FIRE BEHAVIOR ASPECTS ASSOCIATED WITH LINEAR DISTURBANCES IN ALBERTA, CANADA

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ABSTRACT

Recently, a number of large spring fires have highlighted the fire-suppression problems created by linear disturbances in Alberta, Canada. Grass commonly colonizes these areas and, when in a cured condition, this fine fuel readily contributes to the ease of ignition, rapid rates of fire spread, and overnight fire growth. The Forest Engineering Research Institute of Canada's (FERIC) Wildfire Operations Research Group is investigating this issue by documenting seasonal variations in fuel loads and developing a simple method for readily estimating fuel loads, testing the effectiveness of fuel breaks composed of selected fire-resistant vegetation, examining the effects of mowing as a fuel modification technique, and assessing the effectiveness of firebreak widths in relation to burning conditions.

keywords: Alberta, Canadian Forest Fire Danger Rating System, firebreak, fire intensity, fire-resistant vegetation, fuel break, fuel load, fuel modification.

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INTRODUCTION

The increasing activity in the oil and gas industry in Alberta, Canada, has led to extensive development in the forests of central and northern Alberta. The most visual impact of these developments has been the creation of linear disturbances: powerline rights-of-way, pipelines, seismic lines, roads, and railroads, which range in width from 6 to 200 m. These man-made corridors cutting through the forested areas have made the task of fire suppression more difficult on a number of large wildfires that have occurred in Alberta during the last 10 y. When these disturbances are created, grass (commonly marsh reed or bluejoint [*Calamagrostis canadensis*] in central and northern Alberta) quickly invades the site, and this abundant fine fuel, when in a fully cured state, dries out very quickly after rain, greatly increasing the potential for explosive fire spread. The scope of the problem is sizeable in Alberta and continues to grow with the amount of resource exploration taking place and the resulting linear disturbances crisscrossing Alberta's forests.

When grass is in a cured condition such as in the spring (March–early June) and fall (September–October), or even in winter if no snow is present, it exhibits the following attributes with respect to wildland fire potential: 1) ignition is relatively easy, 2) rapid rates of fire spread are possible, and 3) the fuel beds are capable of carrying fire long distances overnight by "wicking" at a time when firefighting resources are typically reduced.

The fire hazard associated with linear disturbances is a priority for many of Forest Engineering Research Institute of Canada's (FERIC) members who have requested an investigation into techniques to mitigate the potential for large fire occurrence associated with these strips of land. Many values-at-risk within Alberta's forests are located on or in close proximity to linear disturbances, and these would obviously benefit from a reduction in current fire hazard levels.

FERIC's Wildland Fire Operations Research Group is investigating both fire behavior and techniques to reduce fire behavior potential along linear disturbances. This includes a fuel load survey, assessing the feasibility of establishing strips of fire-resistant vegetation, and examining the effectiveness of mowing in reducing potential fire behavior. Firebreak breaching in relation to the fire environment is also being studied.

FUEL LOAD ASSESSMENT

An accurate knowledge of existing fuel loads associated with linear disturbances could help managers make more reliable predictions of fire behavior, for both strategic planning and for near-real operational purposes. Currently a default or nominal value is used for fuel load in the grass fuel types of the Canadian Forest Fire Behavior Prediction (FBP) System (Forestry Canada Fire Danger Group 1992) to calculate fire intensity, which is in turn related to flame length (Byram 1959):

$$I = Hwr/600,$$

where I = fire intensity (kW/m), H = low heat of combustion (kJ/kg), w = available fuel consumed (t/ha), and r = rate of fire spread (m/min). The relevancy of this assumed value for fire behavior predictions in linear disturbance fuel types is presently un-

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Fig. 1. Using the grass disk meter to estimate grass fuel load near Whitecourt, Alberta, May 2005.

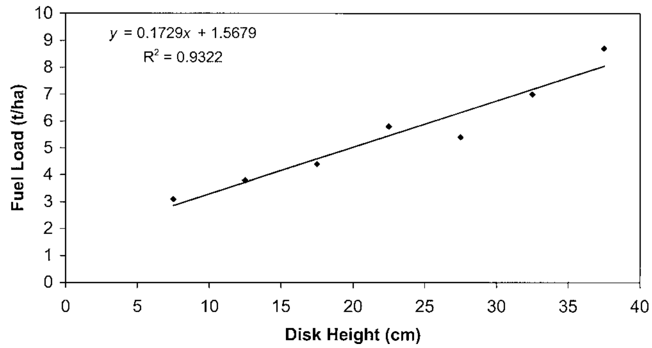

Fig. 2. Relationship between disk height and fuel load for both spring (March–early June) and fall (September–October) fuel load samples collected in Alberta in 2005.

known. Therefore, FERIC is quantifying the fuel loads in a study with three primary objectives: 1) create a database of fuel loads sampled along various linear disturbances in central and northern Alberta, 2) determine a mean fuel load for use in predicting fire behavior in grass fuel beds on linear disturbances in both the spring and the fall fire seasons, and 3) develop a simple field technique for readily estimating grass fuel loads.

During the summer of 2005, FERIC collected fuel load samples along linear disturbances in central and northern Alberta in conjunction with a ‘‘grass disk meter’’ sampling technique originally developed and calibrated in South Africa (Trollope and Potgieter 1986). This technique involves correlating the settling height of the round disk on the grass fuel bed (Figure 1), with the sampled fuel load compressed by the disk's weight (Figure 2). The samples were separated into 5-cm height classes, and mean weights were determined for each class per Trollope and Potgieter (1986).

A total of 64 grass fuel load samples were collected from pipelines, powerline rights-of-way, and seismic lines in May 2005. The locations were recorded and photographed, and resampled in September 2005. The separate fuel load values determined for spring and fall conditions will, in turn, be used to calculate fire intensities for use during going wildfire events or in simulations.

The mean fuel loads during the spring and fall collections were 3.5 t/ha (SD = 1.7) and 5.4 t/ha (SD = 3.5), respectively. In comparison, the Canadian FBP System grass fuel type models use a default value of 3.0 t/ha. This 0.5-t/ha fuel load difference in the spring corresponds to a slight increase (12%) in fire intensity but quite a significant increase (80%) in the fall because the fuel load was nearly double.

FUEL/VEGETATION TYPE CONVERSION

One fuel management technique practiced along linear disturbances involves the planting of less flammable vegetative cover to reduce potential fire ignition and spread. The use of such fire-resistant plants has been studied in Australia, New Zealand, the United States, and in Ontario, Canada, for Bell Canada and CP Rail (Hogenbirk 1996). Several large fires in Alberta in recent years have sparked interest in planting or seeding less flammable vegetation in strategic locations along linear disturbances to minimize the potential for fire spread and, in turn, large fire growth. The goal of this particular FERIC study is to determine if strips of selected vegetative species established along linear disturbances can significantly reduce fire ignition and spread potential.

Less flammable vegetation may have certain desirable characteristics, but the introduction of nonnative species to different locations of the province is a regulated process. The Alberta Department of Sustainable Resource Development has enforceable guidelines on the use of ‘‘introduced’’ species. Thus, any species chosen for testing must be native to the province.

Many fire-resistant plant species tend to have similar physical fuel characteristics. Hogenbirk (1996) found the following traits related to fire resistance, in order of importance: 1) stem density, 2) radius of stems, 3) surface-area-to-volume ratio, and 4) moisture content. These traits have been measured and their relationships to plant ignitability have been determined (Hogenbirk 1996). Surprisingly, moisture content was rated the fourth most important variable. Hogenbirk (1996) also compiled a list of characteristics of the ideal species for ‘‘greenstripping,’’ which is the use of less flammable plants to reduce fire hazard. These plants should 1) reduce the probability of ignition throughout the year, 2) reduce fire spread rates, 3) remain dominant on a site for at least 10 y, and 4) create no additional environmental or safety hazards.

The plants should also 1) grow quickly in the spring, 2) maintain a high moisture content, 3) be low growing, 4) produce small quantities of dead standing crop, 5) produce small amounts of litter, 6) decompose quickly as litter, 7) out-compete other plants, 8) rees-

Fig. 3. A plot established for ignition testing on the grounds of the Vegreville branch of the Alberta Research Council, June 2006. The plot shown contains white clover and is 4 × 4 m in area.

Fig. 4. Difference in fire behavior between fire in unmowed or natural grass (background) and mowed grass (foreground), Fort McMurray, Alberta, May 2005. Both areas were ignited at approximately the same time.

tablish dominance following disturbance, and 9) be cost-effective. It was considered to be most beneficial to find species that green quickly in the spring and are low growing. If green-up could occur even 10 d earlier than normal, the length of the spring fire season would correspondingly be greatly decreased.

A literature search and interviews with vegetation management specialists was accordingly undertaken to identify plants native to Alberta meeting the above criteria. Six species were selected for testing: white clover (*Trifolium repens*), alsike clover (*Trifolium hybridum*), yarrow (*Achillea millefolium*), fireweed (*Epilobium angustifolium*), crested wheatgrass (*Agropyron cristatum*), and sheep fescue (*Festuca ovina*).

FERIC is cooperating with a unit of the Alberta Research Council (ARC) located in Vegreville, Alberta, in this study. Test plots were established and planted on ARC experimental grounds in the spring of 2005 (Figure 3). Plans call for ignition trials and fire behavior studies in the spring and fall of 2006 (if sufficient vegetative growth occurs over the intervening period). Six small plots (4.0 × 4.0 m) will be used for ignition trials, with 1.0 × 1.0-m subplots ignited during the spring, summer, and fall. One large plot (100 × 100 m) will be used for testing resistance of the vegetative cover to high-intensity flame front. In the latter case, a ''line of fire'' will be ignited in standing, cured grass and allowed to run up to a 40-m-wide ''barrier'' consisting of the six species selected for testing. This effectiveness of this fuel break will be observed and documented (e.g., penetration depth). Based on these field tests, the most successful species may then be examined for their operational suitability on existing linear disturbances.

FUEL MODIFICATION

The mowing of grass along linear disturbances is a common fuel modification technique used to reduce both the grass fire hazard and the development of larger fuels (e.g., woody shrubs and tree reproduction), but little research has been done to validate its effectiveness. The objective of this aspect of the FERIC project on linear disturbances is to determine how mowing influences fire behavior in treated areas in comparison to untreated or modified areas. To document this, experimental fires were carried out during the 2004 and 2005 fire seasons near the communities of Fort McMurray in northeastern Alberta and Slave Lake in central Alberta.

The experimental fires involved simultaneous ''line fire'' ignitions in treated (i.e., mowed) and untreated (i.e., natural grass) plots (Figure 4). Each plot measured 50 × 50 m in area. Fire behavior characteristics (i.e., forward spread and flame length) were observed and recorded during the fires. Six pairs of experimental fires have been completed to date, involving four spring comparisons and two fall comparisons. Six more plot comparisons are planned.

In the spring of 2004, the average rate of spread (ROS) in recently mowed plots was approximately 15% less than that attained in the natural or unmowed grass; this also held true during wind gusts. For spring burning in 2005, the plots near Fort McMurray were mowed during the previous fall and allowed to settle over the winter. This resulted in lighter fuel loads, a quicker green-up and, in turn, a substantial reduction in fire spread compared to the previous spring's results, as the average ROS in the mowed plots was only about 20% of that obtained in the unmowed or natural grass plots. All clippings were left in place following mowing.

The experimental fires carried out to date may very well illustrate the differences in fire behavior resulting from the timing of the mowing treatments. Although only two trials involving fall comparisons have been completed, a significant difference was observed in fire behavior in the mowed and natural grass plots compared to the fire behavior observed in the mowed plots during the spring of 2004 at the same sites. This raises the issue of the timing of the treatment and/or repeated burns. More comparison trials are planned in

2006 involving both fall and spring mowing in order to better understand the implications of treatment timing on fire behavior. It is thought that fall precipitation acts to speed the decomposition process, and thus lighter fuel load, and that the winter snowpack compresses the remaining fuel, thereby reducing the fire spread and intensity potential. Fuel loads in the plots that had been mowed in the fall were half those of spring mowing, which would result in a 50% reduction in fire intensity.

Observed flame lengths on the natural grass plots were almost 3 times greater than in the mowed plots (Figure 4). This is a critical bit of knowledge, as flame length is one of the major determinants of the likelihood of successful containment by suppression forces (Byram 1959).

FIREBREAK BREACHING

Because spotting in grass fires in Alberta is not common, firebreaks are typically able to reduce or halt fire spread. In addition to investigating the use of less flammable plant species as fuel breaks, FERIC is also examining the optimum width for firebreaks in Alberta's fire environments.

As part of this study, FERIC is attempting to determine the minimum firebreak width required to control the development of grass fires in Alberta during its spring and fall fire seasons. Toward this end, FERIC is analyzing historic fire weather databases and has developed a software package for gauging the effectiveness of firebreaks in stopping grassland fires based on coupling existing models for firebreak breaching developed by Wilson (1988) with the two major modules or subsystems of the Canadian Forest Fire Danger Rating System (CFFDRS)—i.e., the Fire Weather Index System (Van Wagner 1987) and the FBP System. The rate of fire spread output from the FBP System is being combined with the results from the grass fuel load survey carried in central and northern Alberta in order to estimate fire intensities. Wilson's (1988) models output the probability of firebreak breaching based on fire intensity and firebreak width.

Once the optimum width of an effective firebreak or fuel break has been approximated, the next step will be to apply this knowledge at the landscape level. As it would be impossible both physically and economically to treat all linear disturbances in the province, any treatments applied must be strategically placed in order to be both cost-effective and efficient.

PROMETHEUS, an existing landscape-level fire behavior and growth model based on the CFFDRS (Tymstra 2002), permits the user to alter fuel types and insert firebreaks or barriers to fire spread of varying widths, and then to undertake simulated fire runs over the landscape. This will allow determination of the best alignment of firebreaks and fuel breaks in order to minimize problematic fire behavior associated with linear disturbances.

CONCLUSION

A wide variety of industrial and other forest users in northern and central Alberta stand to benefit from strategies that reduce problematic fire behavior associated with linear disturbances and, in turn, contribute to containing wildfires to the smallest size possible. FERIC is currently undertaking research into four facets of fire behavior associated with linear disturbances, with a view to reducing the potential for adversely impacting the task of controlling wildfires. As more definitive results become available, the findings will be published in FERIC Advantage Reports and made available for downloading on the Internet (http://fire.feric.ca/36202003/36202003.asp).

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