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Assessing the impact of a forest fire on timber production

Highlights

- Fire plays an important role in boreal forest ecosystems.
- Fire has economic impacts on forests that are managed for timber harvesting.
- Landscape-level analysis that considers both spatial and temporal scales should be used when assessing the economic impacts of fire on managed forests.
- Fire economic impact assessment must take into consideration forest policies and regulations governing the managed forest in question.

Fire plays a very important role in many natural forest ecosystem processes, particularly throughout the boreal forest region of Canada where it has significant social, economic, and ecological impacts. Whether the net impact of a fire is beneficial or detrimental depends upon the land management objectives, policies and regulations that guide the management of the larger forest landscape on which the fire occurred. This research note illustrates how to assess the economic impact on timber values, of a fire that has burned part of a landscape used for timber production.

Forests are studied and managed from a variety of perspectives. Stand management focuses on individual stands that are managed independently. Landscape management considers how disturbances affecting one stand have impacts on all the other stands on the landscape within a designated forest management unit (FMU). Classical forest rotation models (such as the Faustmann model) are stand-level models. They can be used to determine how often a stand should be harvested and regenerated to maximize the economic return from that parcel of land. Strategic forest or “estate” planning models, which are sometimes referred to as timber harvest scheduling or annual allowable cut (AAC) models, are often used to help develop and evaluate



Photo courtesy of M. Miller, Ontario Ministry of Natural Resources.



strategies for managing FMUs that can exceed several hundreds of thousands of hectares in size. This research note focuses on the economic impact of a fire that has burned a portion of some larger FMU.

Assessing the impact of a fire

One method to estimate the economic impact of a fire is to consider the value of the forest products that could have been produced from the merchantable volume that burned. This method almost always produces very inflated estimates of the economic cost of a fire. Some people estimate the cost of fires that burn Crown timber by multiplying the volume burned by the stumpage fees that would have been paid to the government had the fire not occurred. In almost all circumstances, this approach also inflates the true cost of a fire. The true cost of a fire is simply the value of the entire “forest” before the fire less the value of that “forest” after the fire.

A simple hypothetical forest

In this research note I demonstrate how to estimate the economic impact of a fire that has burned 10,000 hectares in a simple hypothetical 100,000 ha 32 year old jack pine forest that is being managed to produce industrial fibre that is sold at a price of \$50/m³. I assume the merchantable volume of all the stands grow according to Plonski’s yield table for site class II jack pine in Ontario. I also assume the discount rate is 3% but ignore transportation, harvesting, regeneration and other costs as well as the possibility of salvage harvesting the burned area. (These important factors could readily be included in the assessment of the cost of a real fire in a real forest using the methods I apply to this very simple case.) I also assume the fire regime can be characterized by a single number, the average annual burn fraction of the forest that burns each year (ABF) which I assume is 1.5 %.

A landscape level assessment of the economic impact of a 10,000 ha fire

Most forest land used for industrial purposes in Canada is managed at the FMU or landscape level. Stands within such FMUs are seldom if ever managed independently. Many factors create dependencies between stands. The simplest dependencies are harvest flow constraints which limit increases and decreases in harvest volume. These are determined by mill capacities and other factors such as the need to satisfy forest species and age class cover type constraints designed to address wildlife habitat concerns. Because of the large area under management, firms may substitute different stands for those affected by disturbances such as fire.

The economic impact of a 10,000 ha fire in 100,000 ha forest is the *value of the forest before the burn less the value of the forest after the burn*. Both the burned and unburned forests must be evaluated *with respect to the land management objectives, policies and regulations that govern their management*. To carry out such an evaluation one must know:

- what plans were governing the management of the forest before the burn;
- the expected economic value of the forest given those plans;
- the revised plans that will govern the management of the forest after the burn; and,
- the corresponding expected value of the forest given the revised plans.

Forest managers use many different approaches to develop strategic forest management plans. When they manage flammable forests where significant fire losses are expected, they should use models that account for the possibility of fire losses. The most common method to account for fire losses when developing alternative strategies for managing flammable forest landscapes is to use Reed and Errico’s (1986) aspatial harvest scheduling model. This model, referred to here as model III, develops optimal aspatial timber harvest schedules (and corresponding AACs) given the current age class structure of the forest, the average annual burn fraction, and any policies, procedures or constraints that govern forest management.

The economic impact of fire: stand vs. landscape level

I formulated and solved a very simple model III of my hypothetical forest assuming it is managed over a 240 year planning horizon which is partitioned into 24 ten-year periods. The volume harvested was constrained to be constant and the gross merchantable volume (GMV), growing in the forest at the end of the planning horizon, was constrained to equal the GMV growing in the forest at the start of period 1.

A fire has a very simple impact on a forest – it changes its age class structure. The economic impact of a fire (or its impact on the AAC) is the difference between the expected value of the forest before and after the burn. The expected value of the forest before the burn is obtained by running model III with the age class structure observed before the fire. The expected value of the forest after the burn is obtained by running the model again with the revised age class structure created by the 10,000 ha burn.

Note that the product of the gross merchantable volume growing in a 32 year old stand ($67.7 \text{ m}^3/\text{ha}$) and the mill gate price ($\$50/\text{m}^3$) would be $\$3,385/\text{ha}$ so the apparent cost of a 10,000 ha fire would be $\$33.85$ million. However, the expected value of the forest before it was burned was $\$149,671,949$ and its value after 10,000 ha had been burned was $\$149,648,715$. The cost of the 10,000 ha fire is therefore only $\$23,234$. Why do these figures differ by such an enormous amount?



Photo courtesy of B. Stocks, Canadian Forest Service.

Why do the stand and forest level fire costs differ so much?

The dramatic difference between the apparent value of the timber that was burned (the burn or stand level impact) and the much smaller forest level economic impact of the fire may be surprising. The pre-burn plan called for 10,643 ha of the forest to be harvested during period 1 (in year 5, the middle of the 10 year period) to produce $889,040 \text{ m}^3$ during that period. If those 10,643 ha included the burn and harvesting of all but 643 ha been suspended for that period as a result of the fire, the burn level impact would be a good measure of the economic loss resulting from the fire that would be incurred during that year.



Fortunately, the FMU is managed from much larger spatial (100,000 ha) and temporal (240 year planning horizon) scales and the fire impact should be assessed within this perspective. Since 90,000 ha of the forest would not have been burned, it would be very easy to find a large volume on the unburned area. Meanwhile the 10,000 ha burn would regenerate until it can be harvested sometime in the future. The harvest flow would decrease to some extent as a result of the fire. However, the ability to spread the loss over the entire 100,000 ha forest and the full 240 year planning horizon would mitigate the loss significantly.

Some readers might suggest the harvest flow and terminal volume constraints be removed because doing so would both increase the value of the forest and the loss that results from the fire. However, social (e.g., availability of workers), ecological (e.g., cut block size) and economic (e.g., mill capacities) constraints impact the management of large FMUs. The objective of this research note is not to argue in favour of more or less stringent constraints on harvest flow. Instead, we stress that whatever constrains forest management, it is essential that *the economic impact of a fire that burns a portion of an FMU be assessed with respect to the FMU and the policies and regulations that govern the forest before and after the fire.*

Using forest level assessments to inform fire management strategies

Suppose two fires escaped initial attack in an FMU and the weather forecast is such that one is expected to burn to 15,000 ha and the other to 20,000 ha if not controlled sometime the next morning. The fire manager has requested out-of-region assistance to deal with the fires but has to make do with available resources to fight the fires until they arrive. The predicted behaviour of the two fires is such that the available resources cannot be divided and allocated to both fires as they will be ineffective and both will escape to burn a combined area of 35,000 ha. The fire manager must decide to allocate currently available fire suppression resources to one of these two fires. This assumes, for the sake of simplicity, that timber is the only value at risk in this hypothetical situation. However, timber is but one of many values (e.g., public safety, property and ecological services) that drive fire management programs.

The projected final fire sizes could be incorporated in a GIS coverage map of the FMU. This could in turn be linked to the forest manager's version of model III which could be run to estimate the cost of each fire. Assuming all other factors are equal, the limited suppression resources could be allocated to the potentially most costly fire. Given modern computer technology, fire and forest managers can work closely together in "real time" when confronted with such problems.

Further reading

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Management Implications

- The impact of a fire that has burned a portion of a larger landscape should be assessed from the forest management unit or landscape perspective.
- The cost of a fire will depend on a variety of factors, including: the policies and regulations that govern the management of the forest; the current age class structure of the forest; the prevailing fire regime; and, where the fire is located with respect to the mill, roads and other infrastructure.
- Fire impact assessments can and should inform large fire management decision-making.



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The views, conclusions and recommendations contained in this publication are those of the authors and should not be construed as endorsement by the Sustainable Forest Management Network.

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