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Canadian Forest Service – Great Lakes Forestry Centre

A lightning fire prediction system

INTRODUCTION

In Canada an average of 8,000 forest fires occur each year and the area burned ranges from 0.7 to 7.6 million hectares/year. Average suppression costs are $500 million to $1 billion annually. While just under 50% of fires occur from lightning, they lead to 85% of the area burned. This is largely due to the number of lightning fires that occur in remote locations. Although some of these fires are left to burn to allow natural renewal of the forest, those that require suppression may be difficult to control due to delays in their detection and the arrival of fire fighting resources, allowing the fires to grow and reach higher intensities. Lightning fires also tend to occur in clusters, with as many as 50 to 100 or more igniting in a single day in some provinces, which can strain initial attack systems. With the warming of the atmosphere expected with climate change, an increase in lightning activity can be expected and that coupled with potentially increased receptivity of fuels to ignition means that lightning fires will increasingly influence the landscape and forest fire management activities.

While fire suppression is a provincial or territorial responsibility, the Canadian Forest Service (CFS) has developed effective tools that allow provincial fire agencies to better plan for fire and enhance protection of areas of concern. One such tool is the Canadian Forest Fire Danger Rating System (CFFDRS), the result of a Canadian research program that began in the late 1920s, and which is currently used operationally throughout Canada and in a growing number of countries around the world. It helps fire management agencies by providing outputs that assist them in estimating when and where fires are expected to occur each day. The system takes into account factors such as weather, fuel and topography to estimate ease of ignition and difficulty of control and is used as a guide in a wide variety of fire management activities. CFS scientists continually work to improve the system and recently have enhanced it to more accurately predict lightning-caused fire probability.

GREAT LAKES FORESTRY CENTRE (GLFC) RESEARCH

GLFC fire researcher Mike Wotton and colleagues have developed models to predict the probability of fires igniting from lightning strikes as well as their likelihood of detection. The primary concern to an agency is when a fire actually needs to be suppressed, rather than when it was ignited. A fire may be detected on the day of the lightning storm, many days later, or in rare cases even weeks afterwards, depending on the weather conditions at the site of the strike.

Currently, most fire management agencies use the Canadian Forest Fire Weather Index System's Duff Moisture Code (a measurement of moisture in the upper layers of the forest floor), along with maps of lightning to determine where to expect lightning ignitions to be holding over (continuing to burn) on the landscape. The Duff Moisture Code is a good indicator of lightning fire ignition potential, but there are other factors known to influence ignition probability. These include fuel type, dryness in other layers of the forest floor and polarity of the lightning strike: positive cloud-to-ground lightning strikes tend to have long continuous currents and are of greater concern because they are more likely to start fires.

The new models take into account a number of factors that influence the probability of fire ignition and arrival. A new organic layer moisture model was developed as part of this work to better understand the conditions in the fuel layers at the base of trees where lightning tends to ignite holdover fires. The holdover ignition and arrival models integrate a number of spatially varying factors, such as fuel type, fire management zone and ecoregion as well as various weather-based factors. In Ontario for example, an individual model for each ecoregion was required, as the varying forest type in each region largely influenced fire behaviour. The models are integrated into an operational system that links to the real-time lightning, current weather observations and weather forecasts in the Ontario Ministry of Natural Resources' information system. Holdover ignitions from lightning are tracked for up to 21 days, if they last that long, until they arrive as detectable fires in the system.

The system produces two maps, one of where lightning fires are expected to be holding over, and one of where, on a particular day, those holdover fires are expected to be detected (Image 1). These predictions provide an estimate of the expected number of problem fires in a given area, which helps guide decisions in resource allocation. This is the only such model currently being used operationally in fire management in Canada.

The system continues to be refined through field testing for Ontario, Saskatchewan and Quebec to improve predictions of ignitions. Researchers are working with these provinces to build the linkages in their operational fire management information systems to generate maps of expected fire occurrences for these areas.

Potential uses of the model

The new models are useful in a number of ways. In addition to predicting the expected daily lightning fire occurrence, they can produce maps that show which areas are receptive to ignition for that day, or for longer time frames if forecasted weather data is input into the model. By combining information from a number of areas, a prediction of the number of fires arriving in a region on a particular day, or an index of likelihood of fire arrivals across the province can be created. These predictions guide managers in the development of estimates of fire occurrence, which aids in detection, planning and positioning of both human resources and equipment.

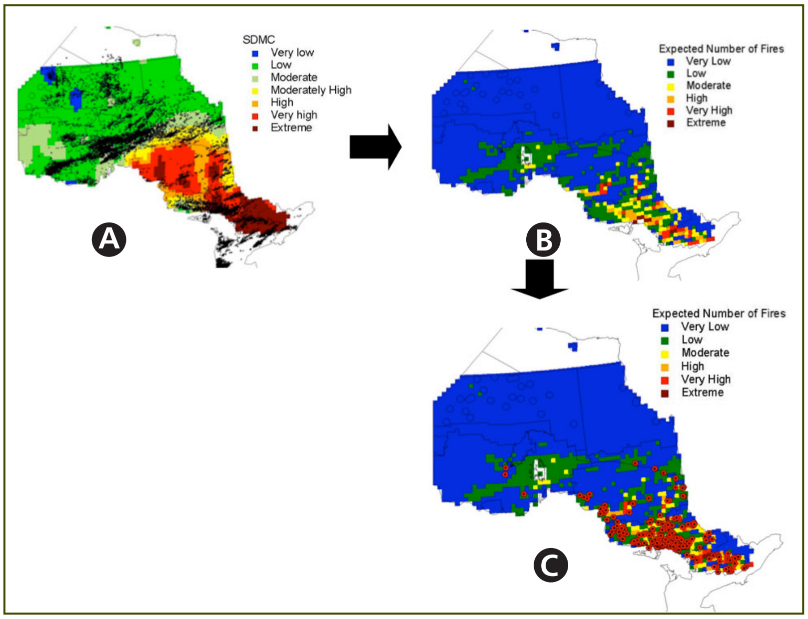

Image 1. Output from the model for a day with significant lightning activity throughout the province. A) Lightning strike locations on a map of sheltered Duff Moisture Code (SDMC) and indicator of the moisture content in the organic layer; B) A map of expected locations of hold over fires in Ontario after the current lightning storm; C) red symbols are actual lightning fire ignitions that occurred on this day.

Future work

Some work being considered for the future includes an attempt to include variables that characterize just how hard it is to detect a fire ignition as well as how hard a fire agency is looking for fires in the first place. An example of the former would be a hazy day where detection probability would be lowered because a small smoke column might be difficult to see. An example of the latter would be an increase in detection probability if a fire agency already has a number of aircraft and fire personnel in an area suppressing recently arrived fires. Researchers also want to develop a variable that accounts for storm size and location of lightning with respect to the storm centre. In addition, they plan to develop a method to update fire risk forecasts in areas based on the predictions from several days prior.

CONCLUSION

Forest fires for which suppression expenditures are significant will continue to be a major concern to resource managers. Models such as those used in the CFFDRS are a useful tool in predicting where new fires will occur, allowing fire management agencies to position their fire fighting equipment and personnel accordingly. By testing these models during the fire season, and with feedback from field staff, refinements to the model can be made to improve their utility. Realistic fire occurrence prediction models such as these could also be useful in wildfire risk analysis and longer term strategic analyses, such as examining changing patterns of lightning fire activity due to global warming.

PRINCIPAL COLLABORATORS

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SUGGESTED READING

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