No**	There is no documented record of a test fire being performed on the following ignition dates: May 4, May 16-18, & June 5-7	**Yes**
15 Ignition Plan	Yes	Meets Policy	No	Yes	Meets Plan	No
16 Holding Plan	Yes	Meets Policy	No	**No**	General procedures for Holding in plan: *1) Holding Boss, FIRB and Burn Boss will develop a plan adequate for current and future weather, fuel, and smoke conditions. 2) Holding Boss will become familiar with the unit prior to ignitions to finalize a plan and identify adequate water sources and holding. 3) Each burn operation will include a holding plan that describes how fire will be contained within the burn project.* No holding boss was identified on ignition days.	**Yes**

Rx Plan Element	Plan Consistent with Policy	Comments	Contributing Factor	Implementation Consistent with Prescription, actions and procedures	Comments	Contributing Factor
17 Contingency Plan	Yes	Meets Policy	No	Yes	Meets Plan	No
18 Declaration	Yes	Meets Policy	No	Yes	The decision to declare was made with several key agency personnel, including the Forest Supervisor, District Ranger/AA, Fire and Fuels staff.	No
19 Smoke Management and Air Quality	Yes	Meets Policy	No	Yes	Meets Plan	No
20 Monitoring	Yes	Meets Policy	No	Yes	Meets Plan	No
21 Post Burn Activities	Yes	Meets Policy	No	**No**	The burn plan notes that: *The Burn Boss will ensure the following items are completed and provided to District Fuels Management Specialist. Element 9: Notifications, Element 10: Prescribed Fire Crew Briefing Checklist, and Element 14: Test Fire* There are no documented records for 2B, test fire, crew briefing, or notifications on the following ignition dates: May 4-5, May 16-18, & June 5-7.	**Yes**
Appendix A: Maps	Yes	Meets Policy	No	Yes	Meets Plan	No
Appendix B: Technical Review	Yes	A thorough technical review is critical to ensure that the burn plan accurately mitigates the risks associated with implementation. See *Findings and Recommendations: Fuel Models Incomplete and Resources Commensurate with Predicted ROS.*	**Yes**	Yes	Meets Plan	No

Rx Plan Element	Plan Consistent with Policy	Comments	Contributing Factor	Implementation Consistent with Prescription, actions and procedures	Comments	Contributing Factor
Appendix C: Complexity Analysis	**No**	Ratings underrated. See Findings and Recommendations, *Complexity Analysis.*	**Yes**	Yes	Meets Plan	No
Appendix D: JHA Risk Assessment	Yes	Meets Policy	No	Yes	Meets Plan	No
Appendix E: Medical Plan	Yes	Meets Policy	No	Yes	Meets Plan	No
Appendix F: Fire Behavior Modeling	**No**	Fuel models are incomplete. See Findings and Recommendations, *Fuel Models.*	**Yes**	Yes	Meets Plan	No

Appendix A.4 - AA Qualifications, Experience, Involvement

The approving Agency Administrator's qualifications, experience, and involvement.

There were two Agency Administrators (AA) during the South Beaver implementation. Both are currently qualified as a RX Agency Administrator Type 2 (RXA2) and WF Agency Administrator Type 2 (WFA2).

The primary AA was qualified as RXA2 in February 2023 and WFA2 in September 2023. He was the approver for the burn plan and signed all the 2A: AA Ignition Authorization forms through the duration of the project as either the Line Officer or Agency Administrator. During implementation, he made several line visits and was engaged with the fire and fuels staff.

Appendix A.5 - Fire Personnel Qualifications and Experience

The qualifications and experience of key personnel involved.

According to the current IQCS records, key personnel were fully qualified for their assigned roles. The qualifications and experience of key personnel at time of ignition is as follows:

- Burn Boss, 5/2-15/2024 (RXB2) – Certified since 2006 over 140 operational days of experience. Also qualified as DIVS and ICT3. Preparer of the South Beaver Burn Plan.
- Burn Boss, 5/16-6/13/2024 (RXB2) – Certified since 2011 with over 90 operational days of experience. Also qualified as DIVS and ICT3.
- Firing Boss, 5/2-4/2024 & 6/5-7/2024 (FIRB) – Certified since 2009, also qualified as DIVS, ICT3, and RXB1
- Firing Boss, 5/16-18/2024 (FIRB) – Certified since 2011, also qualified as DIVS, ICT3, and RXB2.
- Duty Officer – Three different Duty Officers were signatories of the 2A during the duration. Each were listed on the signed Annual Delegation of Authority to act as duty officer and were current at the minimum qualification of DIVS and ICT3.

Appendix B Contributing Factors

Category	Contributing Factor or Condition	Mark "X" If Observed
Planning	Burn area boundaries not aligned with favorable locations for fire containment.	X
	Interdisciplinary team coordination lacking during design and planning of the treatment	
	Lack of proficiency using fire behavior and related modeling tools.	X
	Insufficient holding plan	X
	Insufficient ignition plan	
	Insufficient mop-up and patrol plan	
	Insufficient contingency plan	
	Insufficient technical review	X
	Complexity rating did not adequately reflect the conditions actually experienced.	X
Operations	Burn could not be completed and secured before forecasted worsening weather arrived.	X
	Test fire did not provide accurate representation of fire potential.	X
	Actions taken inconsistent with those described in the burn plan.	X
	Insufficient patrol after burn boss transfers control to local unit.	
Communications	Unit boundaries or special features not communicated or identified accurately.	
	Instructions not given or well understood.	
Equipment	Malfunction or breakdown.	X
	Improper use or selection of equipment.	
	Equipment not set-up and tested prior to need.	
Fire Environment	Extended fire persistence – 2 weeks or more in patrol status.	X
	Actual weather experienced was outside what was forecast.	
	Severe drought conditions contributing to unusually dry fuels.	
Fuels	Higher than typical fuel quantity/loadings	
	Large machine piles	
	Hand piles	
Human Factors	External influences or distractions.	X
	Internal stress or fatigue.	X

If applicable, list contributing factors or conditions identified by this review not already found in the table above to consider for long-term tracking:

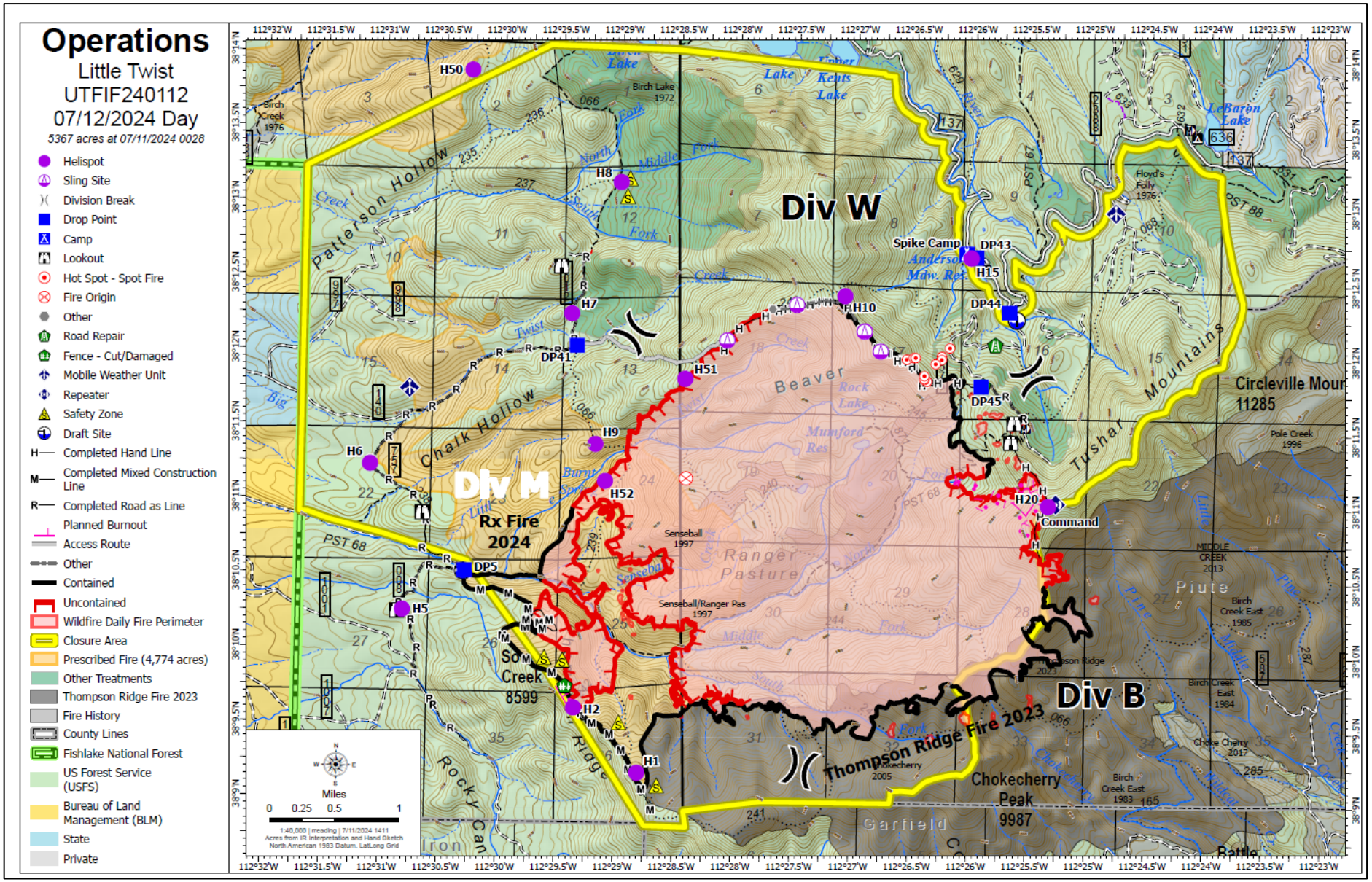
1. Fuel model selection for prescription development – Refer to Appendix G. Fuel Model Discussion
2. Expired Agreements – The Regional BLM agreement to order BLM resources on prescribed fire had expired. Without this being available, ordering nearest/additional resources was difficult. Refer to Findings and Recommendations – *Functional and Funded Agreements*

Appendix C Chronology

Date	Event
May 14, 2018	South Beaver Vegetation Management Environmental Assessment was completed in March 2018, and the Finding of No Significant Impact was signed May 14, 2018.
May 15, 2023	South Beaver Prescribed Fire Plan approved.
April 22, 2024	RX Burn Notification sent to RIFC for planned ignitions on the South Beaver prescribed fire for April 24th-May 31st
April 29	Recon of units with UAS
May 2	First day of ignition using UAS on low-elevation areas of Unit 1. Targeting oak brush and pinyon-juniper. District Fuels Specialist is RXB2.
May 3	UAS ignition continues along with hand ignitions in Units 1 and 5. Mosaic results in oak litter and pinyon-juniper. District Fuels Specialist is RXB2.
May 4	RXB2 switches to leader of visiting WFM for this shift. UAS ignition continues as well as hand ignition in Units 1 and 5.
May 5-May 15	RXB2 responsibility returns to District Fuels Specialist. Burn patrolled by district personnel through these dates. Moisture across the unit was observed on the 10th and it was reported that no smoke was showing that day. No further ignitions were implemented during this time frame.
May 13	0.05" rain (5 100ths of an inch) recorded on portable RAWS (pRAWS)
May 14	Forest-wide RX discussion, with three districts planning concurrent ignitions over the next few days utilizing aviation resources and helitorch. On or about this date, forest leadership (including fire and fuels staff and line officers) reached out to regional office staff to make them aware of the Spring RX planned workload.
May 15	RX Burn Notification was updated and sent to Richfield Interagency Dispatch with planned ignitions in Units 1, 4, and 5 from May 16-21st. Discussions occurred between Burn Bosses about the sequence of aircraft use across multiple districts.
May 16	The RXB2 role taken on by District AFMO remains that way through the declaration. Hand ignitions begin 1412. Claimed approximately 286 acres.
May 17	Helitorch ignitions in Units 4 and 5 with two Type 3 helicopters. Planned acres: 1,000. Test fire 1409 and ignitions continue, 25-30 helitorch barrels. 1,665 acres claimed for 17th.
May 18	Helitorch ignitions in Unit 1 with two Type 3 helicopters. Precipitation in the area but not directly on the unit. About 20 barrels applied, ignitions stopped 1653 due to weather. Claimed 1,705 acres.
May 19	0.01” rain recorded on pRAWS.
May 19 – Late May	No ignitions, burn patrolled regularly.
May 21	0.14” rain recorded on pRAWS – snow at higher elevations.
Late May-Early June	Local resources (one engine and one module) focus on securing Unit 1. IHC ordered to assist with holding actions, prioritizing stopping fire spread to east in Unit 4.
May 30	RIFC notes multiple smoke reports, calls from motorists on I-15.
June 4	IHC arrives in the morning, is briefed and the firing plan is developed to begin ignitions the next day.
June 5	IHC conducts firing (hand ignition) to secure the east edge of Unit 4. Notes from the 2A discussion show everyone understood these ignitions were conducted as a holding action.
June 6	Helitorch operations to reinforce hand firing in Unit 4, 25-30 barrels.
June 7	Continue helitorch ops to reinforce Unit 4. Helicopter released.
June 8	Recon with UAS. Holding actions with ground forces.

June 9	Holding actions with ground forces. IHC released the end of shift.
June 11	Holding actions with ground forces. Ordered helicopter for bucket work. Bucket malfunction issues after configuration, no water delivered this shift. WFM engaged around Senseball hill, goal is to keep fire south and west of trail 066. RXB2 reports activity there is corralled and the module is hiking off.
June 12	Type 2 helicopter bucket work. Local pocket card thresholds hit this day (Winds >10mph, Temp >85^{O,} RH<20%). Fire begins to run to the east in Unit 4. Helicopter sets down; bucket ineffective given the fire behavior. Approximately 651 acres of growth.
June 13	Type 2 helicopter on scene for bucket work. Orientation at Beaver RD, Forest Supervisor present. Significant fire growth in Unit 4 with large visible column. Declaration issued by AA to RIFC over telephone about 1330hrs. 1346 dispatch log reflects everyone off the line due to fire activity, two personnel took refuge in rock scree. (The Rapid Lesson Sharing of this event is located here.) Approximately 200 acres of growth.

Appendix D Map

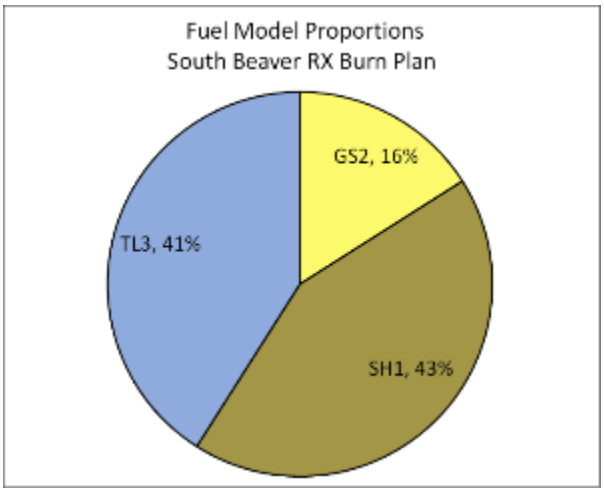


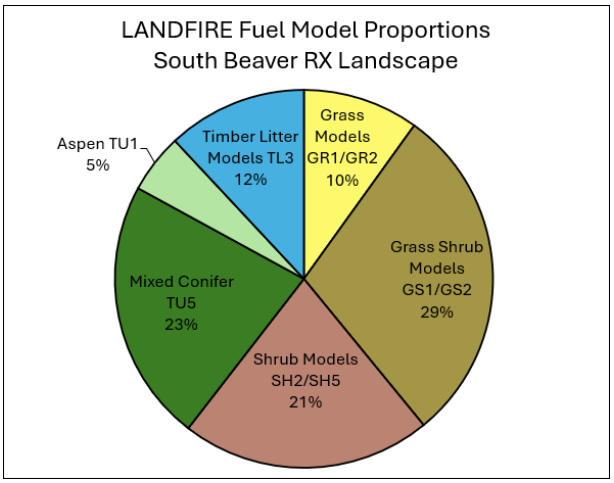
Appendix E. Fuel Model Discussion

Additional Discussions for *Findings and Recommendations* relating to fuel model selection:

Finding:

During the review team's onsite visit, the team noted a discrepancy between the observed fuel models and what was captured in the South Beaver Prescribed Fire plan. In *Element 4: Description of the Prescribed Fire Area,* three fuel models were selected to determine fire behavior prescription parameters: GS2 (representing sagebrush and grass), SH1 (to include Pinyon-Juniper, Gambel oak, mountain mahogany, sparse sagebrush), and TL3 (for mixed conifer and aspen) (Figure E.1). The available LANDFIRE geospatial layers for the project area show a much more complex set of models, which are summarized in Figure E.2.

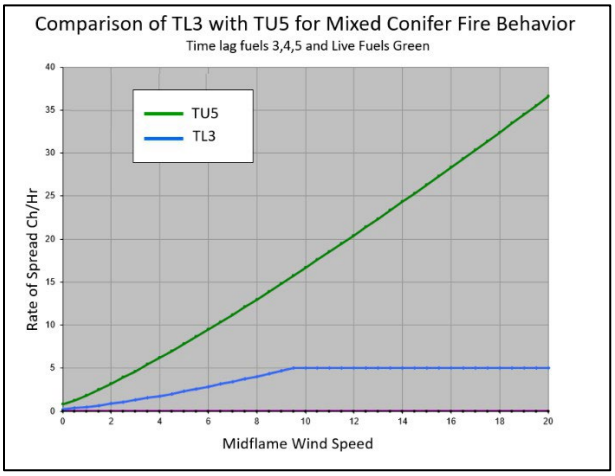


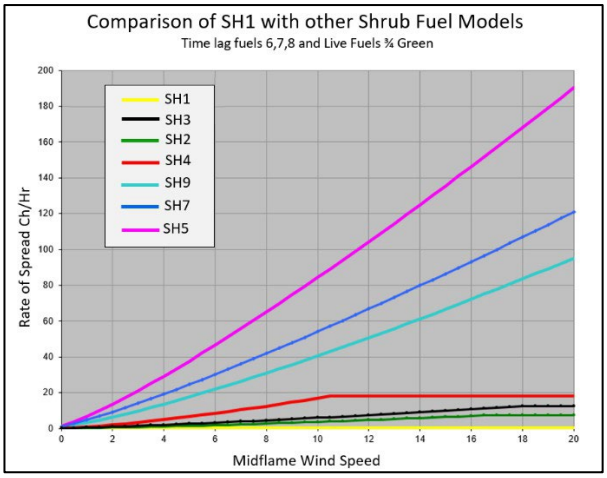


***Figures E.1** (fuels as represented in the burn plan) and **E.2** (fuels as represented in LANDFIRE)*

The use of TL3 and SH1 to represent all the timber and shrub models is problematic because both models produce the slowest rates of spread and flame lengths for their respective categories. The selection of TL3 for conifer fuels doesn't capture the heavy, dense fir and spruce forest with ladder fuels that cover roughly 25% of the project area. LANDFIRE identifies much of this as TU5, which spreads much more rapidly and produces more embers (see Figure E.3). TL3 also hits a wind limit at approximately 10 mph.

Figure E.4 compares the spread rates of SH1 with six other shrub fuel models. The LANDFIRE 2016 data for the project area attributes Gambel oak and pinyon-juniper to faster spreading models SH5 and SH7.





***Figures E.3 and E.4** rates of spread modeled with increasing wind, conifer and shrub*

The oversimplification of fuel models led to an underestimation of fire behavior in *Element 7: Prescription,* which resulted in unrealistic containment rates and insufficient resources indicated to maintain control of the prescribed fire in *Element 11: Minimum Organization and Equipment*. Table E.1 below illustrates this by comparing the fire behavior parameters derived from BehavePlus for the three fuel models used in the South Beaver burn plan (in gray), with five additional fuel models identified by LANDFIRE and on-site validation. Rates of spread are much faster for the added shrub and timber models than SH1 and TL3. Flame lengths are greater. Differences are more pronounced in the high intensity scenarios but still significant at the low intensity. SH5 and TL8 are included because they are abundant outside the project area. SB1 is a suggested model to depict slashed material in treatment units surrounding private land near the project area. The maximum wind speed allowed (a 20' wind speed of 35mph) under the South Beaver burn plan prescription was used for low and desired parameters. Output ranges are based on windspeeds from 0-35 mph.

Table E.1. *The fire behavior parameters are derived from BehavePlus utilizing the prescription identified in the South Beaver burn plan. Gray boxes denote fuel models used in the South Beaver burn plan.*

Fuel Model	Low Fire Intensity			Desired Fire Intensity			High Fire Intensity		
	Rate of Spread	Flame Length	Spotting Distance	Rate of Spread	Flame Length	Spotting Distance	Rate of Spread	Flame Length	Spotting Distance
GS2	1-3 ch/hr	0.5-1'	-	1-4 ch/hr	0.6-1'	-	6-109 ch/hr	3-11'	-
SH1	0.2-0.4 ch/hr	0.2-0.3'	0-0.9 mi	0.4-1 ch/hr	0.3-0.4'	0-0.9 mi	1-2 ch/hr	0.5-1'	0-0.7 mi
TL3	1-3 ch/hr	0.6-1'	0-0.9 mi	0.7-3 ch/hr	0.7-1'	0-0.9 mi	1-4 ch/hr	1-2'	0-0.7 mi
GR2	0.1 ch/hr	0.1'	-	0.1 ch/hr	0.1'	-	6-73 ch/hr	2-6'	-
SH5	4-73 ch/hr	3-11'	-	11-196 ch/hr	6-24'	-	15-235 ch/hr	8-27'	-
TL8	2-30 ch/hr	2-7'	0-0.9 mi	3-38 ch/hr	2-8	0-0.9 mi	3-34 ch/hr	3-8'	0-0.7 mi
TU5	2-22 ch/hr	3-10'	0-0.9 mi	3-33 ch/hr	4-13'	0-0.9 mi	4-38 ch/hr	5-15'	0-0.7 mi
SB1	2-30 ch/hr	2-6'	0-0.9 mi	3-37 ch/hr	2-7'	0-0.9 mi	3-34 ch/hr	2-7'	0-0.7 mi
	Probability of Ignition		38%	Probability of Ignition		63%	Probability of Ignition		77%

Modeling predictions must also be tempered with real-world fire experience and landscape conditions, because BehavePlus calculations have many assumptions and limitations. For example, they assume landscape conditions are uniform, and weather conditions are consistent. Rates of spread in the hundreds of chains per hour, such as 235 ch/hr for SH5, can be startling and may be unrealistic in most situations. During prescribed fire implementation the pattern and method of ignition can be used to increase or decrease fire behavior. Natural or human barriers, topographic features, terrain or vegetative transitions are all examples of how fire spread can be interrupted or slowed. Ultimately the Behave modeling outputs should be combined with experience of the prescribed fire practitioner to help inform the resource needs for control. The burn plan should consider the potential spread rates on the landscape but also articulate why the ROS will not actually be 235 ch/hr in SH5 on the ground, or how the minimum complement of resources in Element *11: Organization and Equipment* will be sufficient to address a ROS of 38 ch/hr in TU5.

Recommendations:

Representative fuel models must be selected when developing a burn plan to ensure that the area description, prescription, and organizational needs incorporate the full range of potential fire behavior. While fire behavior will change seasonally, and different models may apply (especially during a dynamic period of snowmelt and green-up), it is still important to consider all possibilities. Burn plan authors should become familiar with the fire behavior fuel models in RMRS-GTR-153 and learn to select them to match the potential rates of spread, flame lengths, live fuel components, and crown fire behavior of local landscapes. LANDFIRE mapping is available to assist but should be calibrated as needed using ground observations of fire behavior during burns and wildfires in similar terrain. Geospatial tools for running prescription scenarios (such as IFTDSS and FlamMap) can assist in finding trouble spots and potential control opportunities.

Appendix F. Review Team

Team Lead: Darren Olsen, District Ranger, Manti-La Sal NF

Team Members:

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Paul Swenson, Fuels Program Manager, Bridger-Teton NF

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