# Underburning NWT August 2017

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## ABSTRACT

FPInnovations conducted four separate underburns in August 2017 at the CBCFS research site north of Fort Providence, NWT. The burns were part of a fireguard for a future burn but allowed FPInnovations and the GNWT to study how and when underburning can be applied in a pine stand to reduce the potential spread of wildfire and lower the probability of embers landing and starting new fires. Underburns can also be used as lines from which to ignite backburns. To find the optimal fire weather and fuel conditions in which to burn, we burned four fires under different fire weather conditions and documented the resulting fire behaviour and the effects of the underburns.

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# 1. BACKGROUND

The NWT has asked FPInnovations to document ‘underburning’ under different weather and fuel conditions as a potential FireSmart tool to reduce the intensity of forest fires in and around communities. Manual or mechanical treatments are expensive and the NWT has identified large areas requiring FireSmart treatments. Underburning may be an effective and less-expensive method to treat the forests surrounding towns and villages.

The objective of underburning is to blacken the surface and to remove fine and medium sized fuels along with small shrubs. The intention is to reduce potential fire spread, lower the probability of embers starting fires and establish fire breaks or areas from which to burn off from. The underburning carried out by FPInnovations at this site is intended to create a fire break for a future burn, but this opportunity can also be used to document changes in fire behaviour based on a range of weather and fuel conditions.

*An underburn is defined as a fire that is constrained to surface fuel and therefore has a low to moderate fireline intensity (less than 300 kW/m). Underburns are commonly prescribed for dry forest types such as ponderosa pine or mixed conifer to reduce fuel but leave the overstory intact. Underburns are usually classified as low-severity fires (Glossary of Fire Science Terminology).*

To understand expected fire behaviour and fire effects from various fire weather and fuel conditions, experimental underburns are required. Because this was the initial data collection process for this project, these burns were carried out in existing conditions. The goal is to eventually provide fire managers with weather and fuel condition thresholds that they should consider to achieve desired results. We took the opportunity in August 2017 while at the CBCFS research site north of Fort Providence, NWT to begin our collection of case studies. Four burns were completed in different fire weather and hazard (FWI) conditions. These burns were carried out in stands of different densities and surface fuel conditions. We hope to burn in different stands and hazard conditions to compile data to cover most of the conditions that might be encountered when performing FireSmart underburning operations throughout the NWT.

Each underburn will be presented individually as its own Case Study. Fire weather, fuels, fire behaviour and fire effects are described for each. Results will be based on the fire achieving the desired results – blackening the surface, removing the fine and medium fuels along with small shrubs and ensuring that the fire is controllable. The operational objective provided to the crews was to prevent the fire from reaching the crowns by extinguishing the flame on an individual tree basis in the event that the fire began to travel up the bole of the tree. It is anticipated that underburning will be carried out by four person crew. It should not take a whole crew to light and control underburn operations.

## Underburn #1

The first underburn took place on August 3rd at 14:45hrs in an open pine stand that had surface fuels consisting of cured branches, grass and shrubs. Ignition took place using a drip torch and fire control operations were performed by a NWT fire crew (SS10). The plot was 10 m wide by about 50 m long.

## *Fire Weather*

Table 1 shows the weather conditions at the time of ignition and the hourly FWI values.

**Table 1. Weather and FWI for Underburn #1.**

| **Fire Weather** | | | | | |
|---|---|---|---|---|---|
| Temperature ($^{o}C$) | RH% | Windspeed/gust (kmh) | | | |
| 28 | 35 | 10 G 18 | | | |
| FFMC | DMC | DC | ISI | BUI | FWI |
| 91 | 92 | 491 | 8 | 126 | 30 |

These indices calculate a Head fire Intensity Class of 5 in mature jack or lodgepole pine (C3) – so the fuels are very receptive to ignition and fire spread leading to extreme fire behaviour. Crowning is expected.

## *Fuels*

Figures 1 and 2 shows the openness of the burn plot and surface fuels.

**Figure 1. Open plot and shrub layer.**

**Figure 2. Surface fuels.**

The plot was relatively open when compared to the other 3 sites (some trees had been cut) with light surface fuels along with shrubs. The site also had small jackpots of branches on the surface resulting from the tree cutting (Fig. 3). The fuels were very dry and 'snapped' easily. The surface was also crunchy due to the openness of the site.

**Figure 3. Jackpot of fuel – downed branches from the cut trees.**

### *Fire Behaviour*

It was not surprising given the fire weather conditions and the openness of the stand that once fire was introduced to the site it spread quickly and at a high intensity. Trees candled quickly due to the dry fuels and flakey bark and quickly became a problem challenge for the fire crews. While surface burns are defined as having short flame lengths of under 0.4 m, not surprisingly, this was exceeded (see photo below). Fire intensity far exceeded the 300 kW/m used in the definition of threshold for underburning.

This underburn took a whole crew with fire hose and a good water source to control. If left alone, this fire would have grown considerably and would have become a crown fire.

**Figure 4. Aggressive fire behaviour exceeding prescription.** **Photograph taken by Valerie Orich (AAF).**

### *Fire Effects*

Due to the extreme fire conditions and the fuel arrangement (open), the resulting burn was intense, consuming most surface fuels including the surface layer and the larger pieces of debris (Fig. 5). It also (most likely) resulted in tree mortality, which is not an objective of underburning. A panorama photo was taken of the site so it can be revisited next summer to document the number of dead vs live trees (Fig. 6).

If the intent is to underburn the stand and maintain manageable flame lengths for ease of control by fire crews, it is not recommended to do so under these conditions.

**Figure 5. Fuel consumption from underburn.**

**Figure 6. Panorama photo of underburn site. A number of trees were killed.**

## Underburn #2

The second underburn took place adjacent to the first underburn on August 4th at 1400 hrs in a closed pine stand that had a lighter surface fuel load than the first burn. Ignition took place using a drip torch and fire control operations were performed by a NWT fire crew (SS10). The plot was 10 m wide by about 10 m long. Rain did occur over the area the night before which reduced the hazard. Considering the fire behaviour from the first burn we decided conditions may be more conducive for underburning.

### *Fire Weather*

August 4th had the following weather and FWI values (Table 2). Fire conditions were lowered as the site received 5.5 mm of rain overnight at the Survival Zone and 3.5 mm at the weather station at the parking area - both within 500m of the burn site. A lower FFMC and ISI will reduce fire behaviour.

**Table 2. Weather and FWI for Underburn #2.**

| **Fire Weather** | | | | | |
|---|---|---|---|---|---|
| Temperature ($^{o}$C) | RH% | Windspeed/gust (kmh) | | | |
| 28 | 35 | 8 G 17 | | | |
| FFMC | DMC | DC | ISI | BUI | FWI |
| 76 | 70 | 488 | 1 | 103 | 5 |

These indices still produce a Head fire Intensity Class of 1 in mature jack or lodgepole pine (C3) – meaning burning is unlikely to spread much beyond its point of origin due to moist surface fuel conditions.

### *Fuels*

There was a light loading of dead and down fuels in this site, but with abundant small shrubs (Fig 7). Burning was confined to open areas beside the road. Areas farther into the forest tended to only burn where the drip torch fuel was applied, and generally in moss fuels. The surface was soft, not crunchy like conditions during the first underburn.

**Figure 7. Surface fuels.** **Figure 8. Tickle grass.**

Because the underburn did not achieve the desired results, we then tried burning grass on the south side (Fig 8) of the road. As with the underburn, this site also did not burn. The base of the 'tickle grass' was still damp from the rain the day before and the site was in the shade for the majority of the day. Tickle grass is very light grass with a 'fluffy' top. Thoughts were that it should burn easily, but this was not the case.

### *Fire Behaviour*

Fire behaviour was less intense than that exhibited in the first underburn. The rain was enough to reduce fire behaviour in the fine fuels. Figure 9 shows is an example of the fire behaviour that took place with the lower indices. Flame heights were reduced and limited to where surface fuel existed. Fire self-extinguished farther into the stand (away from the road) in the shadier conditions. Conditions led to results that were below the level required for an underburn to meet the objectives of removing all the surface fuels (Fig 9). The fire behaviour experienced replicates that shown in 'Fire Behaviour in Jack Pine Stands' poster produced by the CFS (1988). Plate 1 shows fire behaviour with an FWI of 9 and was referred to as a 'creeping surface fire'.

**Figure 9. Fire behaviour for Underburn #2.**

### *Fire Effects*

Only the open areas had fire that removed the surface fuel. The fire crawled around slowly seeking out areas with fuels and self-extinguished in areas where there was no fuel or in areas that were in the shade or moss. If the site was to be used as a firebreak, underburning would need to be re-applied during periods of higher hazard. Figure 10 shows an example of the patchiness of the burn.

**Figure 10. Patchy burn pattern from light surface burn.**

## Underburn #3

The third underburn took place on August 4th at 1540 hrs, one hour after Underburn #2, with hopes that the extra hour of drying would make the surface fuels more receptive to burning. Ignition took place using a drip torch and fire control operations were performed by a NWT fire crew (SS10). The plot was the same size as Underburn #2 and was 10 m wide by about 10 m long.

### *Fire Weather*

Table 3 shows the weather and FWI values for this underburn. There was 5.5 mm of rain overnight at the Survival Zone and 3.5 mm at the weather station at the parking area - both within 500m of the burn site. This lowered the hazard.

**Table 3. Weather and FWI for Underburn #3.**

| **Fire Weather** | | | | | |
|---|---|---|---|---|---|
| Temperature (°C) | RH (%) | Windspeed/gust (kmh) | | | |
| 29 | 29 | 8 G 14 | | | |
| FFMC | DMC | DC | ISI | BUI | FWI |
| 80 | 70 | 488 | 1 | 103 | 5 |

These indices produced a Head fire Intensity Class of 1 in mature jack or lodgepole pine (C3) – meaning burning is unlikely to spread much beyond its point of origin due to moist surface fuel conditions. The FFMC dropped by one point from the previous hour, but the relative humidity decreased by 6%.

### *Fuels*

Shrubs and a light surface loading of dead fuels were the predominant fuels in this site (Fig 11).

**Figure 11. Surface fuels for Underburn #3.**

### *Fire Behaviour*

Fire behaviour was a slightly more intense than the fire an hour earlier. The 6% drop in the relative humidity allowed more fine fuels to become involved in the burn in the more open, sunny areas along the road (Fig 12). The shaded areas still exhibited low intensity fire that again self-extinguished and only left a fire scar where the drip torch was applied (Fig 13).

**Figure 12. Low intensity fire behaviour.** **Figure 13. Burn scar from the drip torch.**

Flame lengths were slightly higher in this burn than the earlier one and more of the surface fuels were consumed. A number of trees were extinguished when flames started to climb the flaky bark, but not as aggressively as with Underburn #1.

### *Fire Effects*

The burn was better than the one an hour earlier resulting in more burn area. The area that did burn exhibited light surface burns (Fig 14). The fine fuels and grass burned along with smaller shrubs (if located near dead surface fuels).

**Figure 14. A very light surface burn. Only fine fuels, grass and small shrubs consumed.**

Larger fuels were not affected by the underburn. Conditions improved over the hour, but not to the point where larger fuels were impacted or total consumption of shrubs was achieved. The results of this underburn were at the lower end of the conditions required for an effective underburn.

## Underburn #4

This underburn was carried out in the same area as the previous burns and took place 2 days following 3.5 mm of rain on August 7th at 14:40hrs. The rain again acted to reduce the hazard and keep the underburn controllable. Underburn #1 showed us conditions that were too extreme to attempt underburning in and Underburn #2 showed us the conditions for this fuel type that were too low to have a successful burn. We are trying to narrow the range of conditions underburns can be done that remove the surface fuel and shrubs required to reduce fire spread. Although weather conditions were lower than the August 4th burns, the indices were higher hopefully leading to better burning conditions. Again, ignition took place using a drip torch and fire control operations were performed by a NWT fire crew (SS10).

### *Fire Weather*

It was a warm day that had the following weather and FWI values (Table 4). There was 3.5 mm of rain two days prior to the burn - within 500m of the burn site.

**Table 4. Weather and FWI for Underburn #4.**

| **Fire Weather** | | | | | |
|---|---|---|---|---|---|
| Temperature ($^{o}$C) | RH (%) | Windspeed/gust (kmh) | | | |
| 23.6 | 33 | 9 G 18 | | | |
| FFMC | DMC | DC | ISI | BUI | FWI |
| 86 | 71 | 507 | 4 | 105 | 17 |

The indices calculate a Head fire Intensity Class of 2 in mature jack or lodgepole pine (C3) - indicating fuels are receptive to sustained ignition and combustion from firebands, however fire is expected to be limited to a creeping or gentle surface burn. The FFMC and ISI were higher than on August 4th, so the fine fuels should burn more vigorously.

### *Fuels*

This underburning was done in a dense stand of pine with spruce understory and with abundant shrubs on the surface (Fig 15).

**Figure 15. Underburn #4 occurred in a dense stand of pine with a spruce understory. Surface fuels include grass and small shrubs.**

As with the other burns, shading was important in terms of fire behaviour as the back half of the stand was shaded and therefore retained moisture more effectively than the open areas along the road. There were small 'jackpots' of fuel on the surface where fire had the opportunity to increase intensity and help burn the shrubs.

### *Fire Behaviour*

In comparisons to other underburns, this burn was less intense than Underburn #1 and was easier to control; but it was more intense than both Underburns #2 and 3. Although the temperature was lower and the relative humidity was higher the FFMC and wind speeds were higher leading to a higher ISI. Notes made during the burn state that the 'wind gusts at the start of the burn helped to push the fire along'. This allowed the fire to seek out fuel and become established. The photo below shows four areas where the fire found fuel and gained intensity (Fig 16).

**Figure 16. Four areas burning where small amounts of fuel were on the surface.**

The fire did have a few flare-ups and attempted to climb the pine, but these flare-ups were short lived and easily controlled when climbing the flakey bark (Fig 17).

**Figure 17. A small flare-up and fire climbing the flakey bark.**

We compared our photos to the CFS fire behaviour poster. The fire behaviour for our burn relates closely to Plate 2 which had an FWI of 14 and described the fire behaviour as *a low vigour surface fire with flames generally less than 0.6 m high, but with brief flare-ups in patches of fine dead fuels*.

### *Fire Effects*

A greater percentage of area was burned than Underburns #2 and 3 with better consumption of surface fuels. These effects occurred along the road where conditions were drier than they were 10 m into the stand where there was more shade. Farther into the stand the fire effects were minimal and only the line where the fuel was dripped actually burned. It is believed if rain had not fallen two days prior to ignition better surface fuel consumption would have occurred in the shadier areas. In the open areas the fine fuels and those fuels up to 3 cm were consumed. Larger fuels were scorched, but not consumed (fig 18).

**Figure 18. Fuel consumption resulting from Underburn #4.**

## Summary

Four underburns were completed in August 2107 at the CBCFS research site in the NWT. These burns were completed over a range of weather and fuel moisture conditions. These burns were documented for fire behaviour and the resulting fire effects. Weather data along with hourly FWI values were collected for each burn which includes 'days since rain' and precipitation totals. Of the four burns, Burn #1 was over the threshold for ease of control and fire effects, burns #2 and #3 under-achieved and were below the threshold for percentage of area burned and overall fuel reduction. Burn #4 was completed at the lower range of acceptable results and was easier of control. Days since rain and the ISI were the key variables in a burns ability to achieve the desired results of blackening and consuming fine and medium surface fuels and small shrubs.

In Summary:

| Burn # | FFMC | Windspeed (kmh) | ISI | Flamelength (m) | HFI | Resources Required |
|---|---|---|---|---|---|---|
| 1 | 91 | 10 G 17 | 8 | >1.0 | 5 | Crew, charged hose, waterpacks |
| 2 | 76 | 8 G 16 | 1 | <0.2 | 1 | Crew, waterpacks |
| 3 | 80 | 7 G 13 | 1 | <0.2 | 1 | Crew, waterpacks |
| 4 | 86 | 9 G 18 | 4 | 0.5 | 2 | Crew, waterpacks |

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