Natural Resources Canada | Ressources naturelles Canada

Bulletin 62

FRONTLINE EXPRESS

Canadian Forest Service – Great Lakes Forestry Centre

CANFIRE Model

INTRODUCTION

Forest fires are a critical element of healthy forest ecosystems across Canada. An average of 8,000 forest fires occur each year, while the area burned ranges from 0.7 to 7.6 million ha/year. In boreal forests in particular, fire plays an essential role in renewal, however these fires are frequently large, with rapid rates of spread and high fuel consumption. Canadian Forest Service (CFS) fire scientists recently developed the CanFIRE model, which is a useful tool in improving our understanding of forest fire behaviour, the impact of fires on the landscape and their contribution to Canada's carbon emissions. This information is essential for international reporting under the United Nations Framework Convention on Climate Change. In addition, the model is useful for predicting how fire patterns will change in the future, with a warming climate. Currently, average annual suppression costs range from $500 million to $1 billion, but this cost is expected to rise with predicted increasing fire activity and subsequent threats to values at risk.

GREAT LAKES FORESTRY CENTRE (GLFC) RESEARCH

CFS fire scientists have been studying forest fire behaviour and its ecological effects for many decades. They have developed numerous tools, such as the Canadian Forest Fire Danger Rating System (CFFDRS), used by all provinces and territories to plan and manage their forest fire operations. The CanFIRE model will serve to enhance the CFFDRS by allowing rapid estimates of expected wildfire behaviour and impacts. It can also be used to calculate potential scenarios for prescribed burns.

Development and use of the model

There are web-based and PC-based versions of the CanFIRE model that can be used to calculate fire behaviour and fire effects at the stand level. The model can be applied at a landscape scale by aggregating stand-level data. It was originally developed as the Boreal Fire Effects Model (BORFIRE), to study the effects of future altered fire regimes and provide estimates of forest carbon storage and carbon emissions under climate change. The current model provides practitioners with estimates of the immediate physical effects of fire on stands by calculating expected fire behaviour and the resulting ecological effects by simulating regeneration and postfire succession. CanFIRE currently simulates fuel conditions for six major boreal tree species: jack pine, black spruce, white spruce, aspen, balsam fir and white birch, as well as for grass and slash fuel types. Forest stands can be represented as pure or mixed stands in any combination and proportion of species. The model has been adjusted for research applications in other non-boreal forests of North America, and for boreal forests of northern Eurasia. Additional species and fuel types are being developed.

Model Inputs

Inputs to the model are based on the Canadian Forest Fire Weather Index (FWI) System and fuel data. FWI parameters include the Drought Code (DC) and the Fine Fuel Moisture Code (FFMC), the Buildup Index (BUI), and the Initial Spread Index (ISI). The DC is a numeric rating of the average moisture content of deep, compact organic layers, while the FFMC represents the moisture content of litter and other cured fine fuels and is an indicator of its ease of ignition and flammability. The BUI is a numeric rating of the total amount of fuel available for combustion, and the ISI is an indicator of rate of

fire spread. Other inputs include tree species, stand density, stand age, and surface fuel load. For wildfires, tree fuel load values (kg/m^2) are estimated from forest inventory data, while estimates of forest floor and dead woody debris fuel data can be taken from existing field surveys or models. In the case of prescribed burns, fuel load values can be obtained from direct measurements. Fire rate of spread is calculated using the Canadian Forest Fire Behavior Prediction (FBP) System equations and related procedures, which take into account factors such as foliar moisture content and season of burn.

Model Outputs

Once all the values have been input into the model, estimates of fuel consumption, emissions, fire behaviour and future stand composition can be calculated. Fuel consumption is further divided into consumption of forest floor layers and of tree crowns, by species and whether the fire is flaming or smouldering. Estimates of emissions (expressed in tonnes/ha) of carbon, particulate matter and other gases are calculated. A fire behaviour summary also provides information on rate of spread, depth of burn, scorch height and head fire intensity. Future stand composition is predicted in terms of number of stems per hectare by species and size.

The predictions of carbon emissions from the CanFIRE model are combined with the Carbon Budget Model of the Canadian Forest Sector and the Canadian Wildland Fire Information System to estimate annual direct carbon emissions from Canadian wildland fires for international reporting under the United Nations Framework Convention on Climate Change. All three models work together under an overall framework structure called FireMARS to provide annual summaries of Canada's wildland fire carbon emission estimates via the National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS).

Predicted fire scenarios

Future fire regimes under climate change are expected to have increased fire intensity, fire severity (depth of burn) and fire season length. The annual area burned is also expected to increase. These increases will cause a shift in forest composition because of the differences in species' ability to regenerate after fire. Shorter fire cycles will promote fast resprouting species such as aspen and birch, which would in turn increase carbon sequestration rates because of the faster growth rate of these species. However, this will not compensate for the greater carbon loss due to increased fire on the landscape. Changes in forest composition, or fuel types, will also have a feedback effect on fire regime. This will cause changes in forest flammability and fuel load, which affect fire occurrence rate and fire intensity. The net influence of these effects on fire regime dynamics is still under study. Model simulations also indicate that some negative fire impacts under future climate change can be mitigated through increased fire suppression and use of prescribed fire to protect values at risk.

Future work

Additional fuel types and species are being developed for wider application of the model in other Canadian and circumboreal forests. The PC-based version of CanFIRE is near completion and will include ecological effects, such as tree mortality, post-fire regeneration and annual estimates of stand growth by species, including stand density, stand height and tree size.

CONCLUSION

The CanFIRE model is a fire behaviour-based tool for predicting the physical and ecological effects of forest fires. It can be used to predict fire behaviour on wildfires and prescribed fires, and the resulting postfire succession of the regenerating stand. These predictions of future forest composition will be helpful for long term forest management planning. The model also makes an important contribution to estimates of carbon emissions from forest fires, an essential component of Canada's international reporting obligations. By considering future fire scenarios simulated by CanFIRE, forest and resource mangers and policy makers will be better able to plan and prepare for shifting fire regimes under future climate change.

CONTACT INFORMATION

Bill de Groot
Great Lakes Forestry Centre
1219 Queen Street East
Sault Ste. Marie, Ontario, Canada
P6A 2E5
Phone: 705-949-9461
Fax: 705-541-5700
http://cfs.nrcan.gc.ca/centres/read/glfc
E-mail: GLFCWeb@nrcan.gc.ca

CanFIRE
CANADIAN FIRE EFFECTS MODEL

ISSN 1496-7847