Bridger Foothills Entrapment and Shelter Deployment

Facilitated Learning Analysis

"100%, I thought we were dead"

Figure 1: Photo taken from air attack platform at approximate time of deployment

September 5th, 2020

Montana Department of Natural Resources and Conservation

USDA Forest Service, Region 1/ Custer-Gallatin National Forest

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The Deployment

"What do you mean you don't have your shelter?"

Charlie frantically worked to light off the sage with his fusee. Hands shaking, the sage was lighting better than the grass had before. But it didn't matter – there was no more time to burn – the fire was coming up fast on him and his crew from both the south and the east.

Charlie turned around to his crewmembers and noticed that one of them, Sam, was already in his shelter. The spot fire that had cut-off their last possible escape route was now well established on the slope below them, and the trees were crowning out with flame lengths of over 100 feet. The wind was blowing so hard that his helmet went flying off his head. Next thing Charlie realized, he was back at the small oval that they had cleared of ground fuels, looking down on his other crewmember Casey, who was laying in the fetal position with his chaps slung over his back and gear bags piled up around him.

"Get in your f**king shelter!" Charlie screamed to Casey.

"I don't have it - share with me!" Casey shouted back.

"*What do you mean you don't have your shelter?! Did it blow away?!*"

It hadn't blown away, although that would have been easy in the "hurricane-like" winds that were whipping across the hillside in all directions. Casey had taken it out of his pack a few weeks earlier for PT hikes, and never put it back in.

But ultimately, why the shelter wasn't on the hill did not matter. At this moment, Charlie realized how dire of a situation they were in. Casey was roughly 6'2" and weighed in at around 225 lbs, and Charlie was around 6' and 190 lbs. And if they were both going to survive this flame front, they would have to squeeze into his one shelter as best as they could.

They could both feel the heat now, and the fire was "cooking." Charlie ripped out his shelter and struggled to open it. Unlike Sam's shelter, which Sam later described as "shaking out just like a practice shelter, [or] better," opening Charlie's shelter felt like trying to open a ball of tin foil. With Charlie and Casey each pulling at it, they fought to get it open, and valuable moments were lost as they furiously tried to shake it out. The moment they opened the shelter, Casey and Charlie locked eyes, then glanced up at the flames towering above them before they dropped to the ground. The updraft winds at that point were so strong, they had to fight to reach the dirt.

The last-minute nature of their deployment meant that neither Casey nor Charlie were completely in the shelter. Casey had dropped to get his head facing to the north and lined up with the hole he had dug and filled with water, with his legs largely sticking out of the shelter. Charlie was facing nearly the opposite direction, in a crouching position. In this arrangement, neither firefighter could get a seal on the shelter, and embers were blowing in just as fast as Charlie could sweep them out. Casey screamed over the radio that they had deployed, a transmission that was copied by air attack. Charlie then took the radio and remembers transmitting that there were three of them who had deployed, with only two shelters. Air attack, who confirmed that three people had deployed, did not recall hearing that there were only two shelters.

Charlie later described how, in their initial arrangement, "I couldn't take it anymore, I couldn't get air, and it felt like I was in a microwave." In this moment of desperation, Charlie stood up, thinking nothing could be worse than being crammed into the shelter, in the heat, without any way to breathe. Charlie immediately realized how much worse it could get with the fire burning all around and was forced to dive back into the shelter. This time, Charlie was shoulder to shoulder with Casey, which allowed them to get a slightly better seal.

The experience, however, was still far from comfortable. Unable to breathe and battling through the extreme heat, Charlie "was certain we were gonna die. [I thought] every second was our last second." Casey described the sensation of trying to breathe as like "if anyone has ever been cleaning around you and it's extremely potent – it's like that but it's on fire." To try to alleviate the heat, he began splashing plastic water bottles on himself and Charlie, squeezing 4-5 bottles out along their backs.

Sam was equally certain that they were not going to survive. "100%, I thought we were dead. No doubt … I couldn't breathe." To try to get a breath, he wet down his shirt and started digging a hole into the ground. Although opening the shelter had been easy, Sam struggled in the wind to create a strong seal. For the fifteen or so minutes that Sam remained in the shelter, he was absolutely terrified for his life.

Sam's experience

"I deployed my shelter and within probably a minute or two could hear, feel, and see the fire going over and around us. The inside of my shelter glowed red … there was no place to get a cool clean breath. Embers blew inside my shelter and I would push them out. I tried to dig in the ground to get a clean breath and was unsuccessful. At some point I remember Charlie asking how I was doing. I responded with 'Not good man, I can't f**king breathe.' I thought about my wife and kids and knew with some certainty that I was dead."

Casey and Charlie emerged from their shared shelter around 8 minutes after they first got in, after the initial flame front had passed. Their surroundings, however, still resembled a hellscape. Casey's line gear, which he had been unable to throw very far away from the deployment site, was on fire and burning Charlie's leg, so Charlie kicked it farther away. Outside of the circle, the cans of bug spray and sunscreen in the bag exploded. Combined with the combustion from the remaining fusees, the explosions caused the gear to burn down to nothing.

Even without the flames, the heat, smoke, and winds were still so intense that Charlie and Casey re-entered the shelter, where they remained for another eight or so minutes, getting continuously hammered by the wind. Eventually, while getting oxygen was still nearly impossible, it became clear that they were going to be miserable whether they were in the shelter or out. Knowing that everything was nuked around them, and the worst of the heat had passed, they emerged from the shelter again. But the beating afflicted by the fire was still far from over.

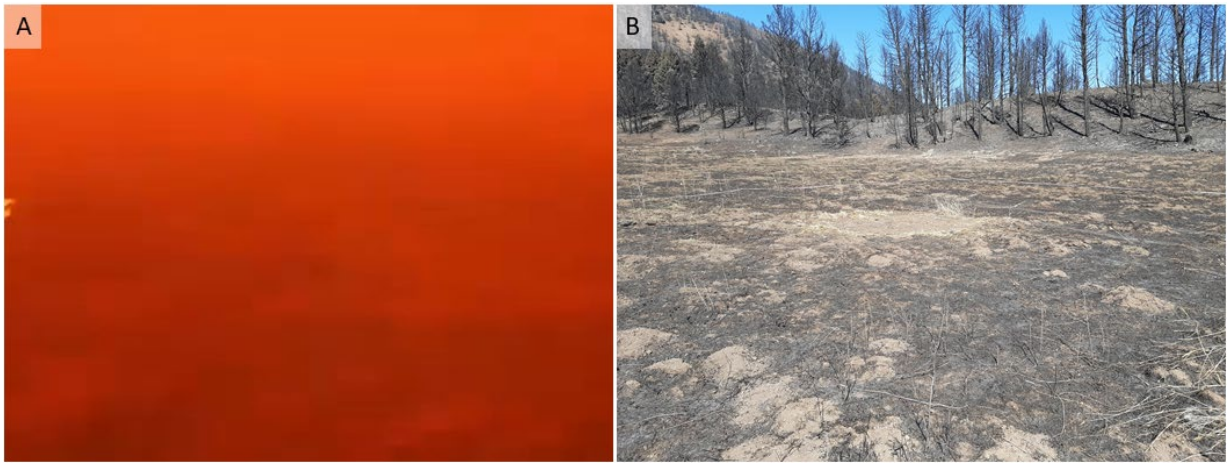

Figure 2A: Picture taken from the deployment site, when Casey and Charlie first emerged from their shared shelter and 2B: picture of the deployment site, taken a week after the incident.

Executive Summary

At 1343 on Saturday 9/5/2020, members of a Montana Department of Natural Resources and Conservation (DNRC) Helitack Crew from the Central Land Office in Helena, MT deployed fire shelters on the Bridger Foothills Fire near Bozeman, MT. Three firefighters were entrapped; only two had fire shelters with them.

Weather forecast for Saturday included a Red Flag Warning due to hot, dry and windy conditions, with a Haines index of 6. Fire activity began picking up at approximately 1030. The Helitack Crew considered their helispot, an approximately 12-acre grass and sage field, their safety zone. They also had two planned escape routes. By 1300, they retreated upcanyon ahead of the flame front. Shortly after arriving at the helispot, fire activity entrapped them, and the crew then created the best possible fire shelter deployment site to survive the flame front.

Injuries from the entrapment included distress to the eyes and airways, excessive smoke inhalation, and minor burns, but all three were able to walk away from the deployment site on their own to receive medical evaluation. This is their story.

A Note to the Reader

The firefighters involved in this deployment came to decisions that made sense to them at the time. To learn from this unintended outcome, it is important that you read this without the assumption that this could never happen to you. Instead, please consider that you read this with the luxury of hindsight bias. Our intent is that you find the lessons that you can apply to your program to hopefully avoid experiencing what these folks went through. Names have been changed to respect the privacy of interviewees.

The Story

Setting the stage

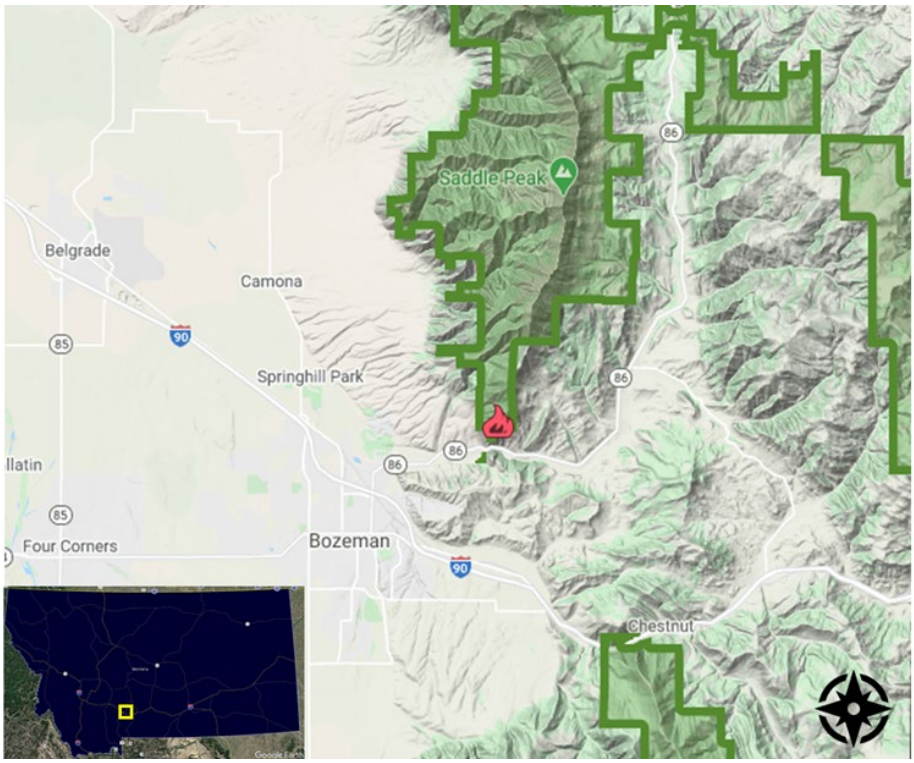

Figure 3: Vicinity map of the Bridger Foothills Fire (indicated by the fire icon) in relation to nearby Bozeman, Montana. US Forest Service ownership is represented by the dark green border. Outside of the Forest Service, lands are primarily privately owned.

The lightning-ignited Bridger Foothills Fire was detected around 1500 on Friday, September 4th, 2020 along the west side of Bridger Ridge. The fire was located approximately 2.5 miles northeast of Bozeman, Montana. Initial attack forces from local fire departments, US Forest Service, and other cooperators responded immediately, but were unsuccessful in halting the fire given the extremely dry conditions. By Friday night, the fire threatened roughly 100 homes within Bridger Canyon.

Local weather conditions in the Bozeman area were hot, dry, and windy for Saturday, September 5th. A local weather station placed the Energy Release Component (ERC) at 97th Percentile and the Burning Index (BI) at the 99th percentile, while the Severe Fire Danger Index (SFDI) was at Severe, the highest rating.

The spot weather forecast for near the fire, requested on Friday evening by the Gallatin County Sheriff's Department for the next day, predicted temperatures from 92-97°F and relative humidity ranging from 6-11%. Winds that day were forecast for 5-10 miles per hour (mph) out of the south, shifting to 10-20 mph out of the west with gusts up to 30 mph in the afternoon. Winds off the ridgetop were forecast for 25-35 mph out of the west. The predicted Haines Index of 6 indicated high potential for large, plume-dominated fire growth.

Initial attack for the Bridger Foothills Fire included four smokejumpers, several engines from both wildland fire agencies and local fire departments, multiple helicopters, and retardant tankers. The Custer-Gallatin National Forest had initial protection responsibilities for the fire. As it grew to threaten county protection and the possibility for evacuations arose, the Type 3 Incident transitioned to a unified command structure. Unified command included Incident Commanders from the Forest Service, Gallatin County Emergency Management, and the Gallatin County Sheriff's Department.

By Friday evening, the fire had crossed the Bridger Ridgeline to the east and established itself on the steep, rocky slope above Mayfield Gulch. This part of the fire was designated as Division A. Resources on the division at that time included one Hotshot Crew, one local Type 6 Engine Crew, a local Call When Needed (CWN) Helitack Crew, the DNRC Helitack Crew from Helena (hereafter referred to simply as the Helitack Crew), and the remaining smokejumpers that had yet to fill overhead positions.

The strategy Friday afternoon and evening in Division A was to attempt to secure the north flank of the fire on the east side of the ridge. The hotshot crew was furthest up the slope working their way down, with the other resources forming a "throw-together" crew working below. As the handline progressed down the ridge toward Mayfield Gulch, it became indirect and the plan was to burn off the handline when and where possible. That evening, Charlie, Sam, and Taylor were on the hill for the Helitack Crew, helping to establish the line until about 2230. At this point the three men were released from the line, with their point of contact informing them that the handline would be burned off that night and they should rest up to be ready for tomorrow. They then hiked upslope and contoured north to their campsite, which was located between their helispot and the handline along an old two-track.

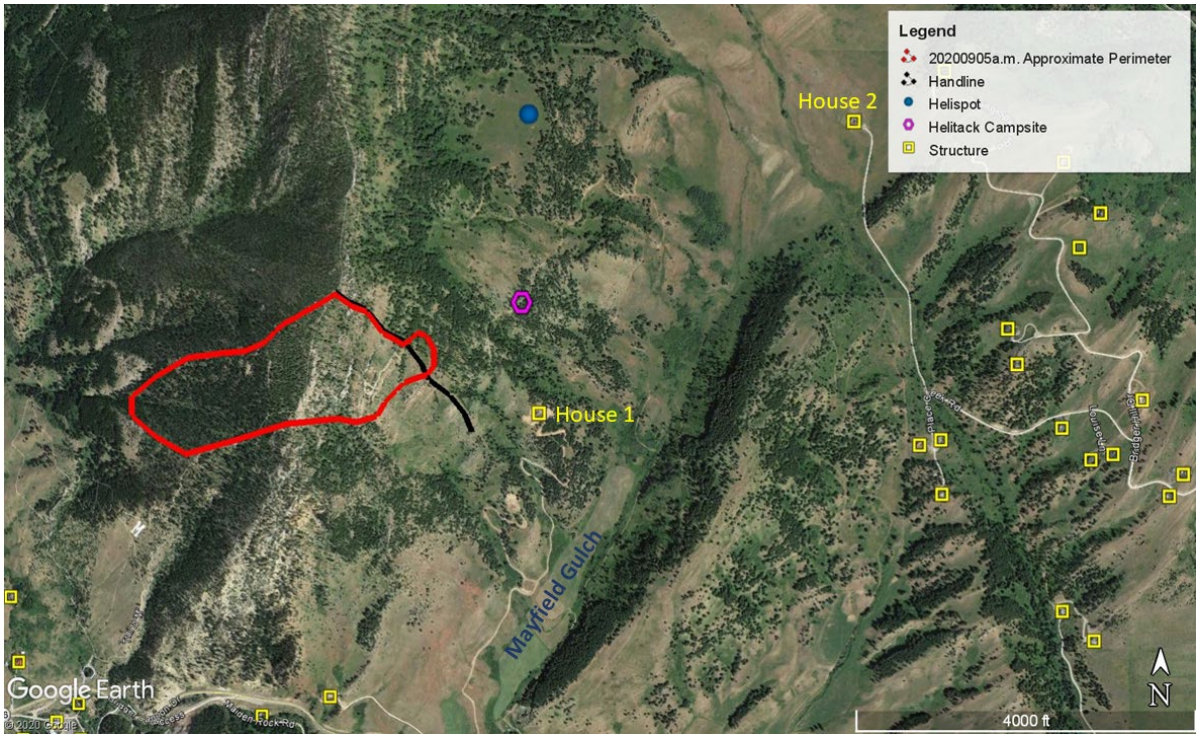

Figure 4: The fire perimeter on Saturday morning and features of the surrounding area, including the handline that was completed Friday night, the Helitack Crew's campsite, and the helispot.

The morning of

Figure 5: A photo, taken at approximately 0605 on Saturday morning, of the trees torching above the Helitack Crew's campsite.

The Helitack Crew woke up Saturday morning at 0600 to the sound of trees torching. These trees, which they could view from their campsite, were likely part of a slop-over outside the handline that the hotshot crew had been digging and burning off all night and into the early morning. Given the approximately 1-acre slop-over, the priority for Division A on Saturday morning was to send the Hotshot Crew back up the handline to contain the slop and continue down the ridge towards the other ground resources working below.

The radio briefing at 0700 emphasized the weather forecast and communicated a change in the tactical frequency for Division A. The Helitack Crew copied the radio briefing, and Sam remarked to Taylor that "with weather like that, they should probably pull all the resources off the hill and focus on structure protection." Following the radio briefing, the Division A Supervisor requested that the Helitack Crew come down to House 1 to discuss the day's plan face-to-face. The Helitack Crew, however, had a crew swap planned for first thing that morning at the helispot, as that Saturday was the last day of Taylor's season. They also needed to replenish their gear with water and food, all of which prevented them from immediately rejoining the operations from the night before.

After talking to the Helitack Crew about this planned crew swap, the Division A Supervisor left the area for a reconnaissance flight planned for 0830. Between the flight, tying in with operations, and tracking down a vehicle and a dozer for the division, it would be several hours before he would be back in the area of the Division A ground operations. Knowing this, the Division A Supervisor assigned the engine boss from the local Type 6 Engine 662 to be the point of contact for the division while he was away, a change that the Helitack Crew was not aware of.

The Helitack Crew, meanwhile, hiked farther north along the two-track they had camped on. This brought them back to the helispot that they had used the day before to access the handline. The helispot was in an approximately 12-acre opening, which sat on a relatively flat bench at 6,350 feet above sea level. The opening rises slightly as it nears the toe of the slope of the main Bridger Ridge approximately 1,000 ft above. Fuels at the helispot were predominately 18 to 24-inch grass with pockets of sage spread throughout, bordered by a mix of lodgepole pine and Douglas-fir forest. A localized depression within the opening created a sage-free area from which the helicopter would take off and land.

The crew swap was ultimately delayed. Knowing the weather forecast for the day, the Helitack Crew used this time to improve the scratch line around their gear, which had become standard practice in the event of unexpected fire behavior. They took this improvement a step further by removing all grass within the scratch line, creating an approximately 8 by 10-foot oval cleared of vegetation. The helicopter manager, Charlie, also mowed down the taller grass around the oval using his tool like a sickle.

Figure 6: The helispot that the Helitack Crew used to access the handline and conduct the crew swap. They also considered this area their safety zone, and they would ultimately use it as a deployment site.

While still waiting for the helicopter to arrive for the crew swap, Charlie noticed that this was the greenest field they had seen on this assignment. To test the receptiveness of the grass, he borrowed a lighter and attempted to light it in several spots around the gear oval. The grass held too much moisture, however, and would not ignite.

The crew's helicopter, 88M, eventually arrived at the helispot at approximately 0940. Casey arrived with the Type 2 ship to replace Taylor and bring breakfast, water, and Gatorade for the day. Following the swap, 88M returned to the helibase with Taylor as well as Charlie and Sam's personal gear (PG) bags. Back at the helibase, Taylor helped 88M's pilot, Blake, hook up the bucket before 88M returned to the fire for bucket drops.

Re-engaging with the fire

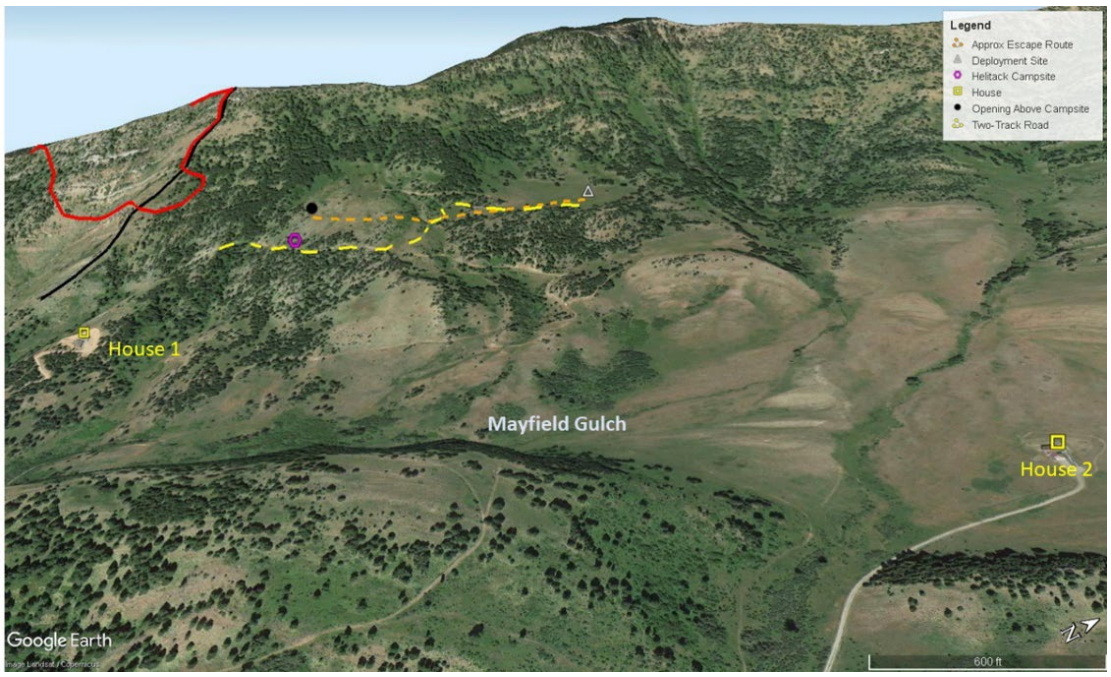

Figure 7: The Bridger ridgeline, as viewed from the East. Map includes the fire perimeter Saturday morning and the handline, as well as other relevant information related to the Helitack Crew's movement throughout the day and planned escape routes.

After coffee and breakfast at the helispot, Charlie, Casey, and Sam headed south towards the fire, where Charlie and Casey had staged their chainsaw and fuel at the campsite that morning. On the walk, the three discussed the weather forecast for the day, and they all agreed that they expected the fire to move up canyon to the north. They discussed their escape routes and safety zones, which included dropping down to the house about ¼ mile below them (House 1), or returning to the helispot they just left, about ½ mile back to the north, for helicopter pickup or use as a safety zone. They also discussed continuing east/north-east beyond their helispot to another safety zone near House 2, which was visible downslope about ¾ of an air mile away.

NWCG definitions

Escape route: A preplanned and understood route firefighters take to move to a safety zone or other low-risk area

Safety zone: An area cleared of flammable materials used for escape in the event the line is outflanked or in case a spot fire causes fuels outside the control line to render the line unsafe.

Upon returning to the campsite, the crew decided to leave the gear staged on the two-track and hike upslope into the opening above them. Similar in size to the helispot opening, this area also consisted of primarily light fuels; however, it was more sloped to match the surrounding terrain. From this location, they could tell by 1030 that the fire was heating up. Sam was concerned about their location relative to the fire, but he also had the least wildland fire experience of the crew, so he deferred to Charlie and Casey's expertise. Recognizing that fire activity would likely continue to increase throughout the day, no one planned to stay in that opening all afternoon. With that in mind, they set a trigger point: if the fire crossed the handline they had worked on the night before, they would leave that opening via one of their escape routes.

That morning, the Division A supervisor had intended for the Helitack Crew to re-engage on the lower part of the handline. Charlie assumed, however, that the entirety of the handline had been secured the night before with burnout operations. He therefore decided that they would be more useful serving as contacts for aviation resources from the opening above the campsite. If fire activity or spots necessitated it, they would be able to direct retardant or bucket drops in that area. This would also keep his crew closer to their gear in the helispot opening, in case they were pulled off this fire for another initial attack. To relay this plan, Charlie phoned the Division A Supervisor, who was still not back on scene in Mayfield Gulch. During the conversation, Charlie informed him that they had completed the crew swap and would remain up canyon of the rest of the division, positioned to help direct air resources.

Shift in fire activity

Given the increasing fire activity and the forecast for the day, the members of the Helitack Crew were all shocked when the tankers for the fire conducted all four of their retardant drops on the west side of Bridger Ridge. They had expected that the retardant drops would reinforce the handline they had worked on the night before. These drops were instead used to secure the flanks on the west aspect, and after the four drops the tankers were released. Helicopters 2TC (Type 3) and 7KA (Type 1) reinforced the retardant lines on the west side that morning, while the east side of the ridge relied on bucket drops from three Type 2 helicopters: state ships 88M and 98M, as well as 210MA.

At 1045, the hotshot superintendent left the upper portion of the handline to return to House 1 after one of his crewmembers was struck in the ribs by a rolling rock. As the superintendent made his way

down the handline to check on the injury, he was able to get a better picture of fire activity overall. At this point, he remembers thinking that the handline may not hold the fire given the forecasted weather.

The Helitack Crew was also noticing a steady increase in fire activity throughout the morning. Charlie had been observing light upslope winds of 5-8 mph out of the east, with gusts up to 17 mph. Around noon, he and his crew observed the smoke below them blowing upcanyon. Now knowing that the tankers would not be reinforcing the handline on their side of the ridge, the wind direction combined with the fire activity led the Helitack Crew to move their gear from the two-track to the northern edge of the opening. It was now staged in a direct line to the helispot.

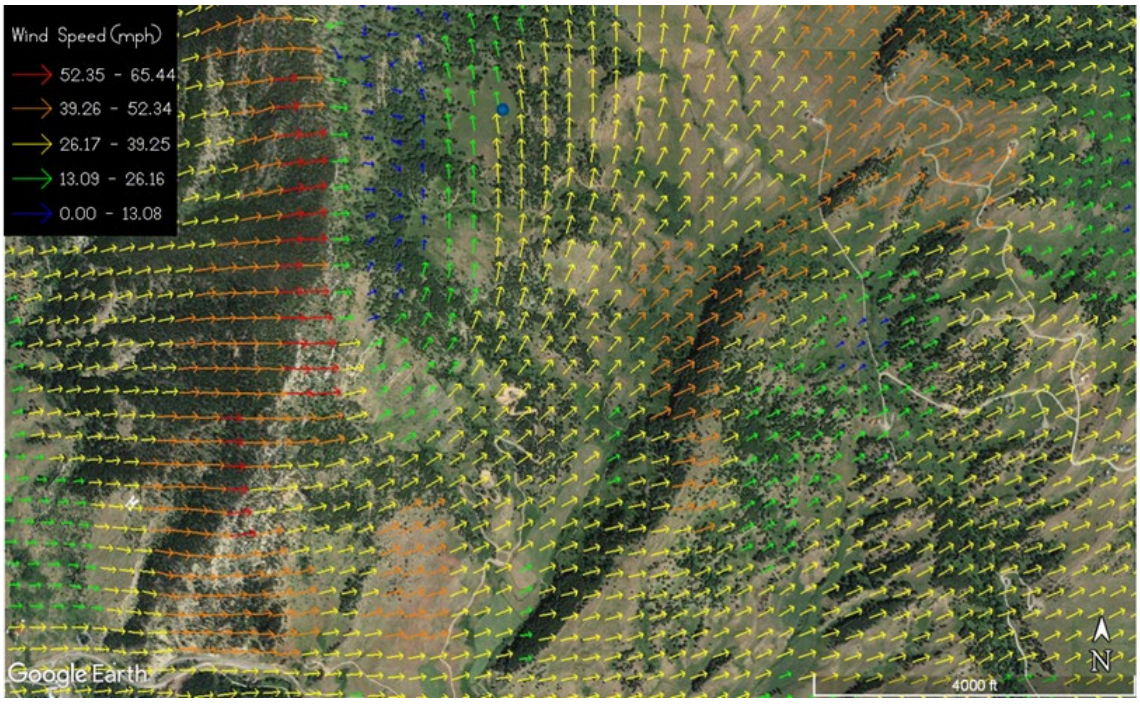

Figure 8: WindNinja model, conducted for Saturday 9/5/2020 for the Bridger Foothills Fire. Arrows display terrain influences on wind direction and color indicates speed. Wind speed used was 30mph from 250° to model forecasted ridgetop winds of 25-35mph out of the west. The helispot is designated by a blue dot.

It was at this time that the crew also became concerned that the fire had crossed the handline and thus activated their trigger point. To confirm the location of the fire relative to the handline, Charlie called the Division A Supervisor, who still had not returned to the east side of the ridge. Not being in a position to answer Charlie's question, the Division Supervisor replied that he would call back in 20 minutes, when he was back at House 1. Beyond the cell phone, the Helitack Crew had not been able to establish consistent, positive communication on the new tactical frequency, and thus could not communicate with anyone else in the area of Division A ground operations.

The Hotshots and the throw-together crew continued to work on the handline until shortly after 1300. At this point, the Division A Supervisor, who had recently returned to the Mayfield Gulch area, pulled resources off the line due to current and anticipated fire activity. With that call, the CWN Helitack Crew moved down Mayfield Gulch toward the highway with two Type 2 Hand Crews that had arrived to join Division A that morning. Priorities for the division then shifted from line construction to structure protection. Engine 662 and the Hotshot Crew dropped down to join a Type 6 Brush Engine from the local

fire department that had been pre-positioned at House 1. Resources above the house included the Helitack Crew, who were still positioned in the opening above their campsite, and four of the hotshots who remained on top of Bridger Ridge directing bucket drops.

Air attack, who had just transitioned into the position at 1300, similarly recalls a pickup in fire activity almost immediately after he arrived. Shortly after, one of the hotshots on the ridgeline informed him that the Helitack Crew was somewhere north of the fire, above House 1. Concerned and unsure of their location, air attack contacted the Helitack Crew directly.

At the same time the Division A Supervisor was pulling the resources off the line, he phoned Charlie to check in. Charlie reassured him that they were in a good place, with a solid safety zone. “I didn’t like what they had going on,” the Division Supervisor later recalled, “but at some point you have to trust your crew leaders.” Then, “things went nuclear” in terms of fire activity above House 1, and he became very concerned about their location. He communicated to air attack that the Helitack Crew was now his number one priority, and structure protection was number two.

Figure 9: View of fire activity from the north end of the opening above the campsite, taken as the Helitack Crew moved back towards their helispot and first called for extraction.

Not too long after talking to the Division Supervisor, Charlie noted that, from their vantage point, “things were really starting to cook.” It also became evident that the fire had crossed the handline when their helicopter, 88M, was suddenly visible dropping buckets on a spot fire directly downhill of them. With it confirmed that the fire had crossed their trigger point, the crew bumped back to where they had staged their gear at the north end of the field. Thinking they still had plenty of time for a helicopter pickup, Charlie called to 88M, asking him to meet them at the helispot. This first call for pick up occurred at approximately 1315.

Blake, the pilot for 88M, described hearing that call over the radio as his first “gut-wrenching” moment of the day. He had been working all morning on bucket drops for the hotshots and the throw-together crew, but from 1200 onwards those drops became increasingly difficult due to wind, smoke, and communication issues over the radio. As the winds tossed him around, it took all of Blake’s focus to complete bucket drops.

A note on communication

Like many fires, the Bridger Foothills Fire was rife with radio communication issues on Saturday 9/5/2020. These issues included a change in tactical frequency for Division A that the Helitack Crew was unable to get to consistently work on their radio, a change in air to ground frequency that was not immediately communicated to all resources, and a nationwide Forest Service software push that left Bozeman Interagency Dispatch with inoperable radio consoles. Work arounds, however, were quickly developed, such as coverage from neighboring dispatch centers, alternate frequencies, and cell phone use.

Up until the call for pick up at the helispot, Blake did not know where the crew was with any certainty. He had received one strobe from them sometime between 1000 and 1130. He then checked in again in the early afternoon after fire activity first started to heat up, at which point they indicated to him that they were "all good." Those same communication challenges that complicated bucket drops, however, made it so that Blake was only picking up bits and pieces of ground communication.

When the Division A Supervisor made the call to pull all resources off the handline, Blake again wanted to check in on his crew. Not able to reach them directly, he asked air attack to contact the crew. He eventually heard through the air to ground frequency (A/G) that they were in a big green field and they were safe. Having discussed escape routes with the crew prior to taking off from the helispot that morning, Blake assumed from this transmission that the crew had followed the third escape route and were currently located in the field around House 2. Reassured that they were safe, he returned to bucket drops.

After the call for pick up from the helispot, however, Blake suddenly realized that the crew was not where he had assumed. At this point, the smoke from the fire was significant, and the wind was pushing it directly up the canyon and against where Bridger Ridge makes a slight turn to the east, directly north of the helispot. Given the smoke and the turbulence, Blake knew he could not fly directly from where he was dropping buckets to the helispot. Instead, he tried to bump out of the canyon to the east and fly on the leeward side of the lower ridge that runs parallel to the Bridger Ridgeline. As he came up around the north side of the helispot, he hit a "wall of smoke" and immediately realized that he was not getting to the crew that way.

Immediately before deployment

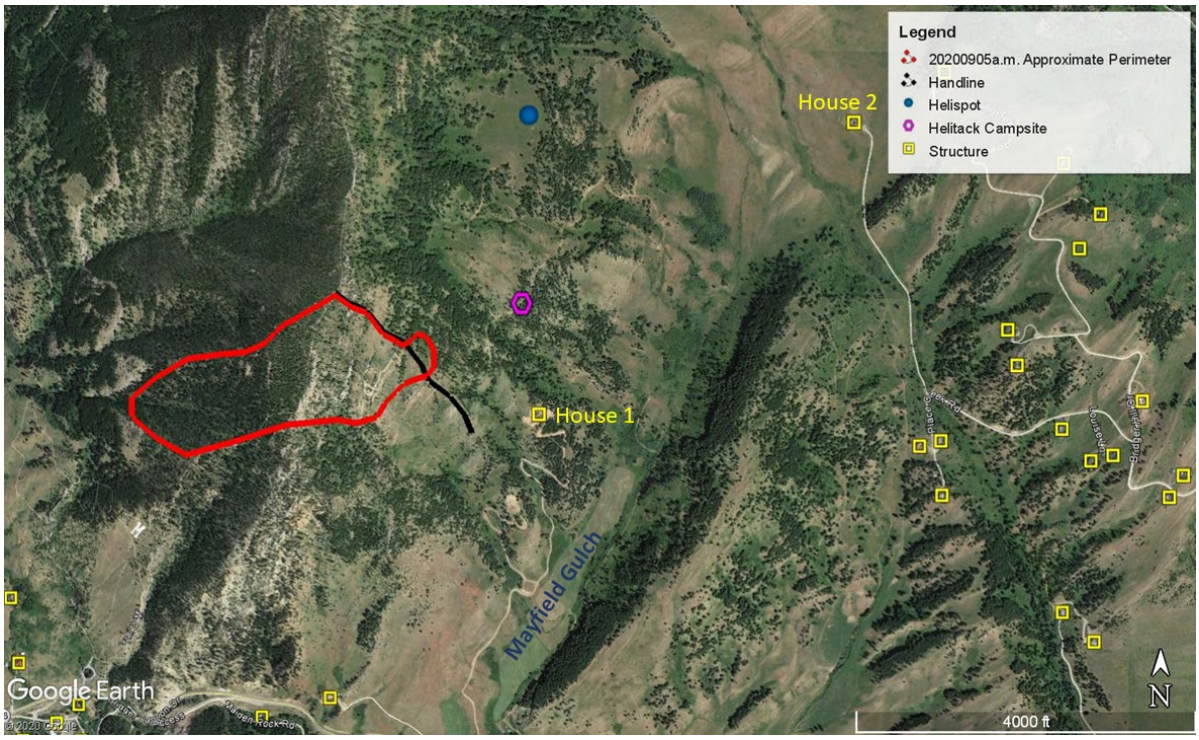

Figure 10: Replication of the map depicting the notable landmarks of the Bridger Ridgeline area, including the approximate perimeter of the fire on Saturday morning, the handline that was completed Friday night, the Helitack Crew's campsite, and the helispot. Re-produced here for ease of reference.

After calling for pick up, the Helitack Crew made their way across a small draw back to the helispot. Casey led the way at a near-running pace, while Sam and Charlie followed at a fast walk. Sam, who was carrying a small cubitainer (cubie) of water and the chainsaw, tripped and fell; Charlie urged him to leave the cubie and continue on without it. At this time, they also received a transmission from air attack: were they aware of the spot fire by the house? Thinking that air attack was referring to the spot above House 1 that they had observed prior to leaving the opening above the campsite, Charlie responded that yes, they were aware of the spot.

Air attack had not, however, been referring to the spot above House 1. Blake, after hitting the wall of smoke, had noticed a spot fire immediately downhill of the helispot. Deeply worried about the Helitack Crew's location relative to this spot fire, Blake called the spot into air attack, asking him to relay it to the Helitack Crew. Air attack had already communicated the location of that spot fire to the Division Supervisor and the Hotshot Crew over A/G. He had also conveyed the possibility for the spot to move upslope towards the main Bridger Ridgeline and up Mayfield Gulch towards House 2. Assuming the Helitack Crew had heard that transmission, he followed up with a transmission directly to the Helitack Crew simply to confirm that they were, in fact, aware of the spot.

As soon as the Helitack Crew reached the helispot opening, Casey remembers urging Charlie to call 88M again; "You need to call him – we need extracted right now!" Charlie, however, remembers Casey asking if he could light off the field to reduce fuels. Charlie, not wanting to remove the opportunity for

helicopter pick up, told him no. Shortly after, the crew became aware of the spot fire below them on their own.

Sam first noticed the smoke from the spot as they approached the helispot opening. When he pointed it out to the other two, they told him not to panic - “it is just drift smoke.” It quickly became evident, however, that it was not drift smoke, but rather smoke from the now well-established spot fire directly below them. At this point, they knew that the spot fire made the option of moving down and out to House 2 impossible due to the steep terrain, heavy fuels, and fire behavior. With this realization, Charlie made a second call to Blake, requesting immediate pick up. From their vantage in the opening, they could see a small window for possible extraction, with less wind and clear air to the north. The crew remembers hearing Blake reply with a hard “no.”

Figure 11: Picture taken from the air attack platform at 1326. The image captures fire activity leading up to the shelter deployment.

Blake, however, recalls replying to this second call for extraction with “there’s no way I can get in there” at approximately 1330, which was also the response remembered by air attack. Blake was already north of the helispot and could not see the opening that the Helitack Crew was describing. From his position in the air, the wall of smoke began north of the crew and continued down through Mayfield Gulch. Blake flew down drainage along the wall, looking for holes in the smoke. Not finding any openings and concerned about the spot fire running up the hill, Blake instead decided to get a bucket to buy time for the crew.

Now knowing that there was no chance for helicopter pickup, Casey immediately began to ignite his fusees. With no escape routes remaining, and the story of Wag Dodge from Young Men in Fire in mind, he wanted to reduce the fuels in the helispot opening as much as possible. Sam quickly joined, and together they worked on burning out a larger area around the gear oval that they had scraped down to mineral soil that morning. Charlie, meanwhile, was on a small hill to the north of their gear, looking down onto the spot fire to assess if there was any other way out.

The second “gut-wrenching” moment for Blake came when he heard air attack announce that the spot fire below the Helitack Crew had grown to over an acre in less than a minute. Blake, who was making his way back towards that spot from the dip-site, was “slammed by winds so hard” that he was sinking despite pulling full power. Forced to jettison the water from the bucket, Blake knew that there was nothing he could do to slow the spot fire beneath the crew under those conditions.

On the ground, Charlie had determined that there was no viable escape option and returned from the hill to where Casey and Sam continued to burn out around the gear. They were having little success, however, in creating solid black. The grass was not easily lighting even with the fusees, and when the grass did ignite it did not carry. The erratic winds that were constantly switching directions by 180° did not help either. Charlie tried at first to help by grabbing his sig torch, but the torch would not work; it barely dribbled fuel. As he and Casey frantically tried to fix it, the torch caught on fire. Charlie was forced to throw it aside and pick up fusees as well.

NWCG definitions

Entrapment: A situation where personnel are unexpectedly caught in a fire behavior-related, life-threatening position where planned escape routes or safety zones are absent, inadequate, or compromised.

Fire shelter deployment: Removing a fire shelter from its case and unfolding it to use as protection against heat, smoke, and burning embers.

It was not until the thermal winds from the rapidly growing fire beneath the crew began to consistently push upslope that they had much success in burning off the meadow vegetation. With the flame front rapidly approaching from both the south and the east, Charlie desperately began searching for burnable vegetation, and started to light off pockets of sage farther out from their gear. Casey came running back to the gear, instructing Sam to deploy his fire shelter.

As Sam deployed his shelter, he realized Casey was not doing the same. "Where's your shelter?" he asked. Casey replied, "I don't have it," and with that, Sam deployed. He did not offer to share his shelter with Casey; he remembers not even thinking about it until after the fire had passed. He later recalled that "it was not my best moment."

Casey began arranging the flight bags and his own PG bag to try to deflect the heat. He lined up the three flight bags along the downhill side in front of the spot fire flame front, and his overnight bag on the opposite side between himself and Sam. In preparation for the flame front, he threw his chaps over his back, tossed the line gear farther away from their deployment site, and grabbed the radio and water bottle before hitting the ground, where Charlie found him curled up minutes before the fire hit.

Notes on fire shelter use

Water in a fire shelter: Do not use your water to wet your clothing or your bandanna inside the fire shelter. Wet clothing conducts heat to the skin more quickly than dry clothing, so burns are more likely. As the water on the clothing evaporates, it increases the humidity inside the shelter. Moist air will cause more damage to your airway than dry air at the same temperature. The best way to use your water is to drink it. Take canteens into your fire shelter if you have time. Continue to sip the water to replace lost fluids.

Sharing a shelter: Never plan to share a shelter unless someone is without one. The shelter is designed for one person. Sharing a shelter greatly increases your risk of injury because it reduces the amount of insulating airspace and increases the chances your body will contact hot shelter material. If you can't avoid getting into someone else's shelter, yell at them so they know you are coming in. Always enter from the side away from the flames or hot air, so you don't expose the occupant to the full force of the wind and heat. Your head should be by the other occupant's head.

Post-deployment and extraction

When Blake heard over A/G that the crew had deployed, he was still getting rocked by the winds and desperately trying to get into the helispot. Air attack asked Blake to relay the GPS coordinates for the helispot, which Blake hadn't recorded during his previous trips to the location. He instead tried to record the position from the air. Unable to get the coordinates and fly the helicopter at the same time, he set down and sent a rough estimate of the helispot position. It was then that Blake realized that he was nearly out of fuel, lower than he typically liked to go. This forced him to return to the helibase, later recalling that "it was the worst day of my life."

Figure 12: Photo taken by one of the crew members, immediately post-deployment.

Once all three firefighters emerged from their shelters, the first challenge was trying to get their breath back. Casey remembers struggling to slow down his breathing to get enough oxygen to stay conscious. Sam lay face down on the ground, legs still in the shelter, struggling to breathe. Charlie called over the radio for oxygen, hoping that someone would be able to get to them. The crew was in contact with air attack, but ground communication with the Division A Supervisor was spotty to nonexistent. They were also able to contact their crew supervisors, who were now in route to Bozeman from Helena.

As they sat and tried to breathe, the crew began to feel abandoned. They were increasingly aware that winds and fire activity would prevent a medical response or extraction any time soon. Meanwhile, they could hear radio traffic over A/G concerning other events on the incident, making them feel like they were not a priority. There was also miscommunication and misunderstanding around the exact location of the deployment site and where they moved to after they emerged from their shelters. Eventually, feeling frustrated and deserted, the crew decided to try to walk out on their own along the two-track. They recall the Division Supervisor advising them to head south in order to reach House 1.

Because they started moving, air attack enlisted the help of another fixed wing, B-2, who could fly lower to pinpoint their location and assess conditions for possible air extraction. Once B-2 got eyes on the crew, the helicopter pilots all desperately wanted to fly to them. 210MA had been up in the air since the deployment, hovering with a bucket and looking for any opportunity to get in and help. The pilot for 210MA indicated that if anyone was going to attempt to reach the crew, they had to go in light due to winds. Therefore, 2TC, who had recently refueled, was holding hover on the ground nearby to burn off fuel. 2TC was eventually given the go ahead to attempt extraction. As a local pilot familiar with the area from previous search and rescue missions, it was determined that he would have the best chance of success.

"I wanted to get them bad. I mean, I wanted to get them real bad. I've been flying here all my life, I risked as much as I could to get in" the pilot for 2TC would later recount. The air, however, was just too turbulent, and he was forced to abandon the attempt. In retrospect, B-2 questioned his decision to give

2TC the okay for that mission. The air was so choppy that the likelihood of adding a crashed helicopter to the situation was high.

Although a short-haul helicopter was requested by the Helibase and the ICs, the turbulent conditions ultimately prevented any kind of helicopter extraction. Additionally, the Division A Supervisor tried to arrange for a UTV with medical supplies to drive into the crew, but fire behavior and residual heat made that impossible as well.

On the hill, the location where B-2 had initially obtained visual confirmation of the Helitack Crew quickly proved inhospitable. The crew was standing near a fork in the two-track, between the helispot and campsite, where the wind was relentlessly blasting them with heat, ash, and smoke. Fed up, they walked back to the deployment site where they were largely protected from the wind. Having exhausted all options, they sat there, hoping that conditions would change so that someone could come get them or they could walk out themselves. Meanwhile, the three made calls to their loved ones, ensuring them that they were still alive and largely uninjured.

Figure 13: A tree "frozen" in place by wind from the fire event. This picture was taken over a week after the deployment, near the fork in the two-track where the Helitack Crew waited for possible extraction before returning to the helispot.

A couple of hours had passed when the crew started to hear voices coming towards them. Relieved, the Helitack Crew walked towards the approaching figures. They eventually realized that it was the Division A Supervisor along with the superintendent for the Hotshot Crew, who had decided to hike into the deployment site despite the recognized hazards. The five of them continued back along the two-track to House 1, where the Helitack Crew was driven down to an ambulance waiting by the highway. Charlie, Casey, and Sam were then transported to the hospital, where all three firefighters received medical evaluation.

Acknowledgments and Moving Forward

Throughout our interviews and conversations with folks surrounding this incident, we quickly realized just how complex the Bridger Foothills Fire was as it transitioned from initial to extended attack. A consistent theme worth sharing is just how bad things could have been when the fire blew up on Saturday, September 5th, running across Highway 86 and burning dozens of homes and structures in its path. During those four hours between deployment and extraction, the individuals managing the fire were responsible for coordinating the relocation of the helibase due to fire behavior, the evacuation of the public from Bridger Canyon, and the mobilization of search and rescue for a lost hunter in the area. The long-standing, positive relationships and close coordination between wildland fire response agencies and Gallatin County not only contributed to the deployment response, but also to minimizing the risk to private landowners and hundreds of responders as the fire progressed.

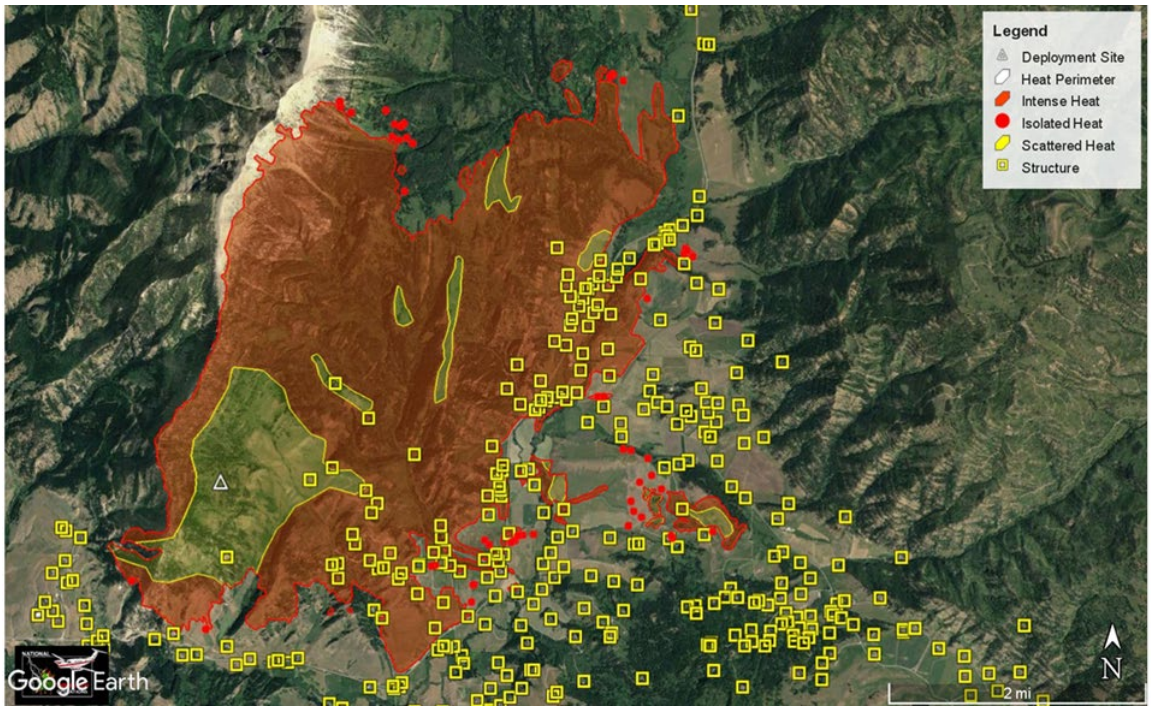

Figure 14: The fire perimeter at the end of the day Saturday 9/5/2020, with area homes highlighted to depict the complexity of the incident.

As with many unintended outcomes, this incident involved countless potential learning opportunities at multiple levels within wildland fire response agencies, from the field personnel to agency leadership. While we sincerely believe that all challenges and successes should be shared and learned from whenever an opportunity is presented, the intent of this FLA was to focus on the immediate events leading up to entrapment, the entrapment itself, and surviving the shelter deployment. With this focus, we do not intend diminish or minimize other opportunities for learning in any way. It is our aim, rather, for this FLA to reveal more questions than it does answers. We hope there will continue to be conversations around this event, and that the stories shared in this FLA will serve as a catalyst for further reflection within all wildland firefighting agencies.

That said, the FLA team, as well as individuals involved with the deployment, agree that there are a few lessons worth highlighting. We encourage every reader to add to this list as they see fit.

- What does your initial or annual refresher for entrapment avoidance and shelter deployment training look like? Is it realistic enough to provide the background knowledge you may need someday?
- What is your organization's protocol for Personal Protective Equipment (PPE) inspection? Is your gear in a condition conducive to serving its purpose?
- What is your organization's protocol for daily gear checks?

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Appendix A: Equipment Report

Introduction

The following discussion is derived from a site visit, visual inspections of personal protective equipment (PPE), and interviews with the firefighters who deployed fire shelters

Shelter Deployment Site Overview

NTDP staff conducted the site visit on September 11, 2020—6 days after the fire shelter deployment. The equipment involved in the deployment was left on site and was exposed to snowfall and wind during the time between the shelter deployment and the site visit.

Fire Shelter Deployment Site Description

The shelter deployment site was located near the edge of a 12-acre, flat bench that dropped off into the valley below. The opposite end of the bench transitioned into rising terrain. The fuels around the deployment site consisted of 18- to 24-inch tall grass, sagebrush, and adjacent mixed conifers. The firefighters estimated that the winds were 35 to 40 miles per hour (mph), which shifted in many directions and gusted to higher wind speeds as the flame front passed over them. See figures 1 and 2.

Figure 1: The area surrounding the deployment site looking towards the edge of the bench that drops into the valley below. The deployment site is circled in red.

Figure 2: The area surrounding the deployment site looking towards the rising terrain. The deployment site is circled in red.

Fire Shelter Deployment Site Preparation

The shelter deployment site was an 8- by 10-foot oval that the firefighters had previously lined and scraped down to mineral soil. The firefighters used this area of bare ground to stage their extra equipment (food, water, flight helmets, overnight gear, etc.) during the shift. See figure 3.

Figure 3: A close-up of the deployment site. The deployment site is circled in red.

Fire Shelter Deployment Sequence

Removal of the Fire Shelter from the Fireline Pack

Firefighter 1 (FF1) and firefighter 3 (FF3) wore two different styles of fireline packs. Both pack designs included a bottom-mounted compartment for stowing the fire shelter in a horizontal position.

FF1 and FF3 took off their packs and set them on the ground before removing their shelters. Both firefighters mentioned that they had no problems removing their shelters from their fireline packs.

Opening the Fire Shelter Polyvinyl Chloride (PVC) Bag

FF1 and FF3 stated that the red pull-tab strips and PVC bags opened and performed as designed.

Fire Shelter Deployment—FF1

FF1 was not wearing gloves for the duration of the fire shelter deployment.

FF1 described how he grabbed the left and right shake handles and noticed that he was holding the handles in the wrong hands. He swapped hands and continued to open the accordion folds and shake out the long folds. He stated that the fire shelter "shook out just like a practice shelter, better…wind helped."

To get into the fire shelter from the standing position, FF1 placed one foot in, fell to the ground face down, and then pulled the other foot in. He reoriented his position to move his feet towards the oncoming fire to get fully deployed.

FF1 attempted to completely seal the fire shelter to the ground surface, but burning grass and embers did blow into the fire shelter. He said that he had difficulty breathing from the smoke and that he could see the glow of the fire through the sewn seams in the fire shelter. FF1 lifted a corner of the fire shelter a few times to get better air, but it was worse outside the fire shelter. He poured water on his shirt and dug a small hole in the soil to get cooler air to breathe. FF1 estimated that he remained inside the fire shelter for 15 to 20 minutes.

Fire Shelter Deployment—Firefighter 2 (FF2) and FF3

FF2 told FF3 that he did not carry a fire shelter and that he needed FF3 to share his fire shelter.

FF2 was not wearing gloves for the duration of the fire shelter deployment. FF3 initiated the fire shelter deployment without wearing gloves.

FF3 described his fire shelter as a "ball of tinfoil." He said the accordion folds were difficult to open. He mentioned that the fire shelter did not open like a practice fire shelter, and this threw off his recollection of the normal steps to deploy a fire shelter, which he learned during practice deployments.

Both firefighters worked together to pry open and shake out the long folds. Both firefighters dropped to the ground, in opposite directions (feet-to-head). FF2 positioned himself face down with his mouth over a breathing hole he had previously dug into the soil and filled with water.

FF3 positioned himself face down in a crouching position that he described as a "downward dog-like yoga pose," with his head facing the opposite direction of FF2. FF3 stated, "I realized I needed to protect any exposed skin as embers were flying." He recalled that he rolled down his sleeves, popped up his shirt collar, reached into his left leg pocket for his flight gloves, and put them on for the duration of the fire shelter deployment.

Initially, neither firefighter could lie fully prone under the fire shelter. They could not establish a good seal to the ground, which allowed ash, embers, and smoke to enter the fire shelter. FF3 had his left leg sticking out of the fire shelter; FF2 had both legs and part of his back sticking out of the fire shelter. A fireline pack that was adjacent to the deployment site ignited, and FF3 felt the heat on his left leg. He was able to kick it farther away from the deployment site.

FF3 became distressed by the smoke and difficult breathing conditions inside the fire shelter, and he exited the fire shelter to try to get better air to breathe. He exited the fire shelter and stood up, but the fire conditions outside the fire shelter were much worse. He immediately dove back to the ground and repositioned himself under the fire shelter, shoulder-to-shoulder with FF2. FF3 recalled that this re-positioning helped improve his breathing conditions. They eventually got most of their bodies under the fire shelter and established a better seal to the ground.

Both firefighters remained under the fire shelter for about 7 to 8 minutes. FF2 reached out from under the shelter to access water bottles in an adjacent plastic bag. He poured the water in the bottles onto both of their backs.

FF2 and FF3 exited the fire shelter for a moment, but the fire conditions were still too intense. They re-entered the shelter for several more minutes. FF2 and FF3 estimated the total time they were under the shelter to be about 15 minutes.

Fire Shelter Analysis

FF1 Fire Shelter

- Firefighter information: FF1 was 71 inches (5 foot 11 inches) tall and weighed 185 pounds.
- Fire shelter information: The regular-sized fire shelter was manufactured according to Forest Service Specification 5100-606C in October of 2016.
- Post-deployment fire shelter inspection observations:
    - Polyvinyl chloride (PVC) bag(s): The fire consumed both fire shelter PVC bags—PVC bags, pull-tab strips, and nylon pull straps. See figure 4.

Figure 4: Both polyvinyl chloride (PVC) bags, red pull-tab strips, and yellow nylon pull straps.

    - Shell outer laminate: The foil had visible evidence of exposure to heat and delamination. The foil had 4-inch tears in two spots on the end cap. See figures 5 and 6.

Figure 5: The fire shelter used by firefighter 1 (FF1) showing the conditions of the shell outer laminate and two (2) yellow shake handles.

Figure 6: The fire shelter used by firefighter 1 (FF1) showing the conditions of the end cap portion of the shell outer laminate. The foil shows visible signs of heat in three (3) areas that are circled in red. Two (2) red arrows point to the torn foil.

- Shell inner laminate: Nothing to note.
- Seams: Nothing to note.
- Hold-down straps: Nothing to note.
- Floor laminate: The foil had visible evidence of exposure to heat on the floor of one end cap. The opposite end cap had a 4-inch tear and visible evidence of physical abrasion. See figure 7.

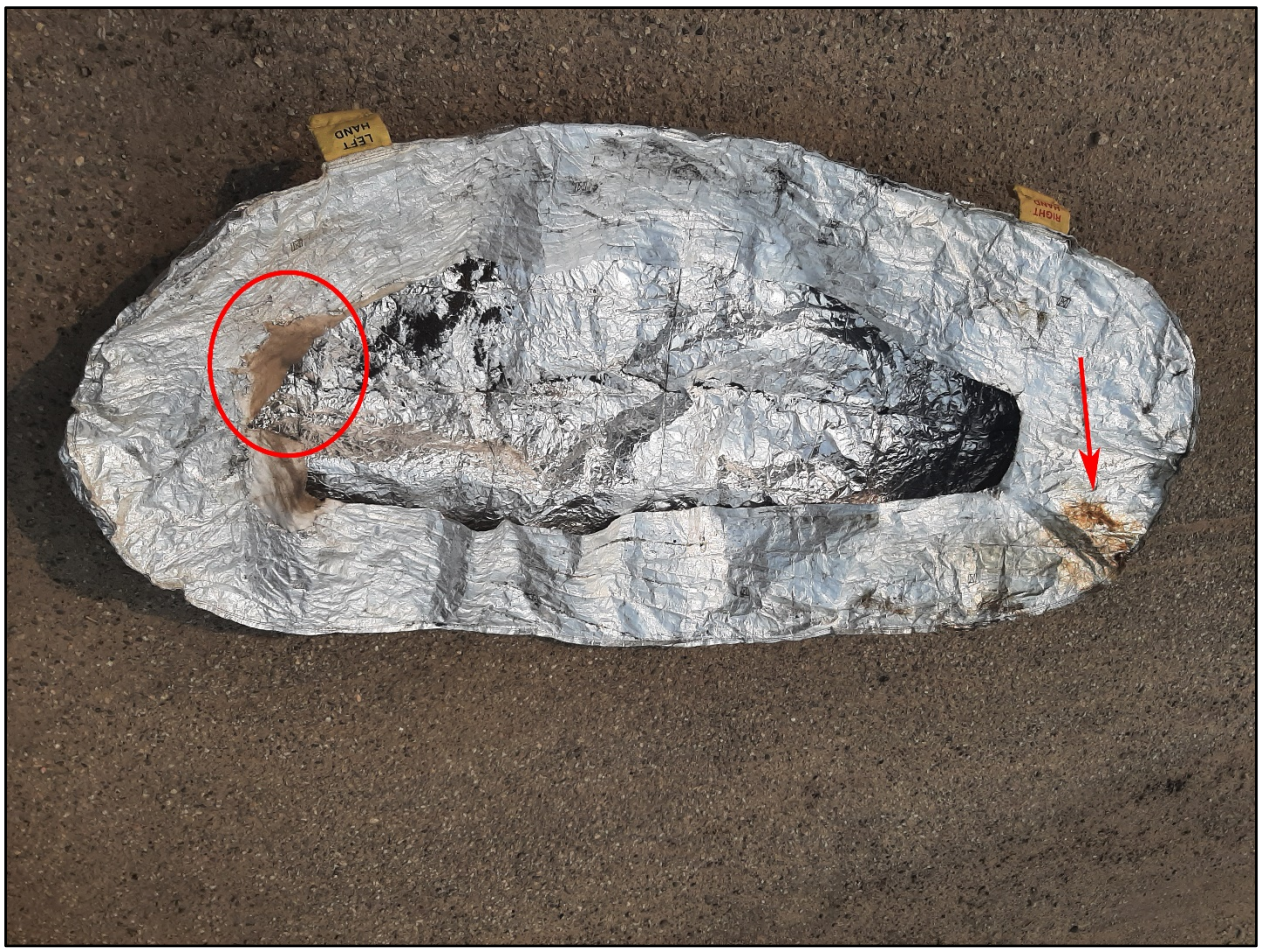

Figure 7: The fire shelter used by firefighter 1 (FF1) showing the conditions of the shell inner laminate, floor laminate, and shake handles. The physically abraded and torn laminate is circled in red. A red arrow points to the visible signs of heat on the foil.

FF2 and FF3 Fire Shelter

- Firefighter information: FF2 was 74 inches (6 foot 2 inches) tall and weighed 225 pounds. FF3 was 72 inches (6 foot) tall and weighed 190 pounds.
- Fire shelter information: The regular-sized fire shelter was manufactured according to Forest Service Specification 5100-606 in February of 2005.
- Post-deployment fire shelter inspection observations:
    - Shell outer laminate: The foil on the main body and end cap had visible evidence of exposure to heat, physical abrasion, numerous tears, and delamination. See figure 8.

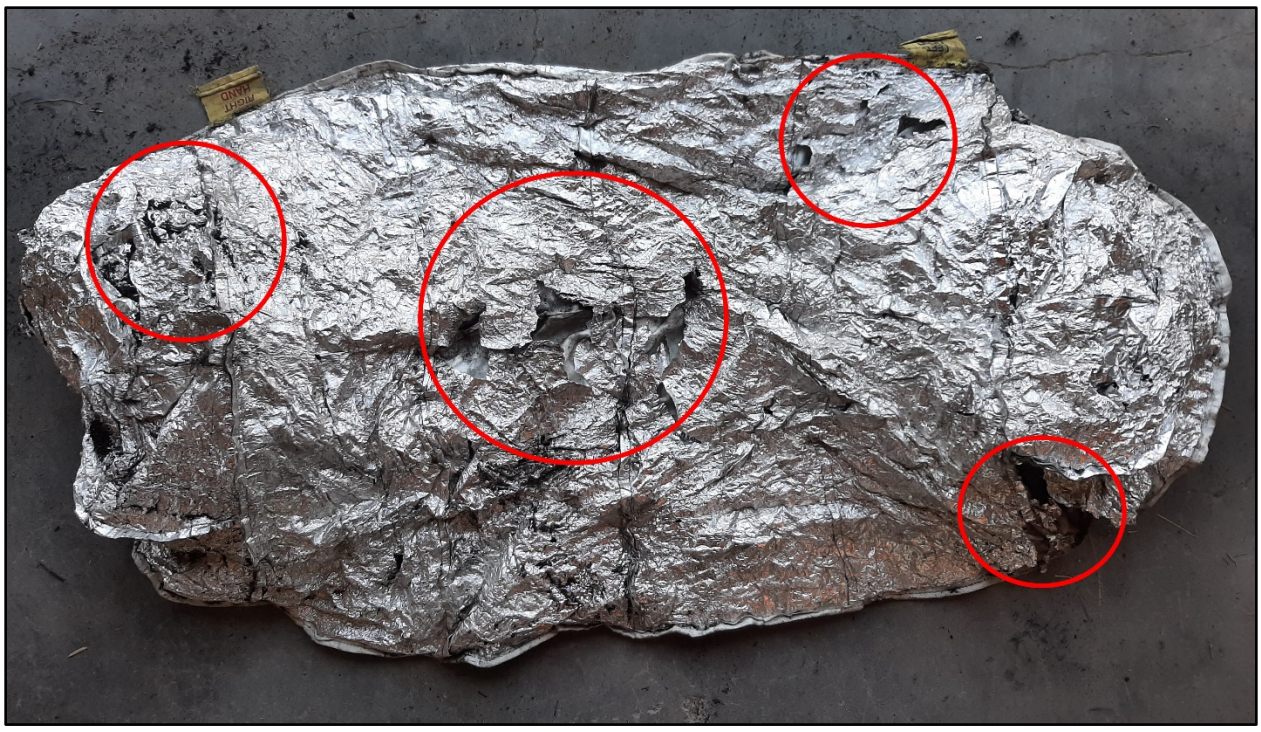

Figure 8: The fire shelter shared by firefighter 2 (FF2) and firefighter 3 (FF3) showing the conditions of the shell outer laminate and shake handles. There were several areas where the foil is delaminated and abraded away, circled in red.

- Hold-down straps: Nothing to note.
- Shell inner laminate: The foil of the main body had visible evidence of delamination and was abraded away.
- Seams: Two of the floor seams had 8-inch tears. One of the floor seams had a 6-inch tear.
- Floor laminate: The foil of both end caps had visible evidence of delamination and was abraded away. The silica cloth on one of the end caps showed signs of heat and embrittlement. The laminate had two circular abrasion holes. See figures 9 and 10.

Figure 9: The fire shelter shared by firefighter 2 (FF2) and firefighter 3 (FF3) showing the conditions of the shell inner laminate, floor laminate, and two (2) shake handles. There were several areas where the foil was abraded away, circled in red. Red arrows point to torn floor seams.

Figure 10: The floor laminate portion of the end cap. The heat-embrittled silica cloth is circled in red.

Table 1 shows the characteristics and comparisons of materials under various temperature conditions.

Table 1—Material characteristic and corresponding temperature ranges

Material and characteristic	Approximate temperature (degrees Fahrenheit)
Silica cloth–embrittlement	2,000
Foil/shelter cloth bond–delamination	500
Nylon–melting	500
Fire shelter PVC bag–melting	285
Human survivability	300

Discussion

The shell outer laminate aluminum foil of both fire shelters showed visible evidence of exposure to heat and delamination. Delamination of the foil occurs at 500 degrees F. The floor laminate on the end caps of both shelters showed the greatest amount of foil delamination. The silica material portion of the floor laminate of the shelter that FF2 and FF3 shared showed spots of embrittlement, which occurs at 2,000 degrees F. The embrittlement and delamination of these areas was most likely from direct contact with hot embers combined with physical abrasion of the firefighter's boots pressing the shelter floor against the ground surface.

Both shelters had tears in the floor laminate. The shelter used by FF1 had a 4-inch tear in the area where the delamination was concentrated. The shelter shared by FF2 and FF3 had three torn floor seams. These seam tears appeared to be from pulling stress, most likely associated with sharing the shelter.

Summary

Temperatures approaching 300 degrees F are at the upper limits of human survivability due to airway damage and breathing difficulty. The firefighter's equipment that was recovered from the deployment site indicated temperatures up to 2,000 degrees F. Digging an area down to mineral soil for their equipment likely reduced the amount of direct flame contact onto the firefighter's fire shelters and contributed to their survival during the shelter deployment. The fire shelters that the firefighters deployed on the Bridger Foothills Fire functioned as designed, prevented serious thermal injuries, and likely saved the lives of the three firefighters.

Fire Shelter Reminders

Fire Shelter Sizing

All firefighters must be aware that the fire shelter is available in regular and large sizes. The large fire shelter is recommended for firefighters who are taller than 73 inches (6 foot 1 inch) or whose girth is larger than 53 inches.

Sharing a Fire Shelter

The fire shelter is designed for one person. Sharing a shelter greatly increases your risk of injury because it reduces the amount of insulating airspace and increases the chance that your body will contact hot shelter material.

Water Inside a Fire Shelter

Pouring water onto yourself while inside a fire shelter is not recommended. As stated in the fire shelter training document, wet clothing conducts heat to the skin more quickly than dry clothing, so burns are more likely. As the water on the clothing evaporates, it increases the humidity inside the shelter. Moist air will cause more damage to your airway than dry air at the same temperature.

Fire Shelter Inspection

The fire shelter is a required personal protective equipment (PPE) item for fire area activities. Wildland firefighting operations are rough on equipment. All firefighters need to establish a personal readiness protocol to confirm they will be carrying the equipment and PPE they may need. Conducting fire shelter inspections after the new year and periodically throughout the season will help ensure your shelter is in serviceable condition. Firefighters must carefully consider various factors to determine the frequency of their inspections. This may vary depending on types of assignments, exposure to weather conditions, and general handling.

Fire Shelter Deployment Training

Firefighters should consider training scenarios where they can practice fire shelter deployments in realistic field conditions. It is important to understand the elements you will need to contend with in a fire entrapment and shelter deployment situation, such as physical exertion, mental stress, strong and turbulent winds, noise, and reduced visibility, to mention a few. Firefighters should train as though their survival is at stake.

National Wildfire Coordinating Group Fire Shelter and Personal Protective Equipment Website

For comprehensive and updated fire shelter information, visit the National Wildfire Coordinating Group Fire Shelter and Personal Protective Equipment website.

The "Fire Shelter Training" section provides information on how the fire shelter works, how to deploy the fire shelter, how to select a deployment site, what a firefighter might experience during an entrapment, training, care, and inspection of the fire shelter. This section includes:

- Fire Shelter Training Reminders–2020
- New Generation Fire Shelter Legacy Training Booklet (PMS 411)
- New Generation Fire Shelter Video

The "Tech Tips and Publications" section includes:

- 2005 Large New Generation Fire Shelter Now Available
- 2011 Fire Shelter Inspection Guide and Rebag Direction

The website also provides real-life videos featuring Fire Shelter Deployment Stories and Common Insights as well as Fire Shelter and PPE Reports.

Appendix B: Fire Behavior Report

Topography

Topography of the area is generally a long, south to north ridgeline with valleys to the east and west. Top elevation of the ridge is 7400 feet above sea level directly above the deployment site, rising to over 9000 feet, north of the fire area. From Mayfield Gulch, directly below the deployment, to the ridge is approximately 1500 feet of elevation. Maximum steepness is 72 percent slope with the average being 29 percent slope. Although the deployment site is flat, the slope directly below the site has an average slope of 24 percent for 200 feet of elevation. Aspect is generally east and south.

Fuels

Fuels in the area are described by open Douglas-fir forests with grassy meadows of various extents and wooded draws. Fuel models represented are 101, 102, 104, 165 and 183 with very small areas of shrub models.

Fine dead fuel moisture at the time of the deployment is calculated to be 3 percent and probability of ignition at 90 percent. Fuel moisture in the area were approximately; 10-hour fuels 8-10%, 1000-hour fuels 9-11%, live Douglas-fir 100-107% and duff 12-30 percent. Live herbaceous fuels were assumed to be cured, less than 30%, and live woody fuels were assumed to be less than 60 percent. Energy Release Component for the 5th was 45, which is Very High and Burning Index was calculated at 38, which is classified as Extreme.

Weather

Last spot weather forecast prior to deployment posted at 1232 hours stated:

```
"1231 PM MDT Sat Sep 5 2020

.REST OF TODAY...

Sky/weather.........Mostly sunny.
LAL.................1...no thunderstorms.
Max temperature.....91-95.
Min humidity........9-13 percent.
Wind (20 ft)........
 Slope/valley.......West winds 10 mph, becoming 13 to 17 mph with gusts to
around 25
                    mph. A few higher gusts over 30 mph are possible late
this afternoon.
 Ridgetop...........West around 22 mph.
Mixing height.......15200 ft AGL.
Transport winds.....West around 22 mph.
Haines index........6 or high potential for large plume dominated
                    fire growth.
CWR.................0 percent."
```

Multiple weather sources and models validate this forecast. Weather taken from a house nearby, shows observations at the time of deployment to be:

- Temp: 87 degrees

- Humidity: 14 percent
- Wind: 18 mph with gusts to 28 mph from the southwest

Model outputs from Wind Ninja indicate an expected wind at that weather station to be 14-28 mph from the southwest with stronger winds adjacent to the site. On-site observations of needle freeze on Douglas-fir trees indicates a slope effect, turning surface winds to approximately 168 degrees.

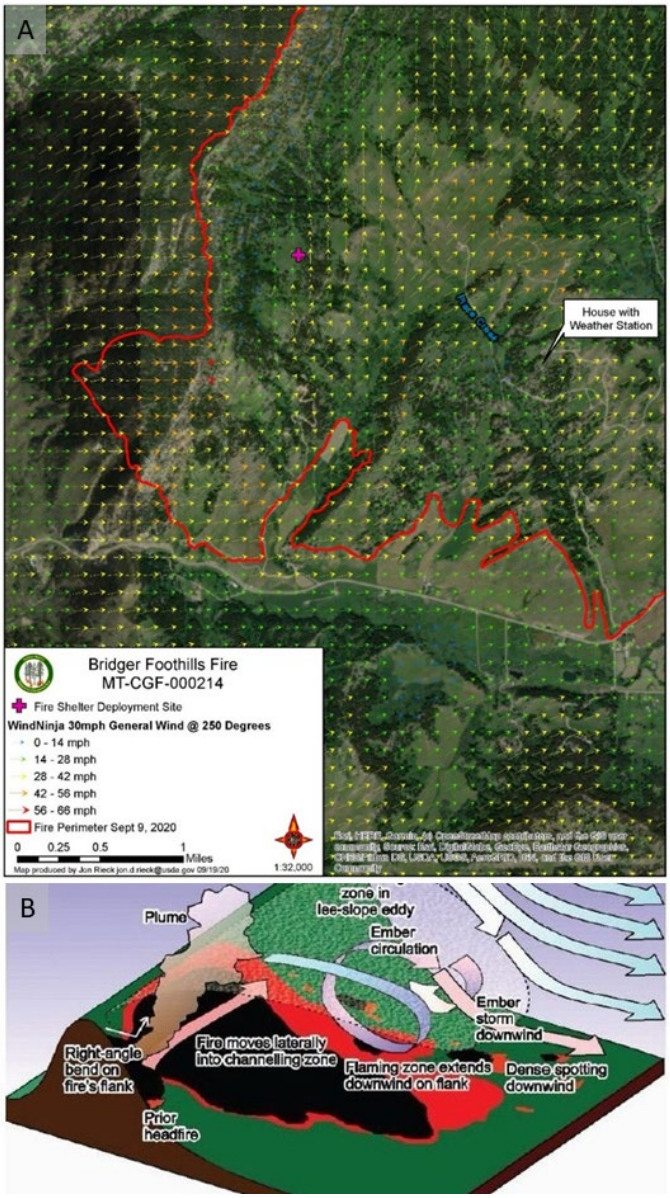

Figure 1A: Results of the Wind Ninja model using a 30-mph wind from 250 degrees and 1B: conceptual diagram of slope effect on wind direction.

Fire Behavior

Multiple sources were used to get relative indicators of fire behavior and fire growth. The Farsite fire model was used to project fire growth and plot estimated fire perimeters for the burn period of

September 5. Probable spot fire locations are also modeled by Farsite. Model outputs were validated by observations from resources on the fire and nearby homeowners.

Photos show that the fire was established down to about the 5,900 feet elevation level on the morning of the 5th, on the east side of the ridge. Fire behavior was active throughout the previous night.

Figure 2: Fire activity on the Bridger Foothills Fire for the night of September 4th. Photo credit: Rachel Leathe, Bozeman Daily Chronicle.

Fire growth was wind driven, primarily by torching and spotting and short to moderate length runs in light grass fuels. Due to the terrain effect on winds and turbulence, the fire would have been spreading in four different directions at the time of the deployment. The undulating terrain is conducive to catching spot fires on ridges and the spot fires growing together rapidly. Significant fire growth began around 1200 hours. From this time, it took about 2 hours for the fire to reach the deployment site. Rates of spread are indicated to be up to 3 miles per hour. Rate of spread near the site was generally less than ½ mile per hour, with spread in the adjacent grass fuels up to 3 miles per hour.

Conditions at the deployment site

Flame length, as an indicator of intensity, was less than 4 feet at the site, less than 8 feet nearby but greater than 100 feet when the adjacent trees were torching. Although flame lengths from the trees were high, fireline intensity at the deployment site was much lower, as indicated by the damage to the fire shelters. However, at an estimated 550 BTU/ft-s, fire intensity would have been far greater than the approximately 1 BTU/ft-s required to injure a firefighter wearing flame-resistant clothing.

Crown fire is indicated to be passive, torching and spotting, not active crown fire. It is likely that passive crown fire approached the site three different times in rapid succession; first from the east, second from the south and third, from the north.

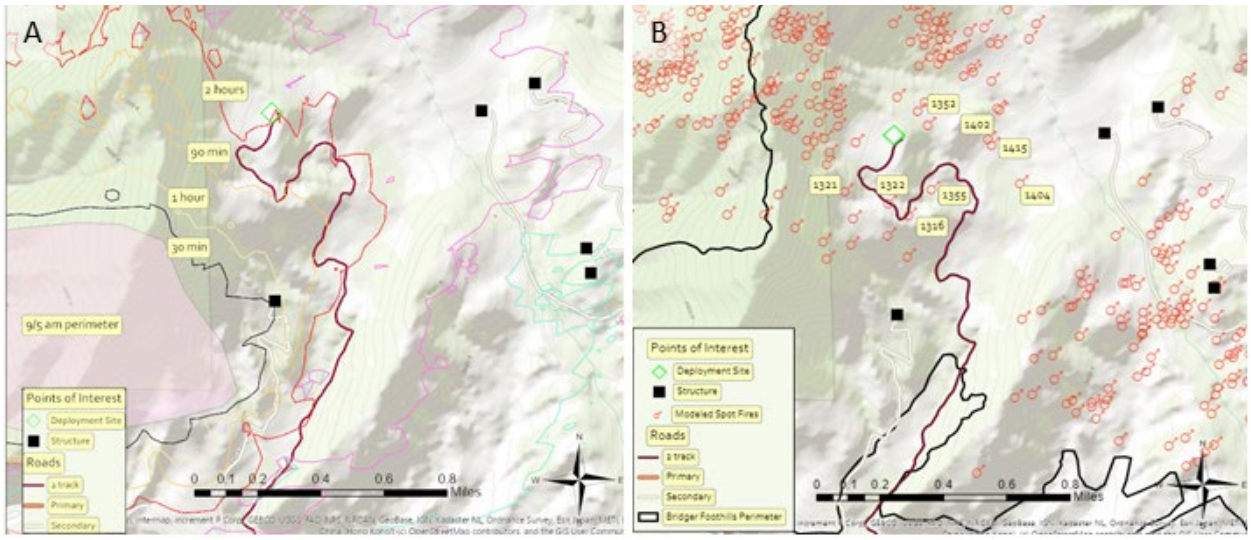

Figure 3A: Fire perimeter progression for the Bridger Foothills Fire, beginning approximately 1200 hours and 3B: modeled spot fires around the deployment site with approximate time of ignition

Several spot fires are expected to have impacted the site. The two of most interest are modeled to have occurred at about 1315 hours and 1320 hours, both downhill from the site. Two other spots are modeled to have occurred somewhat later and may have impacted the site in the second wave. Two more modeled spots are validated by actual observations, giving confidence in the model.

Safety Zones?

Using the existing calculations for safety zone size, and the experienced 100-foot flame lengths, minimum safety zone size would 11.5 acres. That is using the assumptions that the fire is on flat ground and the fire stops at the edge of the safety zone.

SSD = 4*flame height = 4*100 = 400 feet SSD

Proposed safe separation distance models would indicate a safety zone size of between 17 and 37 acres due to the slope and wind. The average recommended size being 27 acres.

SSD = 8 * Slope wind Factor * Height of the surrounding vegetation
SSD = 8*2-3*30 = 480 - 720 feet SSD

Questions

1. Do you update your expectations of fire behavior based upon spot weather forecasts?
2. How often do you assess fire behavior?
3. Are you familiar with local wind and fire spread directions?
4. How long does it take to travel your escape routes?
5. How big is big enough for a safety zone?

Sources

Weather

Spot weather forecasts from Billings NWS
Weather observations from the Feel Good Ranch weather station, through 1544 on September 5
Modelling weather from Ennis RAWS

Observations

Matt Corley, ATGS, interview, 9/15/20
Ken Keys, Feel Good Ranch, phone conversation, 9/16/20
Bob Culbreth, Incident Commander, phone conversation, 9/21/20 1230 hours
Mike Carisch, pilot 2TC, conversation, 9/18, ~1000 hours
Photo Credit, Rachel Leathe/Bozeman Chronicle,
https://www.bozemandailychronicle.com/news/photo-gallery-bridger-foothills-fire/collection_b879d7f8-a2c7-505e-9cb0-7f0780c79418.html#56

Modeling

See documentation and WFDSS Analysis Notes for Bridger Foothills / Run5 9/5 and 9/6 S&R frontal

FlamMap 6 Version 6.1. Build Date: August 3, 2020.

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