Methods for Spatial Simulation of Fire Regimes

Steve Cumming, Jean Marchal & Eliot McIntire

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A fire regime:

A quantitative description of the fires characteristic of a particular place (Whelan 1994)

- Frequency
- Size
- Cause
- Annual Area Burned = Frequency X Size
Spatial Simulation of Forest Landscape Dynamics

1990s Technology

Now +200yr
2010 Technology
The SpaDES platform

Making modern scientific forecasts, backcasts, and decisions

Eliot McIntire
Percolation Fire Models

Arrival: Poisson
Escape: Bernoulli
Growth: Percolation

1990 Technology
Spatial Ecology of Fire in the Boreal Mixedwood

...the quest for the fifteen...

2001

Steve Cumming

15 = 3 * 5
Recent progress from Québec

• Statistical models of
  – fire frequency (Poisson, negative binomial)
  – fire size (tapered Pareto distributions)
  – common covariates of landcover and fire weather

• Methods for converting results to simulation model parameters;

• Applications to evaluating feedbacks limiting fire rate under climate change.
Study Region, 197,000km²
Lightning (a) and Human-caused fires (b) 

2000-2010

(we also were told the final sizes and dates)
Forest cover type

Monthly Drought Code
1. Exploiting Poisson additivity to predict fire frequency from maps of fire weather and land cover in boreal forests of Québec, Canada. Marchal, Cumming and McIntire. Ecography 2016

Poisson rates can be scaled to arbitrary cell sizes and compositions.

For small, homogeneous cells, can be converted to Bernoulli probabilities.

Results for human caused fires (not shown) also depended on road density.
2. Land cover, not monthly fire weather, drives fire sizes in Southern Québec forests: implications for fire risk management. Marchal, Cumming and McIntire. PLOS ONE in review.

Evidence of *dramatic* negative feedbacks on fire size.

Recently disturbed areas and increased amounts of hardwood forests *sharply* reduce the size of proximate, subsequent fires for as long as it takes the conifers to dominate the regenerating canopy (15y – long time)
Pattern Oriented Modelling

Derive cell-level fire spread probabilities from predicted fire size parameters.

The procedure is involved; only some results are shown.
Bringing it all back home.

Simulation experiments linking

- statistical models of fire regime parameters;
- a vegetation dynamics model;
- downscaled climate forecasts.
Negative feedbacks constrain fire regime response to climate change.
Conclusions and direction

• This is all almost automated in SpaDES;
• Some aspects are still a little clunky, but;
• Integrated, empirical modeling of fire regime and other ecological processes is possible;
• Statistical methods should be tested on more burny parts of Canada;
• Forecast reliability is now most limited by our vegetation dynamics models.