Masters Dissertation Plan

Craig Robert Shenton

Project Background

The boreal forest of Canada are one of the world's largest stores of carbon, provide a vast array of ecosystem services, and are home to valuable biological diversity. The forest have also played a prominent role in Canada's social and economic development (Drushka, 2003). It is therefore, no wonder that public fire management agencies expend great deal of effort and resources fighting the seasonal wildfires that threaten this valuable resource (Martell 2001). In the fire management literature, it has long been assumed that these fire suppression efforts are effective (Cumming 2005:772). However, in recent years, fire ecologists have begun to question the received wisdom (Miyanishi *et al.* 2002).

The case for effective fire suppression rests on a number of retrospective comparisons between forest regions in Ontario, Canada (Stocks 1991, Ward and Tithecott 1993; Martell 1994; Ward *et al.* 2001). These studies compared the size distributions of forest fires in areas with and without aggressive fire suppression policies, in order to measure the effectiveness of fire suppression at reducing the annual area of forest burned (Cumming 2005:772-773). The results revealed a highly right-skewed distribution in areas with aggressive fire suppression and a relatively flat distribution in areas without such policies. The authors concluded that fire suppression had been successful at reducing the annual area burned over recent decades (Bridge *et al.* 2005:43).

However, Miyanishi *et al.* (2002; also see Johnson *et al.* 2001; Miyanishi and Johnson 2001) argue that these studies failed to control for various spatial and temporal factors, (e.g. the underlying fire-size distributions, the fire-detection efficiency and the probability that small fires are recorded), which have been shown to distort the results of similar studies, and on that basis should be considered unsound.

While both parties agree that fire suppression is primarily intended to reduce the annual area of forest burned, neither have been able to established a workable definition of fire suppression 'effectiveness' (Cumming 2005:781). Cumming (2005:773) has argued that a definition of 'effectiveness' only requires that annual burn rates with aggressive fire suppression be lower than they would have been without it.

Research Design

A quasi-experimental method will be developed that is capable of accurately measuring the effectiveness of forest fire suppression, while also accounting for the spatial and temporal factors outlined by Miyanishi *et al.* (2002). This method will involve comparing the distribution of 'large' (i.e., greater than 200 hectares) fires between two areas with contrasting forest fire suppression management strategies. The two study areas, denoted as the Intensive Strategy (S_i) zone and the Measured Strategy (S_m) zone, will be selected to control for the spatial and temporal factors outlined above, and largely correspond with the so-called 'Intensive' and 'Measured' zones, as defined my the Ontario Ministry of Natural Resources (1997).

The only difference between these zones is that all fires in the intensive zone are aggressively attacked until extinguished, where as in the measured zone, fires that grow greater than 3 hectares (which are said to have 'escaped') are assessed on a cost benefit analysis as to whether continued action should take place (Hirsch *et al.* 1998).

As such, it can be said that the amount of fire suppression effort being employed in the intensive zone is greater than that being employed in the measured zone. With this distinction, it will be possible to use statistical methods to calculate whether the annual proportion of large fires is dependent on the fire suppression strategy being employed. If fire managers are correct and fire suppression is effective, the annual proportion of large fires would be expected to be lower in the intensive zone than the measured zone. However, if the opposite is found to be true, the effectiveness of fire suppression will be in doubt.

Hypotheses

$H_0 \Leftarrow$ Null hypothesis: that the annual proportion of large fires is independent of the amount of fire suppression effort being employed.

$H_S \Leftarrow$ Strategy hypothesis: that the annual proportion of large fires is dependent on the fire suppression strategy being employed∗.

∗ With the annual proportion of large fires expected to be lower in the Intensive Strategy (S_i) zone than the Measured Strategy (S_m) zone, if fire suppression is effective.

Materials and Sources

The analysis will use annual fire statistics over the period 1960-2009, derived from provincial fire management records in the Ontario Ministry of Natural Resources (OMNR) fire database. This database is an archive of all fires detected and reported to the provincial aviation and forest fire management centre. Each fire report includes many variables such as: location, size, forest type, weather, and fire suppression information. The R system for statistical computation (R Development Core Team 2004), Sweave (Leisch 2002) and the R-Studio Integrated Development Environment (R-Studio Development Team 2011) will be used to perform the analysis.

Statistical Methods

From provincial fire management records in the Ontario Ministry of Natural Resources (OMNR) fire database the following annual statistics will be calculated:

E_t the annual number of escapes (i.e., fires ≥ 3 *ha*)

L_t the annual number of large fires (i.e., fires ≥ 200 *ha*)

As Cumming (2005:775) suggests, the observed annual distribution of fires (L_t / E_t) will be used as an estimate of the annual probability (ρt) that a randomly chosen escaped fire (E) will fail to be suppressed and become a large fire (L).

Conditional on E_t (i.e., the annual number of escapes), L_t (i.e., the annual number of large fires) will, therefore, be a *binomial random variable* with an expected value of L_t ρt and variance L_t ρt $(1 - \rho t)$. As such, the hypotheses H_0 and H_S can be operationalised as logistic regression models of the annual variation in ρt, and tested by regressing the observations against the suppression strategy (S_i or S_m) being employed.

Deliverables

a) Present conclusive proof as to whether forest fire suppression in Ontario has been effective.

b) A thorough explanation of how un-controlled for spatial and temporal factors distorted the results of previous studies.

c) A discussion of how the implications of this study should affect the strategies available to forest managers and policy makers in Ontario.

d) An outline of the the methodological problems associated with retrospective statistical analysis.

Timetable

Figure 1 shows the planned timetable from which this project will work towards completion.

Table 1. Planned Timetable of Completion

Date	Work Completed
Jun 13$^{\text{th}}$	Literature Review ($\sim$5000 words)
July 1$^{\text{st}}$	Statistical Calculations
Aug 1$^{\text{st}}$	Research Design, Methodology, Results ($\sim$5000 words)
Aug 20$^{\text{th}}$	Discussion ($\sim$5000 words)
Sep 3$^{\text{rd}}$	Final Dissertation ($\sim$15000 words)

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    6.1 Forest Fire-Ecology

    6.2 Implications for Fire Suppression Policy

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