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Differences in species flammability: identifying less-flammable vegetation

Contents

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Abstract

We tested six plant species or mixes at Vegreville, Alberta to determine their ignition and fire behaviour characteristics and whether they could be used along linear corridors to reduce the fire potential at strategic locations. Nine ignition trials over three years and one grass-fire burning into the test plots were completed to allow ranking of the species based on their characteristics. Three of the species were chosen for additional field studies: white clover, yarrow, and Plateau Rocky Mountain fescue.

Keywords:

Flammability, Ignition, White clover, *Trifolium repens*, Alsike clover, *Trivolium hybridum*, Yarrow, *Achillea millefolium*, Plateau Rocky Mountain fescue, *Festuca saximontana*, Vegetation, Fuel loads, Biomass, Curing.

Introduction

Planting less-flammable species along right-of-ways in Alberta to reduce the potential for fire ignition or spread is an idea that has garnered considerable attention in the local fire community. The use of such plants to reduce the effects of fire is not a new idea, since it has been tested in Australia, New Zealand, and the U.S., and research has been carried out in Ontario for Bell Canada and CP Rail.

Fires involving linear corridors in Alberta are seasonal in nature, and grass is the primary fuel that sustains these fires. Dry grasses are easily ignited and carry fire at high rates of spread while in a cured condition. Grass is typically in a cured state during the spring and fall, and because Alberta's spring season tends to be dry and windy, conditions are generally suitable for grass fires immediately following snowmelt. In the past 5 to 6 years, Alberta has experienced several large, challenging fires where linear disturbances exacerbated the problems encountered in trying to control these fires. This has resulted in increased interest in the linear corridor project being conducted by FPInnovations–Feric Division, and in the use of less-flammable vegetation to minimize the effects of fire in key areas. Currently, Alberta has more than one million kilometres of linear corridors, most of which are covered by grass, making fire a big concern in these areas.

We performed a literature search to identify plants native to Alberta that had the characteristics desirable for reducing fire behaviour (see following section), and held discussions with Alberta Research Council (ARC) personnel to learn from their experience. We then chose six species or species mixtures that appeared to be suitable for testing in field trials: Plateau Rocky Mountain fescue, alsike clover, white clover, yarrow, agronomix, and Rocky Mountain #4 mix. The agronomix (comprised of 40% boreal creeping red fescue, 20% buffalo brand Timothy, 20% AC Parkland Crested wheat, and 20% alsike clover - preinoculated) and Rocky Mountain #4 mix (comprised of 12% sloughgrass, 25% AEC "Hillcrest" awned wheat, 14% Fowl bluegrass Nutricoat, 27% Nortran tufted hairgrass, and 22% Fringed bromegrass Nutra) were obtained from ARC. We also tested a seventh species, fireweed, but because it failed to become established in the study plots, we did not include this species in any of the ignition tests. Although fireweed was the most expensive seed to test, it was the species that was rated highest by Hogenbirk (1996a), so it was disappointing that we could not test it. Study plots were established for each of the chosen species, and ignition testing and fire behaviour tests were performed at different times of the year.

This research took place in cooperation with ARC at its centre in Vegreville. ARC has the expertise and resources to establish, grow, and maintain the species in these plots. Test plots were established and planted in the spring of 2005, and ignition testing and fire behaviour tests began in the spring of 2006.

Characteristics of desirable species

Many species are adapted to fire, and these species tend to have similar physical characteristics. Past research (Hogenbirk 1996b) has revealed the most important traits:

- stem density
- stem radius
- surface area to volume ratio
- moisture content

When Hogenbirk evaluated the relationship between these characteristics and plant ignitability, moisture content was (surprisingly) rated the fourth-most important variable.

Hogenbirk compiled a list of characteristics of the ideal species for "greenstripping", which is defined as "the use of less-flammable plants to reduce fire hazard". These plants should:

- reduce the probability of ignition throughout the year
- reduce fire spread rates
- remain dominant on a site for 10+ years
- create no additional environmental or safety hazards

The plants should also:

- grow quickly in the spring
- maintain a high moisture content
- grow low to the ground
- produce small quantities of dead standing crop
- produce small amounts of litter
- have litter that decomposes quickly
- outcompete other plants
- re-establish dominance following a disturbance
- be cost-effective

Methodology

ARC established and planted seven species plots, each 4 x 4 m in size. (Fireweed was sown in the seventh plot, but failed to become established.) ARC also established a large block (100 x 70 m) sown with a brome grass mixture as the location for a grass fire to carry into the test plots. The six species were established within the middle of this large block in plots measuring 15 x 10 m. We established a 3-m break between plots using plowed soil to prevent fire from spreading between the plots. The large plot was sown in the fall of 2005 (Figure 1), and first visited in the spring of 2006 to observe the growth of the plants.

In each of the six species plots (4 x 4 m), we established nine 1 x 1 m subplots. These were used for ignition tests in the spring, summer, and fall of 2006, 2007, and 2008, with one plot burned in each season of each year. An additional small plot was retained for destructive sampling to determine the fuel load and degree of curing (i.e., the percentage of stems that were dead and dry).

Each ignition test involved lighting a set of bound matches and dropping the bundle into the plot. If the fire extinguished on its own before two minutes had passed, the vegetation was judged to be not flammable. If the fire continued burning, the vegetation was considered flammable. The fire was extinguished (if possible) at the two-minute mark, and the size of the burned area was measured. Weather data (temperature, relative humidity, and wind speed) were collected at the start of each ignition trial for each species or mixture.

Up to 10 ignition tests were conducted for each ignition trial unless the plot burned and insufficient fuel remained for continued testing. We defined the ignition probability as the proportion of the tests in which ignition occurred.

The fuel load and degree of curing were assessed prior to each ignition trial. To do so, we used 30 x 30 cm destructive samples, which were collected, bagged, and then oven-dried. Samples of the vegetation (Figure 2) were also collected and separated into green or dead material to calculate the degree of curing of the sample. We also visually estimated the overall degree of curing to compare this assessment with the results of the destructive samples.

The 100 x 70 m plot was established to test for burning under the predominant wind direction during the spring. The fire was ignited under a northwest wind and allowed to run through the brome grass up to the row of species planted in the middle of the plot.

During each ignition trial and for the larger fire, we collected the following data:

- degree of curing (% of stems that were dead by weight)
- fuel load (t/ha)
- ignition probability (based on the match test)
- fire behaviour (area burned)

The fuel load and degree of curing samples were collected by means of random sampling prior to the ignition of the fire. To do so, we used three samples for the brome grass and one for each of the tested species or mixtures.

Figure 1. Preparation of the soil of the large sample plot using a seeder.

Figure 2. Vegetation growth in the alsike clover plot in June 2006.

We collected weather data using a hand-held Kestrel 3000 weather meter immediately prior to ignition and from the Vegreville weather station at the time of the burn (hourly values). Daily weather data were also collected for the two weeks leading up to the large burn (May 1–13) at the Vegreville station. Monthly data were also collected from the Vegreville weather station.

Each species was ranked from 1 to 6 for each parameter, with the lower numbers representing traits such as no ignition, light fuel loads, etc. The scores were summed for each species or mixture (producing total scores from 4 to 24) for each category, and then the species or mixtures were ranked based on their total score. Note that this is a relative ranking system; scores were not based on specific values of each parameter, but rather on how the species or mixtures ranked within each category.

Results

We compiled the results of the three years of ignition tests, along with the visual data collected from the large burn. Ignition testing took place on the dates in Table 1. We waited at least two days after a rainfall

Table 1. Ignition testing dates from 2006 to 2008

	2006	2007	2008
Spring	May 15	May 10	May 6
Summer	August 10	August 16	July 28
Fall	October 5	October 2	October 15

Table 2. Mean values of fuel load and degree of curing at the time of the ignition tests

		Spring	Summer	Fall
Plateau Rocky Mountain fescue	Fuel load (t/ha)	3.4	5.1	6.6
	Degree of curing (%)	59.0	69.0	76.0
Agronomix	Fuel load (t/ha)	6.0	10.1	9.4
	Degree of curing (%)	85.6	52.3	66.0
Alsike clover	Fuel load (t/ha)	4.4	5.3	8.0
	Degree of curing (%)	87.3	28.7	70.0
Rocky Mountain #4 mix	Fuel load (t/ha)	5.8	6.9	9.3
	Degree of curing (%)	79.6	67.7	88.0
White clover	Fuel load (t/ha)	1.9	2.3	4.2
	Degree of curing (%)	96.7	20.3	57.0
Yarrow	Fuel load (t/ha)	n/a	2.0	4.6
	Degree of curing (%)	n/a	32.0	82.0

Table 3. Ignition probabilities for each vegetation type

	Ignition probability (%)		
	Spring	Summer	Fall
Plateau Rocky Mountain fescue	5	67	44
Agronomix	61	79	19
Alsike clover	38	44	17
Rocky Mountain #4 mix	83	67	78
White clover	0	0	0
Yarrow	Not tested	0	5

Table 4. Monthly weather data during the study period

	Mean daily temperature (°C) / precipitation (mm)		
	2006	2007	2008
April	6.3 / 14.2	3.2 / 53.4	0.5 / 34.4
May	11.2 / 55.5	10.3 / 28.6	10.7 / 37.2
June	15.5 / 28.0	14.7 / 52.6	14.9 / 43.6
July	18.3 / 55.2	19.5 / 55.6	16.5 / 47.4
August	15.7 / 39.2	13.8 / 66.8	16.1 / 69.0
September	11.7 / 94.8	9.3 / 28.2	10.3 / 37.0
October	1.7 / 34.8	4.9 / 8.2	4.8 / 9.2

to ensure low moisture content in the vegetation. The fire in the 100 x 70 m plot took place on May 14, 2007.

Table 2 shows the results of the destructive sampling (fuel load and degree of curing), and Table 3 shows the ignition probabilities for each vegetation type. Table 4 summarizes the mean weather conditions during the year.

Based on the results of the tests, we ranked the species from highest suitability to lowest suitability:

1. white clover
2. yarrow
3. alsike clover
4. Plateau Rocky Mountain fescue
5. agronomix
6. Rocky Mountain #4 mix

In the large block, we ignited a large fire and observed its progress. The fire crossed a 30-m approach through a brome grass mixture that simulated the grass typically within linear corridors. Figure 3 (page 6) shows the results of the burning test.

Figure 3. A photograph of part of the burning test in May 2007. The two plots in the foreground are the clovers.

The spring of 2007 was cool and wet, and the vegetation greened up quickly after a few warm days with the abundant moisture. The degree of curing was monitored after snowmelt in the hope that we could begin burning while the brome grass would carry the fire easily. However, because precipitation was so frequent, the number of acceptable burning days was low and the degree of curing was slightly lower than we would have preferred (93%). As a result of the cool, damp spring, the burn window was narrow and we did not observe extreme fire conditions.

We positioned in-fire cameras along the transition from the brome to the tested species in the plowed areas to capture fire behaviour as the fire moved from the brome grass into the vegetation plots.

Due to the winter and spring conditions experienced in Alberta in 2006/07, extreme fire behaviour did not occur, but the conditions produced moderate fire intensities approaching all plots (up to 960 kW/m fire intensity and a 5 m/min rate of spread). The clovers both performed well, stopping the fire abruptly. The yarrow also stopped the fire when it reached the plot except for one small intrusion. The Plateau Rocky Mountain fescue reduced fire behaviour to an intensity that could be easily controlled, and the agronomix reduced fire intensity and rate of spread by more than half. The Rocky Mountain #4 mix provided no resistance to the fire.

Discussion

Our initial selection of species met the criteria identified for reducing fire behaviour (Hogenbirk 1996a). The critical traits are that the plants should grow low to the ground (and thus produce a light fuel load) and that they should green up quickly (and thus have a high moisture content) in the spring—the critical fire period in Alberta (from snowmelt to greenup). In the remainder of this section, we describe how the top four species meet Hogenbirk's criteria.

White clover

The white clover became established quickly and grew to cover all of the small ignition plot. It was completely flattened following snowmelt each spring, and the small amount of biomass was generally in a cured condition (Table 2). Regardless of curing, there was no risk of ignition during the spring because the fuel was in such close contact with the ground. The white clover turned green very quickly after the snowmelt and grew to about 10 cm in height. This species had the highest degree of curing in the spring, but the lowest degree in the summer. Some grass encroachment occurred during the third season of testing, but ignition did not occur because the clover remained green and was the dominant vegetation in the plot. White clover was consistently the species with the lightest fuel load.

Plateau Rocky Mountain fescue

The Plateau Rocky Mountain fescue performed well in these trials, especially in the spring. It becomes established well, and grew to cover the entire plot. This species is a short grass that greens up very quickly in the spring and then cures in early summer. The summer curing is not a concern because the species performs well during the period of highest risk (the spring). This species never grew taller than 40 cm and had light fuel loads (a maximum of 5 t/ha). Ignition probabilities were low in the spring (5%) and peaked in the summer when the grass went to seed (in early July).

Yarrow

The yarrow took a season and a half to become established, but then grew to cover the entire plot. The yarrow reached a height of about 45 cm and had a long, narrow stem. The base is composed of green, fern-like leaves that do not ignite easily. A major advantage is that no animal species tend to eat it. Grasses and some weed species did encroach into the yarrow plot, but the green base of the yarrow plants tended to prevent ignition. Fuel loads were light to moderate, and averaged 3.3 t/ha.

Yarrow would be an excellent species to establish for a fire break along linear development corridors or around communities because of its ability to stop a ground fire. However, yarrow should be planted along with a grass such as Plateau Rocky Mountain fescue, which becomes established more quickly on a prepared seed bed and therefore provides good early erosion control. The yarrow would then become established over the next two years, and would enhance the vegetation's ability to stop or slow a ground fire.

Alsike clover

The alsike clover performed well, but had one important drawback: it is a relatively coarse fuel that produces heavier fuel loads. It also had a higher ignition probability than the Plateau Rocky Mountain fescue in the spring. It grew quickly and covered its plot completely, with minimal encroachment from other species. It greened up quickly in the spring, but there was abundant dead material remaining from the previous fall. This older material tended to ignite and carry the fire.

Biomass production

Overall, biomass peaked during the first year and levelled off in years 2 and 3. Fuel loads increased from spring through fall in the first two years, then remained relatively constant through year 3. Year 1 (2006) produced the highest biomass and overall fuel loads, both of which decreased during the next two years. This year also received the most spring and summer precipitation during the study period.

Further research

Based on the results of these tests, we selected three species for further field trials: white clover, Plateau Rocky Mountain fescue, and yarrow. In 2007, we sowed two mixtures of these species at Vegreville: one contained 30% white clover and 70% Plateau Rocky Mountain fescue, and another contained 30% yarrow and 79% Plateau Rocky Mountain fescue. We added the fescue to both mixtures because it becomes established quickly and we believe that the mixtures will effectively reduce fire behaviour. An additional site has been sown near the hamlet of Chisholm, Alberta to test these combinations in the field. Research results will be disseminated as they become available.

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