Incorporating a spread event model defined by MODIS hot spots into fire growth modeling
<table>
<thead>
<tr>
<th>Introduction</th>
<th>Calibrating fire growth models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>MODIS Satellite Hotspots</td>
</tr>
<tr>
<td>Model</td>
<td>A logistic regression model for fire spread events based on ISI; extinguishment based on rain</td>
</tr>
<tr>
<td>Conclusions</td>
<td>Predicting fire sizes and fire growth days</td>
</tr>
</tbody>
</table>
Fire managers report: fires either “run” or don't

During fire “runs” (which we will call spread events), it is very difficult to do fire suppression.

During non-spread events, it is possible.
Using FBP or PROMETHEUS requires calibration

To use PROMETHEUS for multi-day large fire simulations and landscape fire research, it is necessary to identify a sub set of burning days from the start date to the end date.

http://www.nofc.forestry.ca/fire/research/management/fgm/prometheus_e.htm
Using FBP or PROMETHEUS requires calibration

Anderson (2009) suggests several reasons:

The assumption that the whole perimeter is active

The need for diurnal adjustment in litter moisture

We argue for an additional possibility: that the FBP System predicts better at the higher end of fire spread potential, because of the burning conditions during the experimental burns the system is based on.

http://www.nofc.forestry.ca/fire/research/management/fgm/prometheus_e.htm
There are several options for calibration

Anderson (2009) collects several options:

- Turn FFMC off at night
- Use hourly FFMC (Van Wagner 1977)
- Use the diurnal adjustment (Lawson and Armitage 1996)
- Use the EMC

We offer another option: the use of the 'spread event' concept.

http://www.nofc.forestry.ca/fire/research/management/fgm/prometheus_e.htm
MODIS active fire mapping can find spread events

Assume that when the fires are running, they will be detected by MODIS Aqua or Terra satellite passes.

http://activefiremaps.fs.fed.us/gisdata.php
Both fire growth days and 'non-growth' days are required

Forest fire records are available from the OMNR, including perimeters – in a few cases, multiple perimeters.

http://www.nofc.forestry.ca/fire/research/climate_change/lfdb/lfdb_map_e.htm
Fire weather indices are the independent variables

The OMNR weather stations provide the weather data and indices needed.
Non-growth days come from satellite data

Start and end dates of fires are recorded, but not 'spread events'. Active fire growth is available through MODIS satellite data.
<table>
<thead>
<tr>
<th>Introduction</th>
<th>We combine MODIS active fire points with fire perimeter polygons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>This includes spatial and temporal merging of data. We also compared it with DFOSS's data on active burning fires.</td>
</tr>
<tr>
<td>Model</td>
<td></td>
</tr>
<tr>
<td>Conclusions</td>
<td></td>
</tr>
</tbody>
</table>
**Introduction**

The resulting dataset has growth day/non growth day vs. FWI component

**Data**

This includes spatial and temporal merging of data. We also compared it with DFOSS's data on active burning fires.

<table>
<thead>
<tr>
<th>year</th>
<th>mon</th>
<th>day</th>
<th>NUMHOTSPOTS</th>
<th>orgunit</th>
<th>firenum</th>
<th>Final_size</th>
<th>Longitude</th>
<th>Latitude</th>
<th>temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>8</td>
<td>11</td>
<td>0 NIP</td>
<td>72</td>
<td>381.7</td>
<td>-88.3132</td>
<td>53.7968</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>7</td>
<td>23</td>
<td>0 SLK</td>
<td>50</td>
<td>430</td>
<td>-92.3227</td>
<td>52.9571</td>
<td>19.4</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>7</td>
<td>24</td>
<td>0 SLK</td>
<td>50</td>
<td>430</td>
<td>-92.3227</td>
<td>52.9571</td>
<td>12.3</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>7</td>
<td>28</td>
<td>0 SLK</td>
<td>50</td>
<td>430</td>
<td>-92.3227</td>
<td>52.9571</td>
<td>20.3</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>9</td>
<td>1</td>
<td>0 COC</td>
<td>10</td>
<td>600</td>
<td>-89.7726</td>
<td>55.6419</td>
<td>16.5</td>
<td></td>
</tr>
</tbody>
</table>
Probability of a growth day depends on ISI
Probability of a growth day depends on FFMC
Probability of a growth day depends on FFMC
There is some difference between suppressed (blue) and observed (red) fires.
Alberta data agree with Ontario data
Extinguishment day is the day after the last growth

Definition:

An extinguishment day is the day after the last growth day. All prior days could have been extinguishment days.

Hypothesis:

Extinguishment days should have more rain than prior days.
An inch of rain has a 50% probability of being an extinguishment day.
The number of simulated spread days does vary

For CHA001-1999, the numbers of spread events and lengths of spread events varied in the simulation. Note, no extinguishment days.
Area burned varies with simulated number of spread days, and which days

For CHA001-1999 (actual size: 19745 ha)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Spread days</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>6</td>
<td>11129</td>
</tr>
<tr>
<td>S2</td>
<td>7</td>
<td>28511</td>
</tr>
<tr>
<td>S3</td>
<td>6</td>
<td>27544</td>
</tr>
<tr>
<td>S4</td>
<td>6</td>
<td>25152</td>
</tr>
<tr>
<td>S5</td>
<td>5</td>
<td>10593</td>
</tr>
<tr>
<td>S6</td>
<td>6</td>
<td>17473</td>
</tr>
<tr>
<td>S7</td>
<td>6</td>
<td>30128</td>
</tr>
<tr>
<td>S8</td>
<td>5</td>
<td>19909</td>
</tr>
<tr>
<td>S9</td>
<td>8</td>
<td>38526</td>
</tr>
<tr>
<td>S10</td>
<td>5</td>
<td>19909</td>
</tr>
</tbody>
</table>
Days are classified as growth; non-growth; and extinguishment days

For DRY 010-2002
Days are classified as growth; non-growth; and extinguishment days.
There are several benefits to this approach

Unlike the other adjustment methods, spread events can be based on weather variables.

Since area burned depends on the number of spread events, the concept can improve area burned predictions.

Work is ongoing on applying the spread event and extinguishment models to more historical fires.
Introduction

Data

Model

Conclusions

NIP075-2002 simulated and actual to July 19

NIP075-2002 simulated and actual to July 19 - 3 burning days
SLK-031-2002: Simulated and Actual perimeter

SLK031-2002: Simulated and actual perimeters (with spread events)
Acknowledgements

Support
NSERC
York University Summer Research Program

Data
OMNR
NASA
USFS
The logistic model gives probability of extinguishment

glm(formula = extdaymodela ~ rain, family = binomial(logit))

Deviance Residuals:
  Min       1Q   Median       3Q      Max
-1.8992  -0.3985  -0.3771  -0.3771   2.3147

Coefficients:
  Estimate  Error    z value  Pr(>|z|)
(Intercept) -2.60770  0.07307   -35.686   <2e-16 ***
  rain       0.10422  0.01111     9.377    <2e-16 ***

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 1951.7  on 3257  degrees of freedom
Residual deviance: 1868.1  on 3256  degrees of freedom
AIC: 1872.1
Rain predicts extinguishment best

Data
AIC for Rain: 1872
Coefficient: 0.1
P-value < 2e-16

Model
AIC for Duff Moisture Code (DMC): 1951
Coefficient = 0.008
P-value = 0.04

DC and other indices are similar to DMC
Oddly, wind speed did not seem to have an effect on probability of a growth day – this goes against what we know

Analysis of Maximum Likelihood Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DF</th>
<th>Standard</th>
<th>Wald</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercep</td>
<td>1</td>
<td>-0.9835</td>
<td>89.0949</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>ws</td>
<td>1</td>
<td>0.0106</td>
<td>1.9919</td>
<td>0.1581</td>
</tr>
</tbody>
</table>