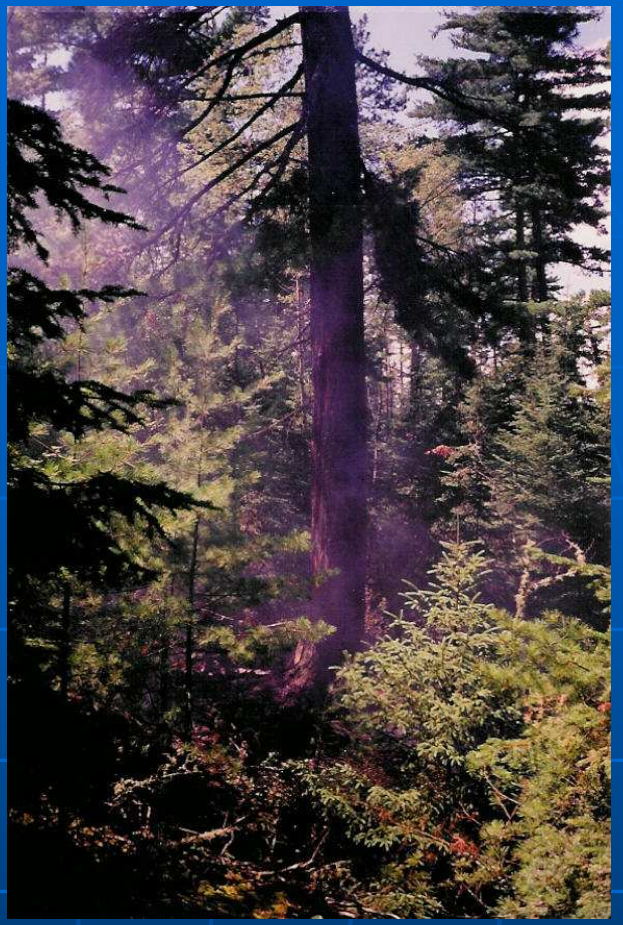


# Methods for the Prediction of Forest Fire Occurrence

Mike Wotton
Canadian Forest Service
Great Lakes Forestry Centre
mike.wotton@utoronto.ca

# Fire occurrence

- Two distinct causes
  - Lightning

  - Human activity

# Fire occurrence

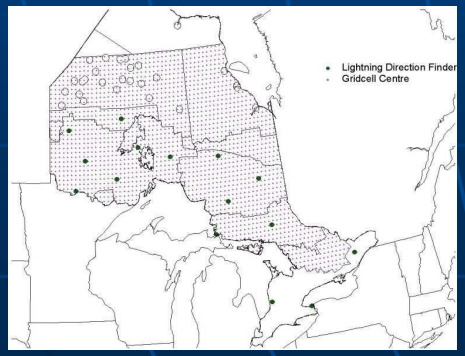
- Outline
  - Fire occurrence in general
    - Lightning & human
  - Recently developed models of fire occurrence prediction
    - Lightning and human

# Fire occurrence

- Across Canada
  - Lightning-causes 48% of all fires
  - Lightning fires cause 85% of the area burned across the country
  - These statistics vary significantly from region-to-region
    - e.g., In the Maritimes >95% of fires are human-caused

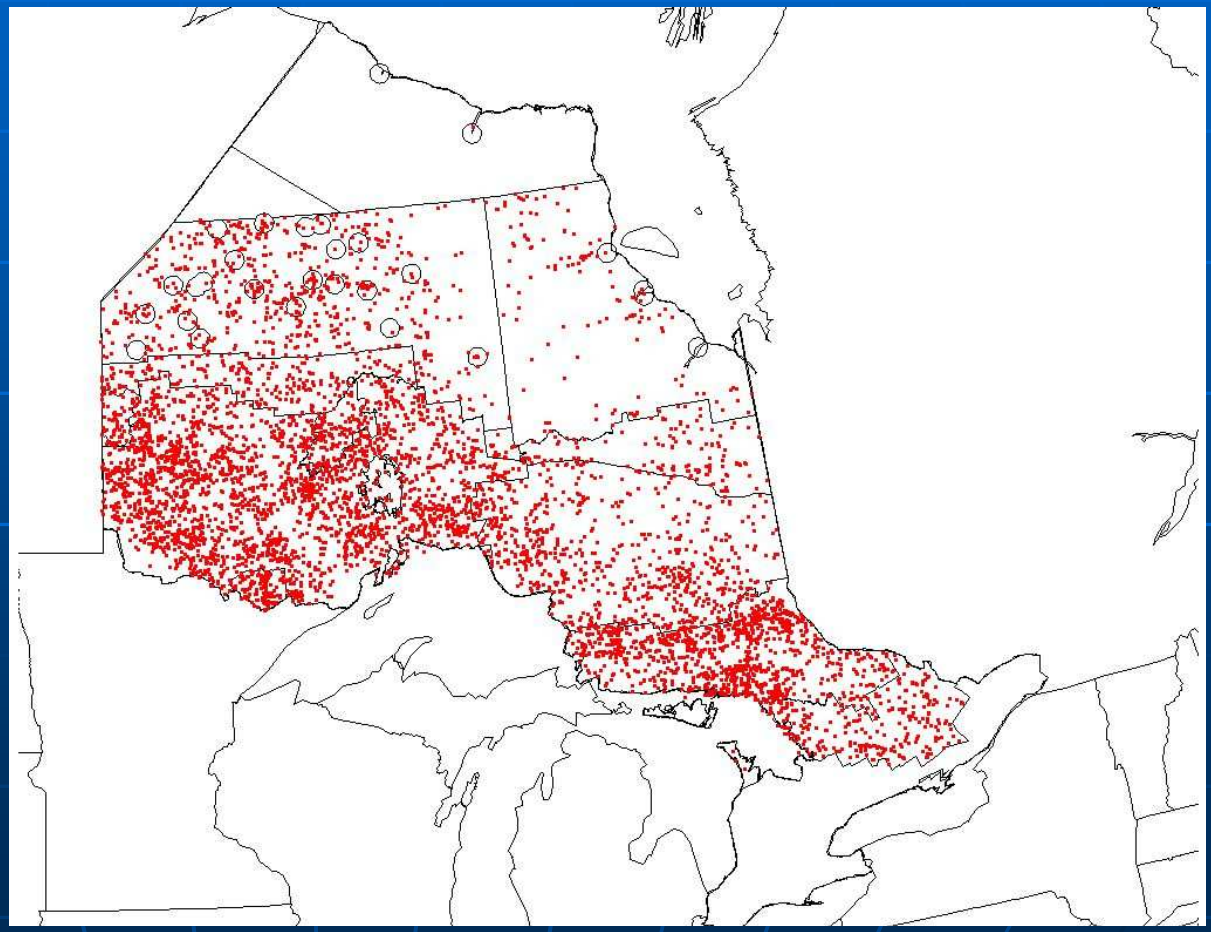
# Fire Occurrence

- In Ontario (over the last 10 years)
  - 47% of fires were lightning-caused
  - 82% of area burned was from lightning fires
    - an average of 625 lightning fires per year
    - An average of 270,000 lightning strikes per year in the fire management zone



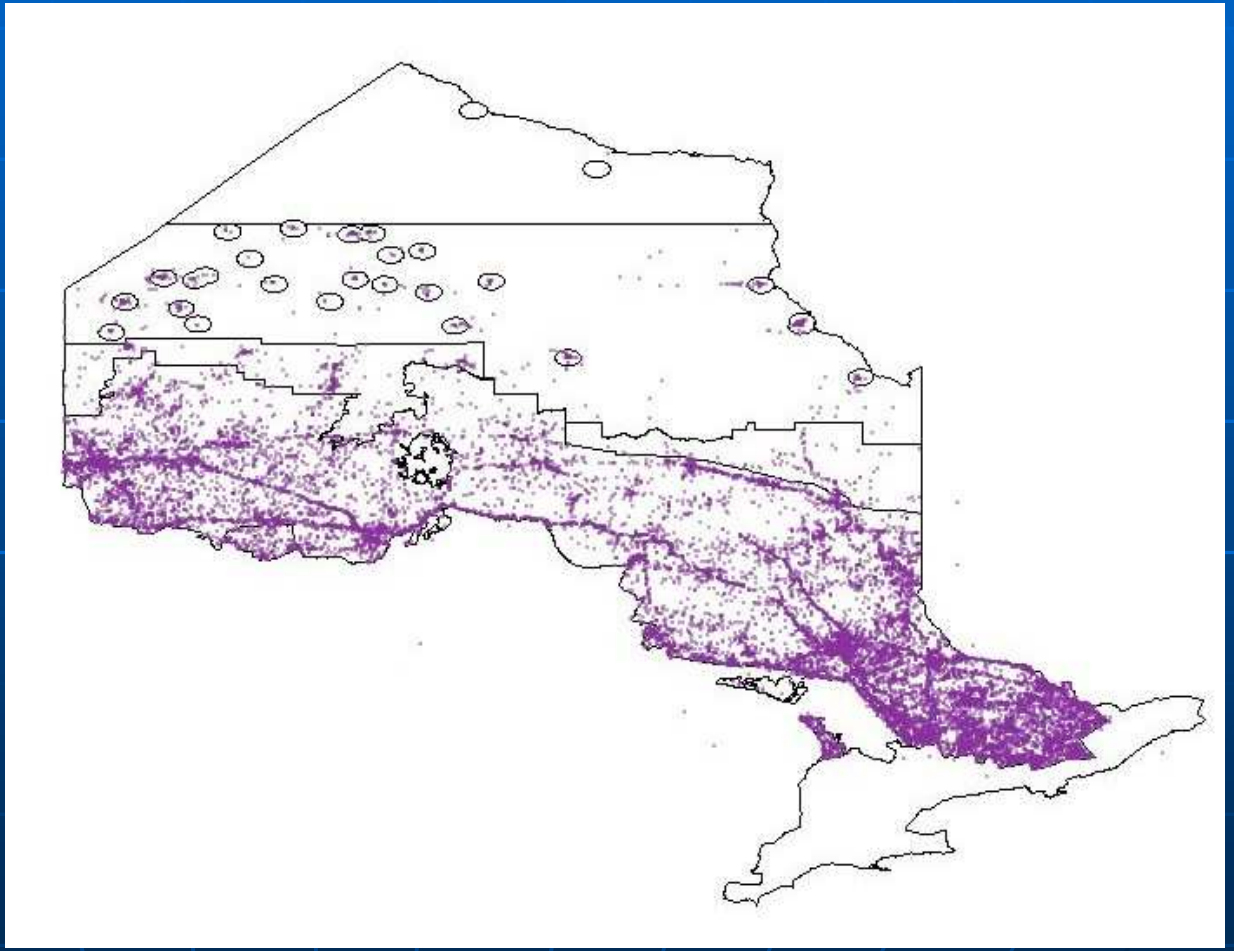
# Lightning-caused fire

**Distribution of lightning-caused fires from 1992 to 2001**



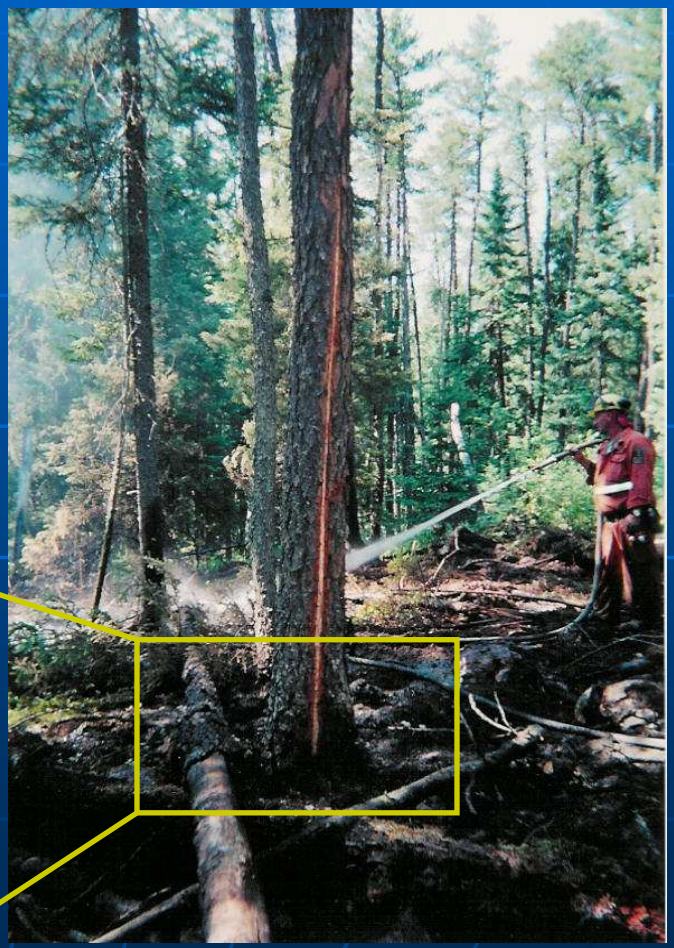
# People-caused fire

**Distribution of people-caused fires from 1980 to 2001**



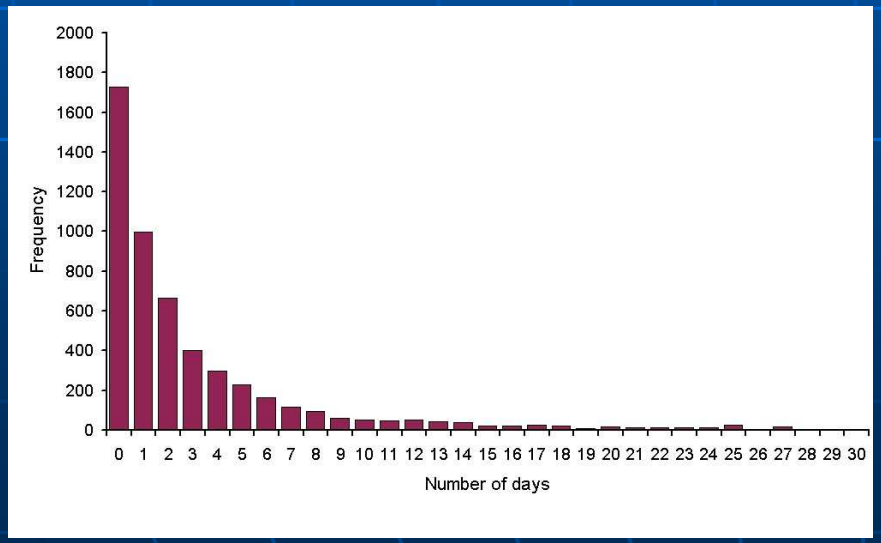
# Lightning-caused fire

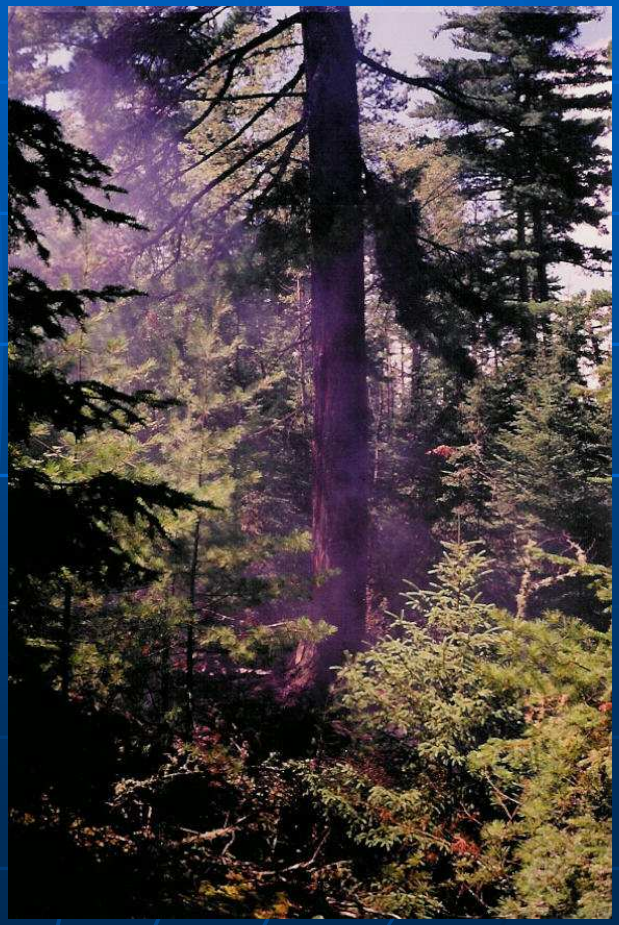
- Lightning-caused fire
  - Ignition
    - Moisture in organic



# Lightning-caused fire

- Lightning-caused fire
  - Arrival/detection
    - Moisture in fine surface fuels



**Holdover Duration**

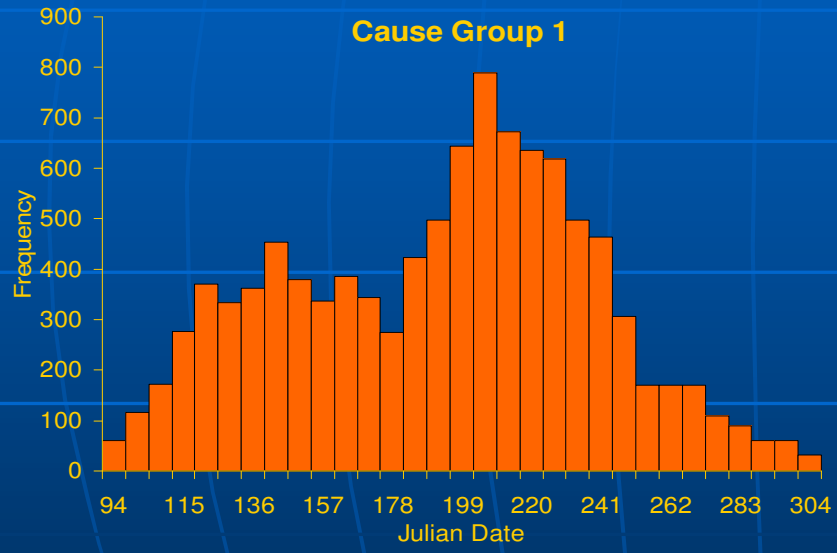
# People-caused fire

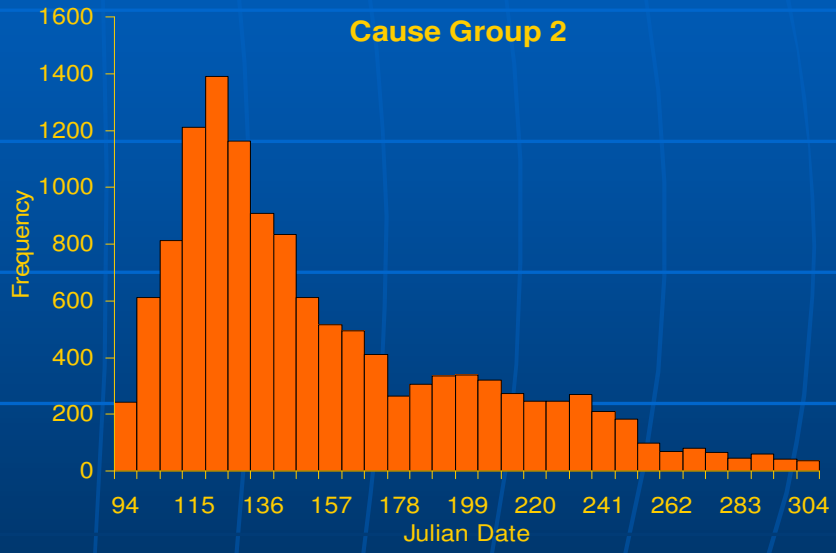
- People-caused fire can occur from several main causes
  - Recreational, railway, residential, industrial etc

- Their occurrence has strong seasonality

# People-caused fire

## Seasonality



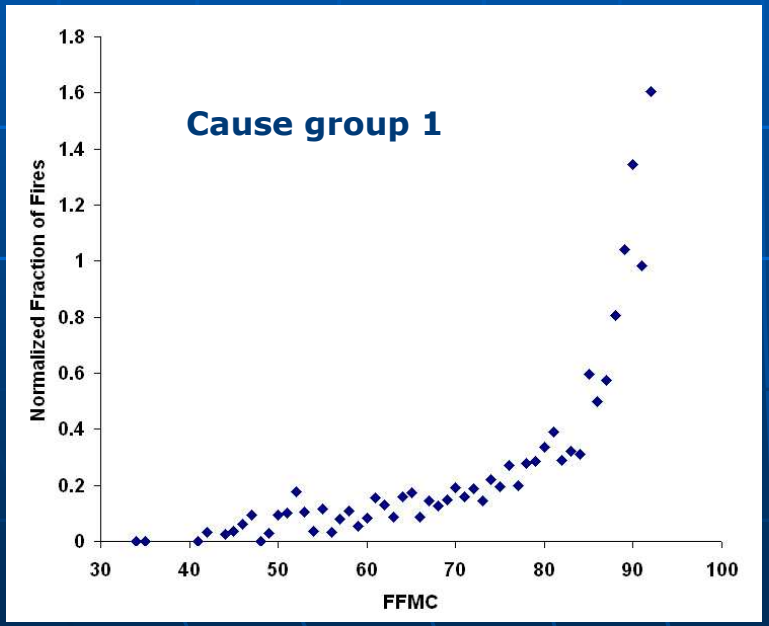



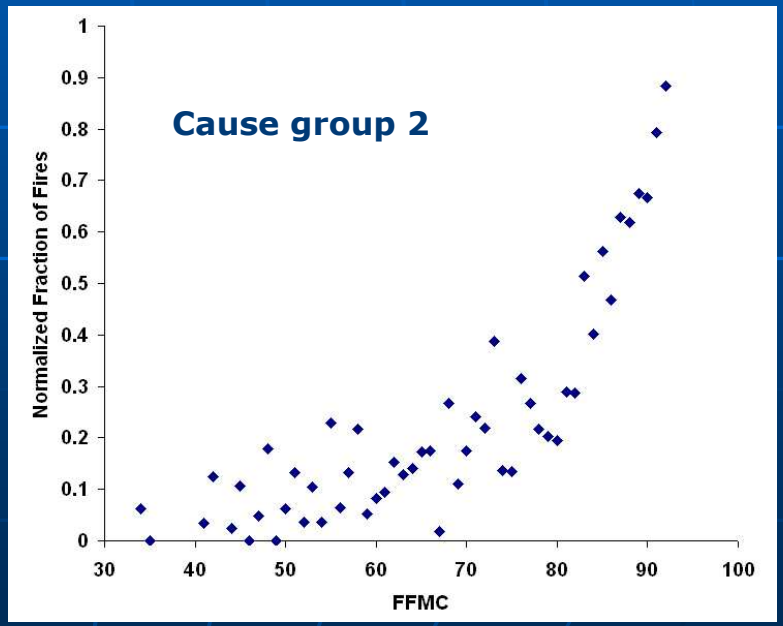

Recreation
Industry (Forest)
Industry (other)
Incendiary

Railway
Residential
Miscellaneous
Unknown

# People-caused fire

- Strong dependence on moisture in the fine surface fuels

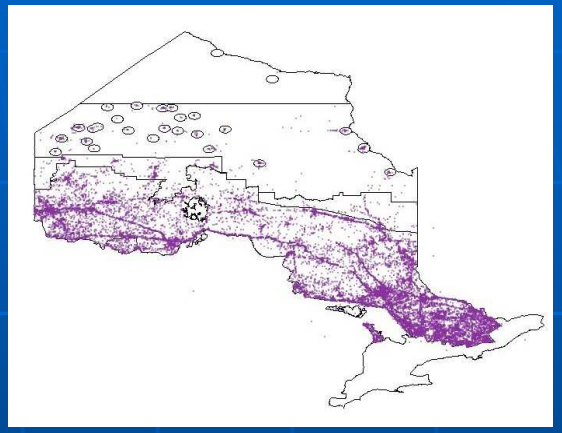


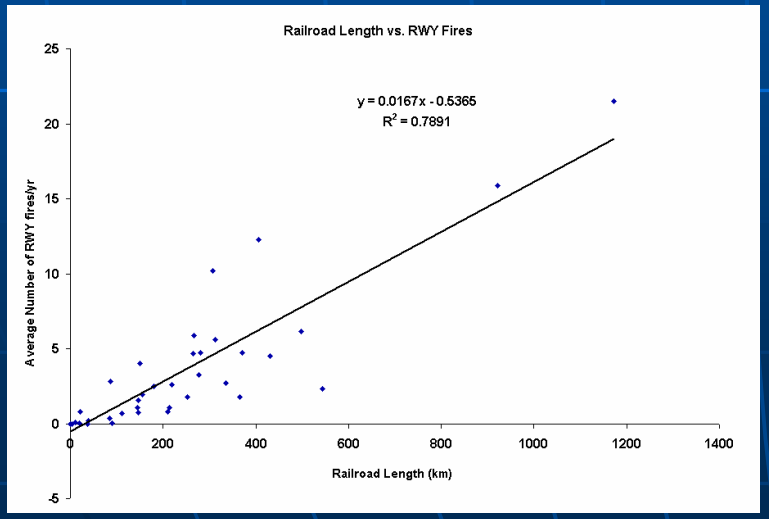




**Fire occurrence in northeastern Ontario (ecoregion 97)**

# People-caused fire

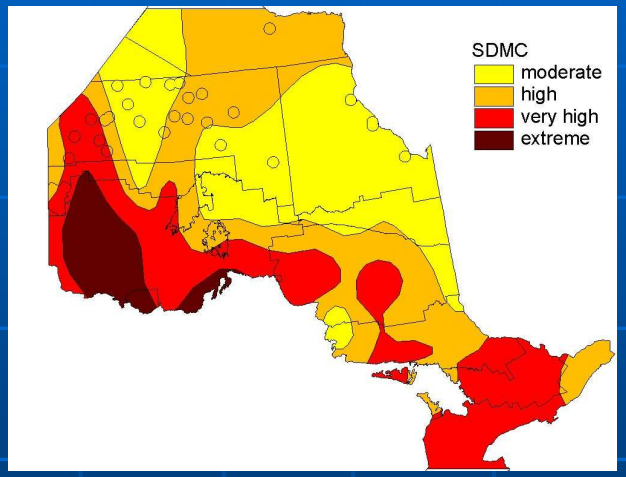
- People-caused fire
  - Strongly influenced by human activity and infrastructure

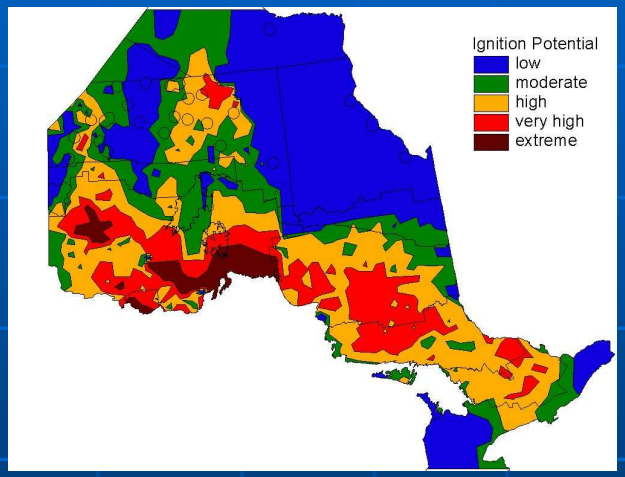


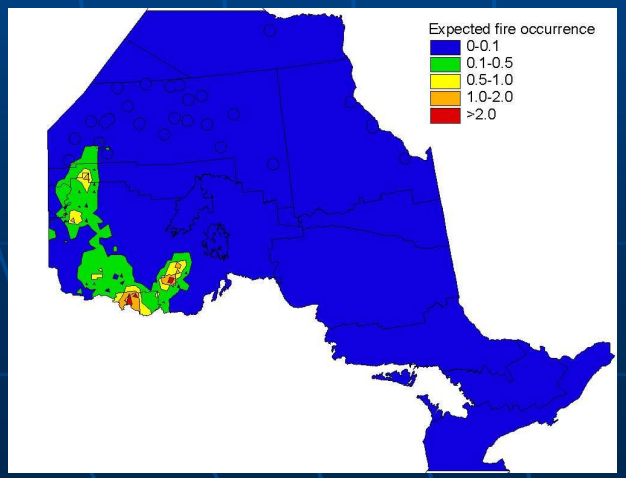


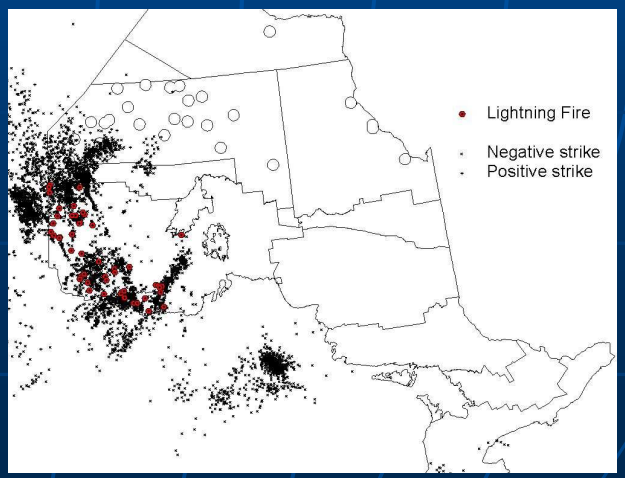

# Fire Occurrence

## Fire Occurrence Prediction Modelling



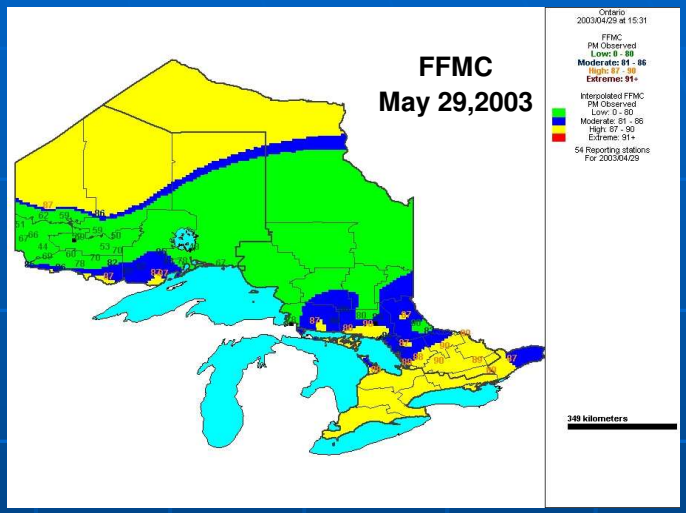



# People-caused fire

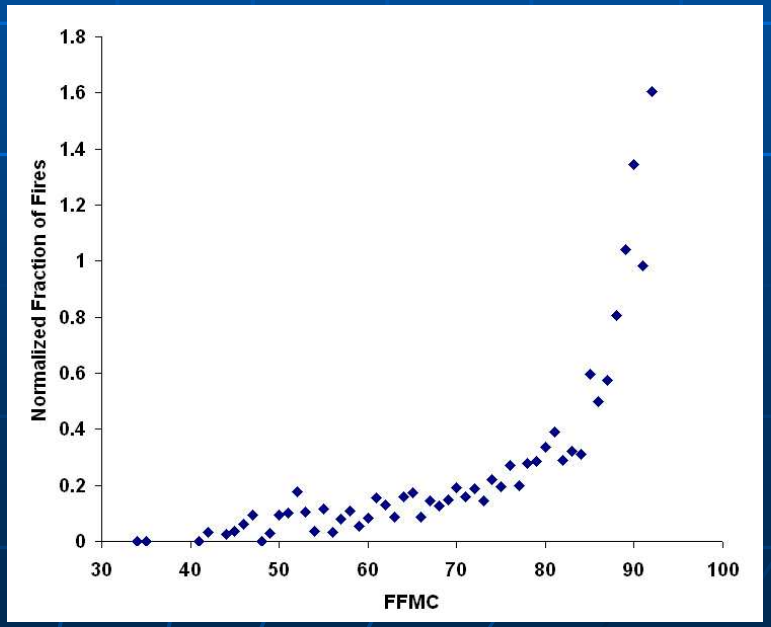
- Ignition depends on
  - fuel moisture
  - human activity




- In this study we modelled the dependence on <u>moisture and seasonality</u>

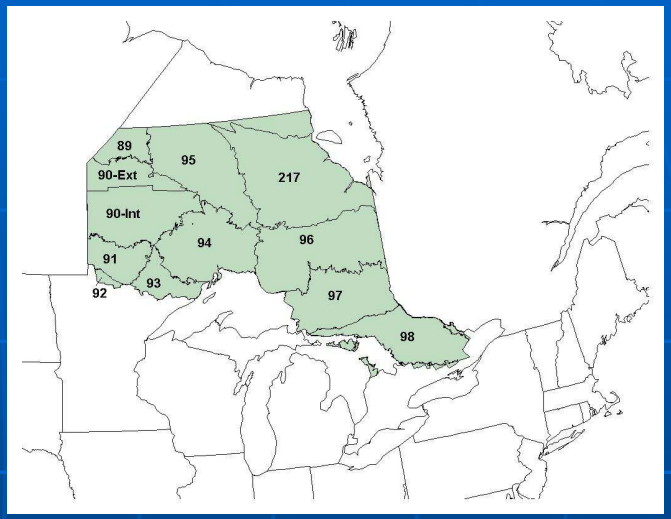
# People-caused fire

- Previous research
  - has shown people-caused fire occurrence follows a Poisson distribution over fire regions
  - The expected number of fires in an region is a function of fuel moisture



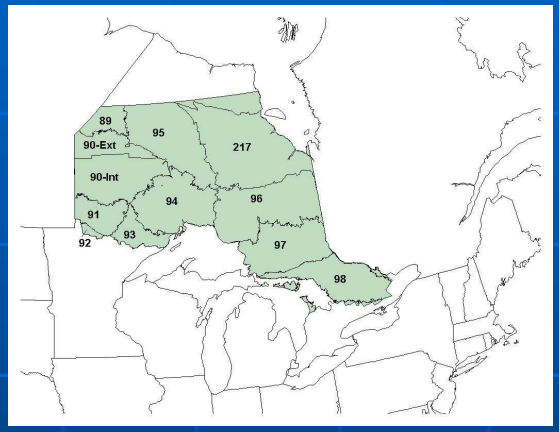
# People-caused fire

- Daily fire occurrence in each of the ecoregions of Ontario were modelled with Poisson regression
- Daily fire occurrence and weather data was taken from 1980 to 2000
- Predictors:
  - FFMC, PsusF, DMC, DC
    - Interpolated to the centre of the ecoregion
  - Sinusoidal seasonal terms



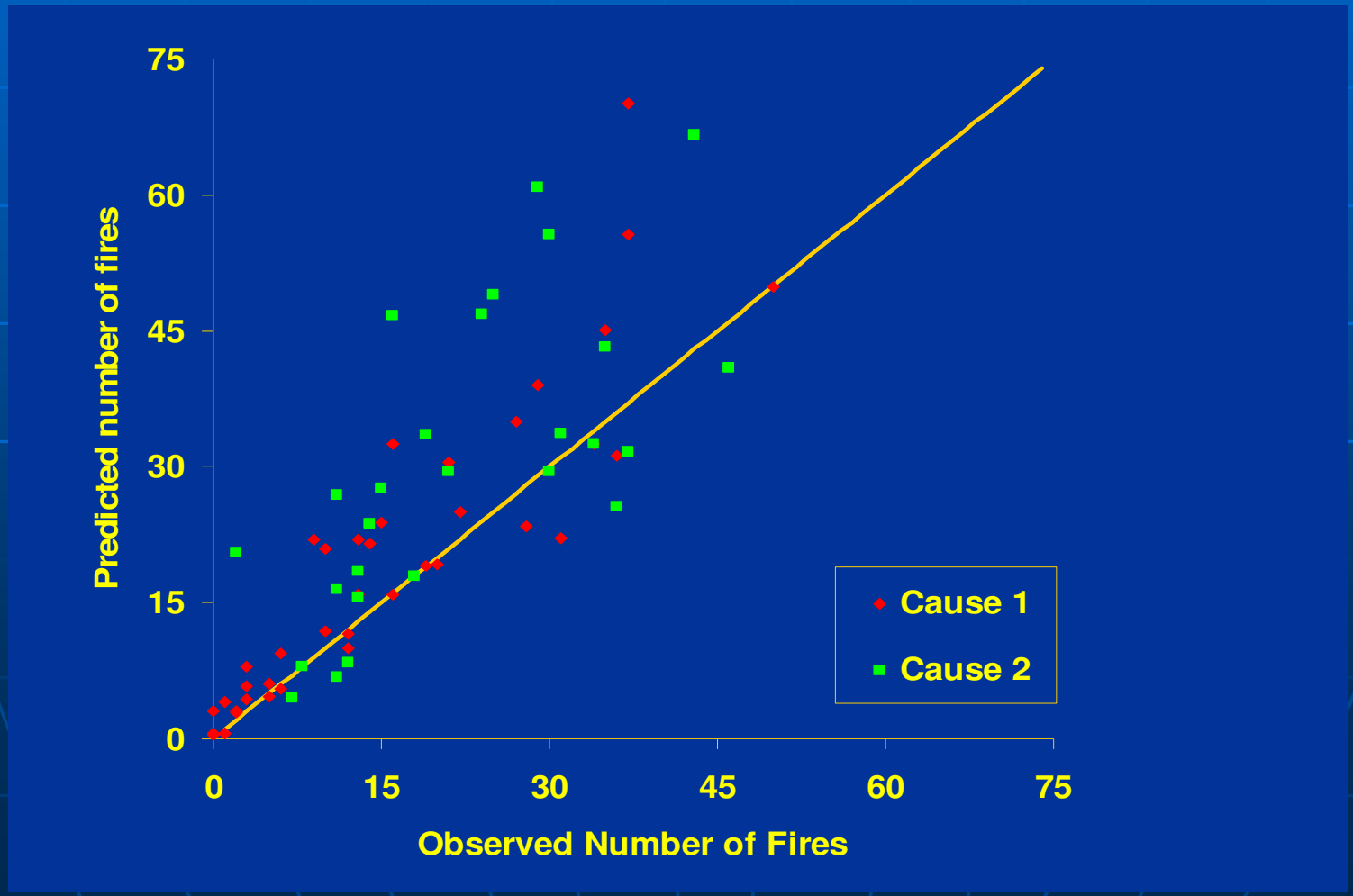
# People-caused fire

- Results
  - Ecoregion-based models of daily fire occurrence included
    - Strongly significant indicator of sustainability of flaming in the litter layer
      - PsusF or FFMC
    - Weaker (but still significant) dependence on organic layer moisture




# People-caused fire

## Annual summaries of ecoregion-based predictions

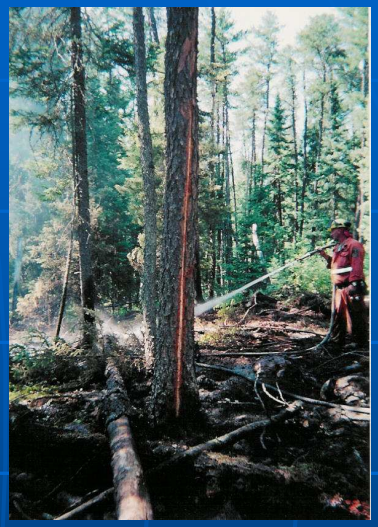


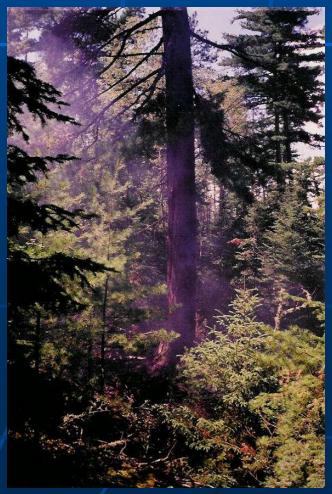
# People-caused fire

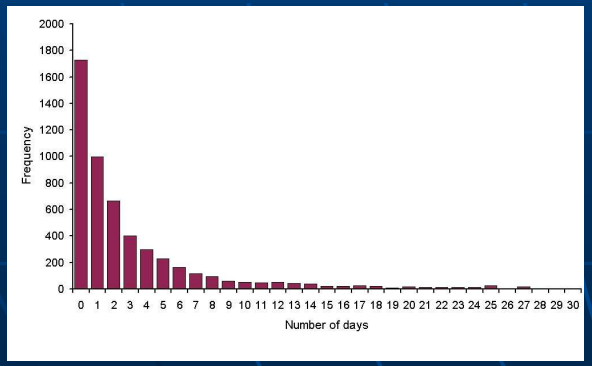
- Future
  - Link moisture-based models with "human-factors" relationships to build more complete model of people-caused fire ignition

# Lightning fire models

- Lightning fire models
  - Modeling as two separate processes:
    - Ignition (from a lightning strike)
    - Day of detection (arrival into the system)



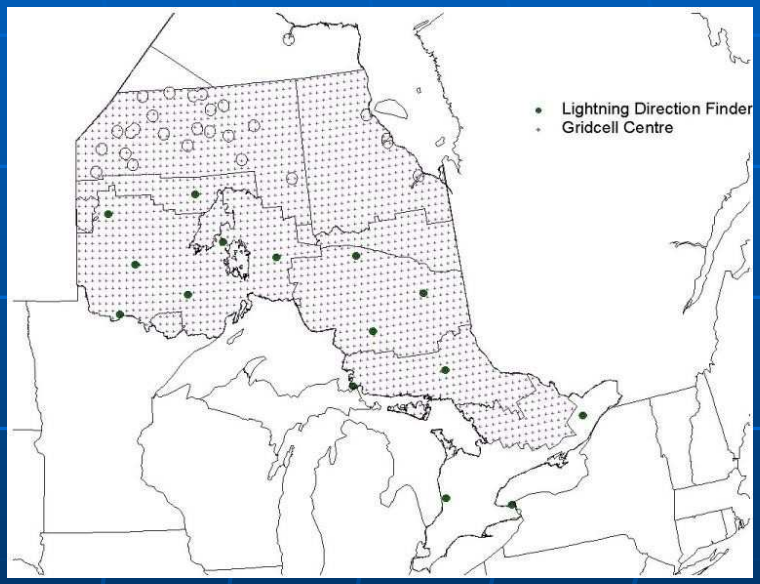





**Holdover Duration**

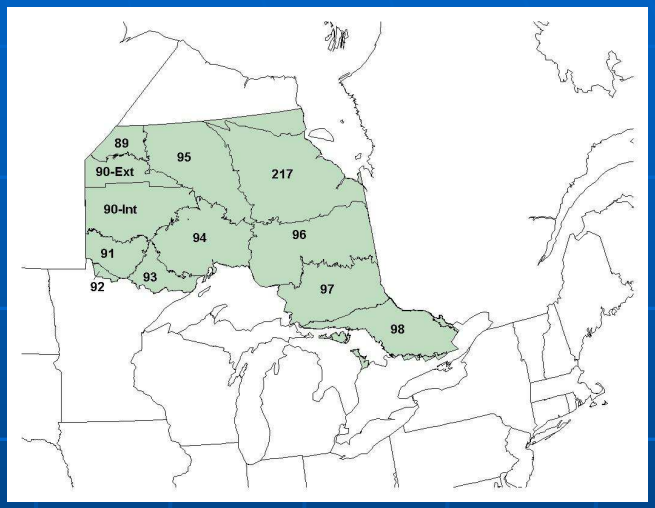
# Ignition models

- Daily data (1992-2001)
  - Lightning
  - Weather
  - Fires
  - Forest type
- Fires, lightning and weather summarized for each day into grids cells (20 km by 20 km)



# Ignition models

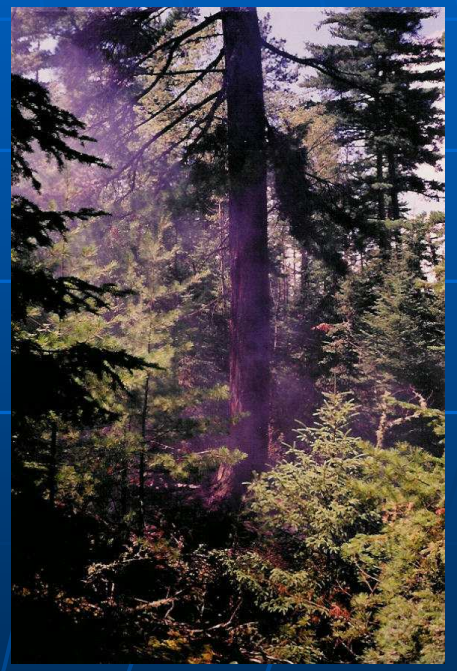
- Daily ignition models
  - A logistic regression model
    - Response variable was :
      # of fires / # of strikes
  - Ecoregion-based models (11)
    - Because the strength of the influence of the moisture variables varied




- Significant influences
  - SDMC strong in all models
  - Percentage of positive strikes
  - Timing of storm (overnight)
  - Weather on 3 days following
    - (rain and duff moisture)

# Arrival models

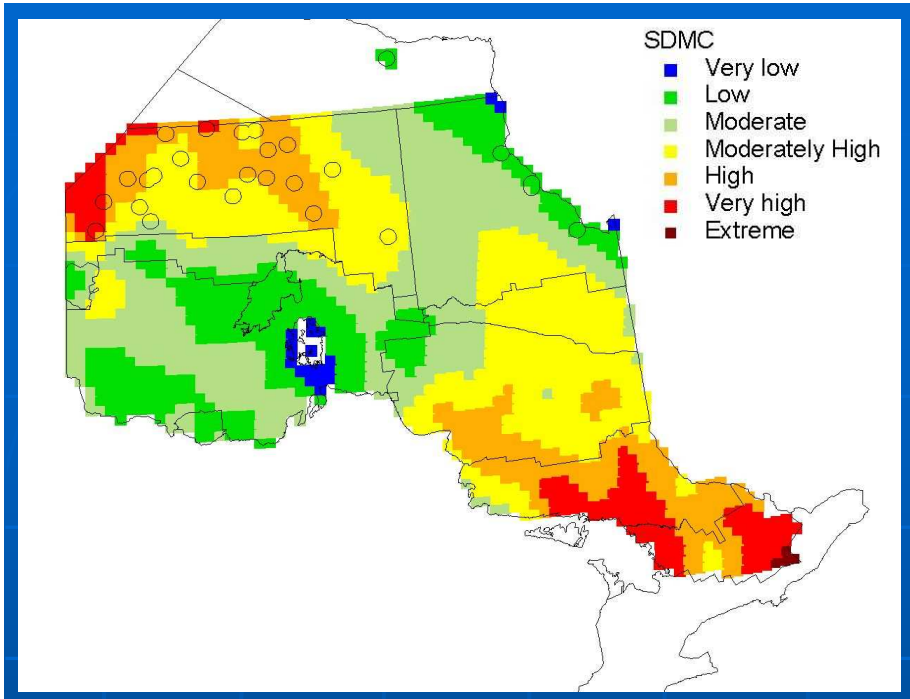
- Probability of an ignited lightning fire being detected on a specific day after ignition
- Logistic regression models
  - Daily evaluation of conditions from start date to detection date at each fire location
    - Weather, fuel moisture, and potential fire behavior
- Ecoregion-based models
  - Due to differences in moisture signal strength

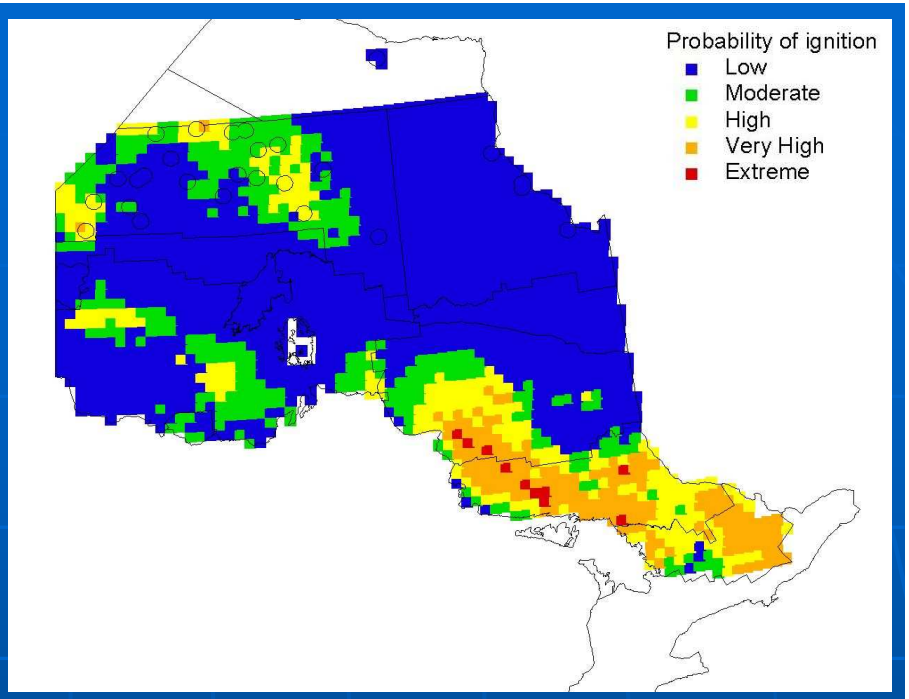


# Arrival models

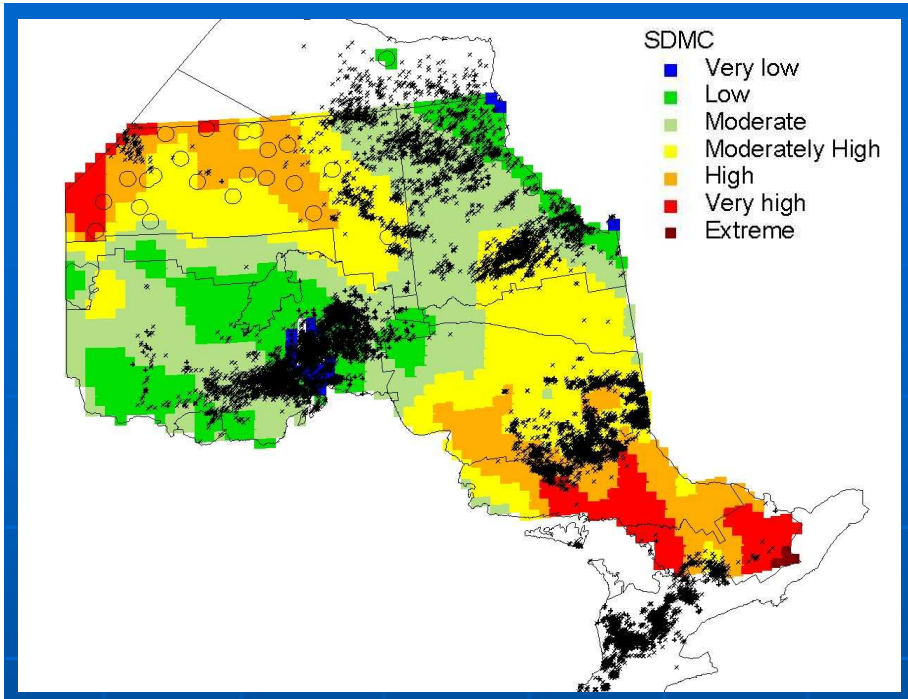
- Results
  - Strongest predictor: variables representing receptivity of fine fuels to surface fire spread
    - PsusF, FFMC, RH, ISI, HFI, WS

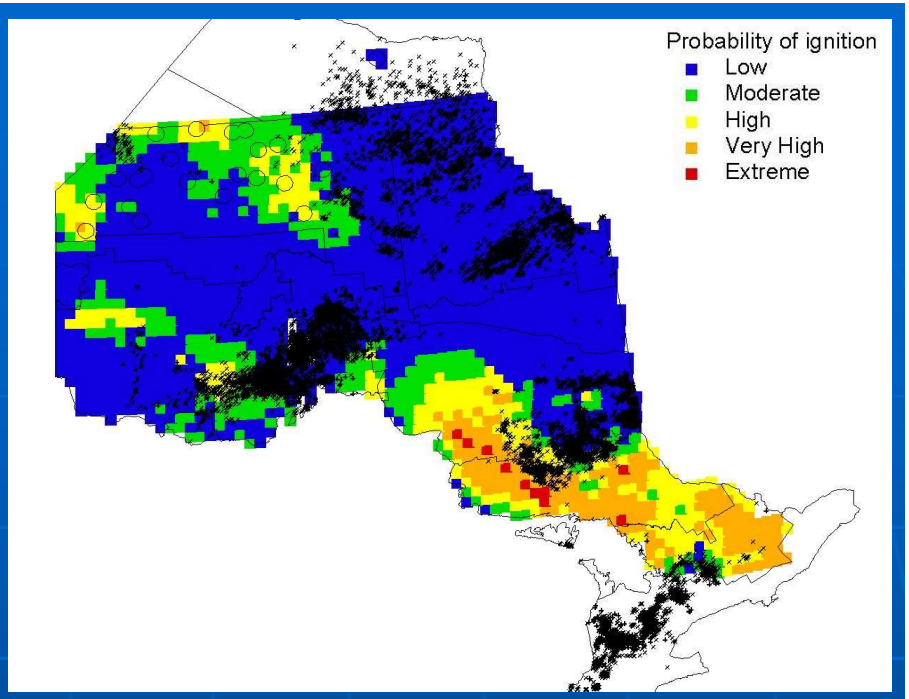
  - also included (but of lesser significance)
    - terms representing moisture in deeper organic
      - DMC or DC


SDMC
Very low
Low
Moderate
Moderately High
High
Very high
Extreme

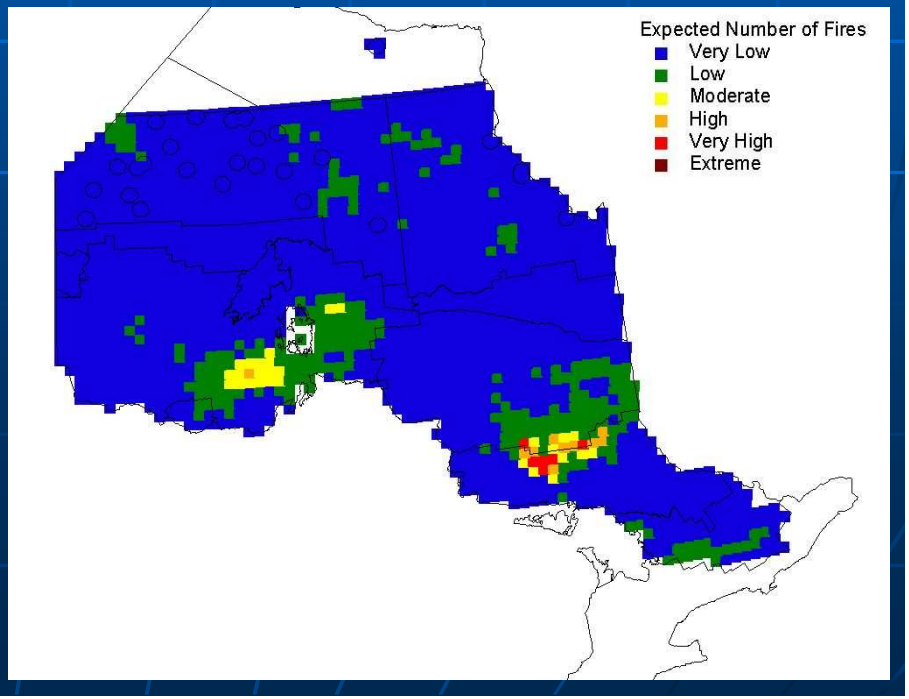

Probability of ignition
Low
Moderate
High
Very High
Extreme

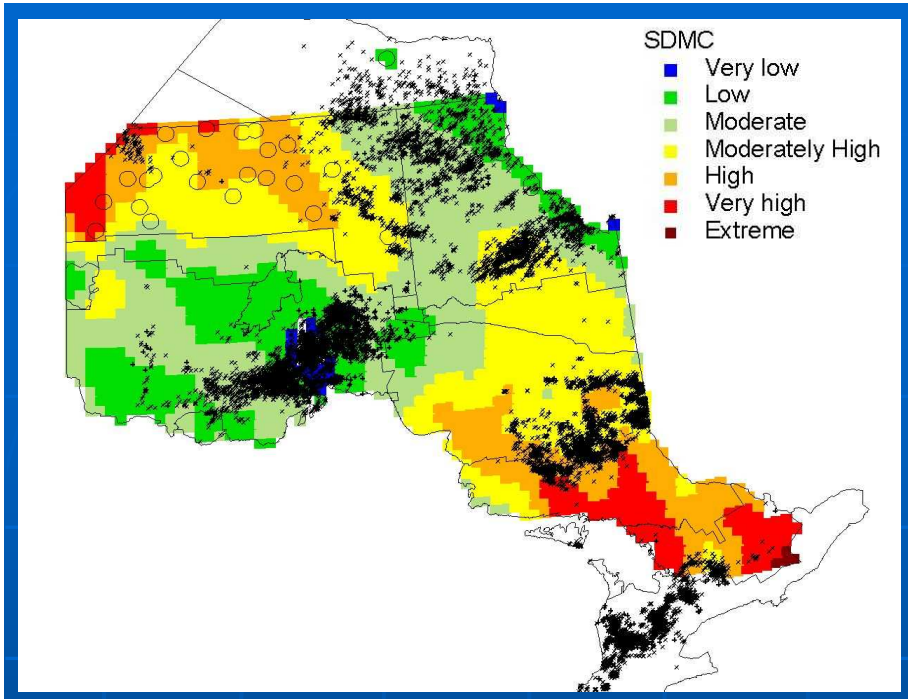
July 21, 2001

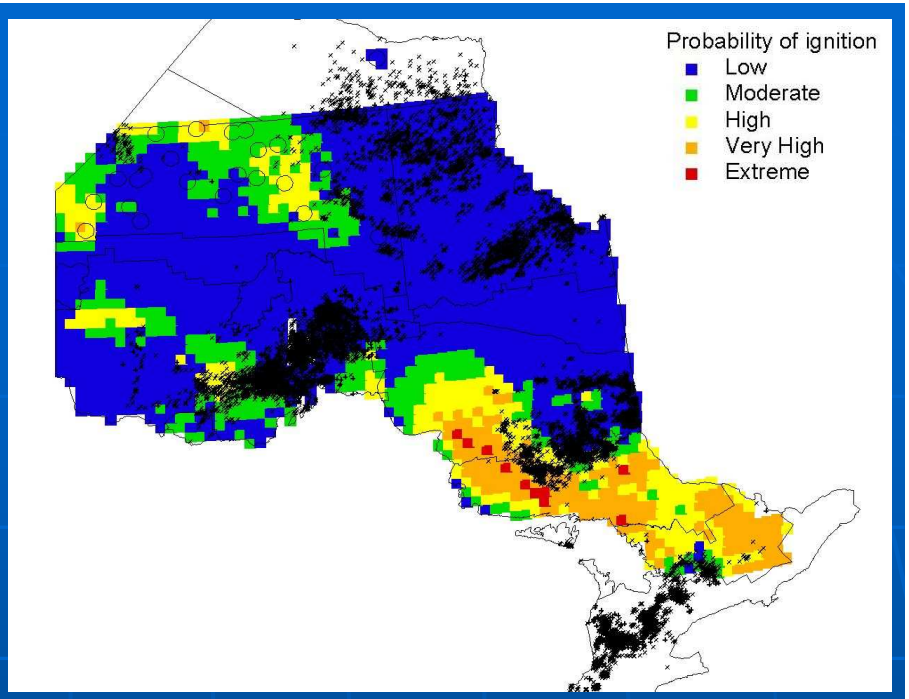

SDMC
Very low
Low
Moderate
Moderately High
High
Very high
Extreme


Probability of ignition
Low
Moderate
High
Very High
Extreme

July 21, 2001


Expected Number of Fires
Very Low
Low
Moderate
High
Very High
Extreme



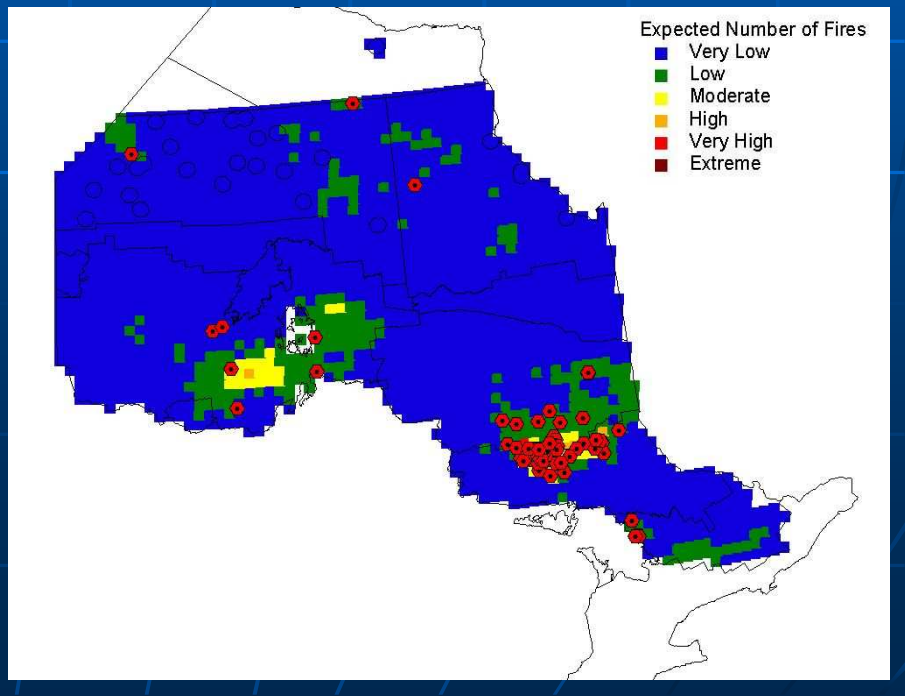



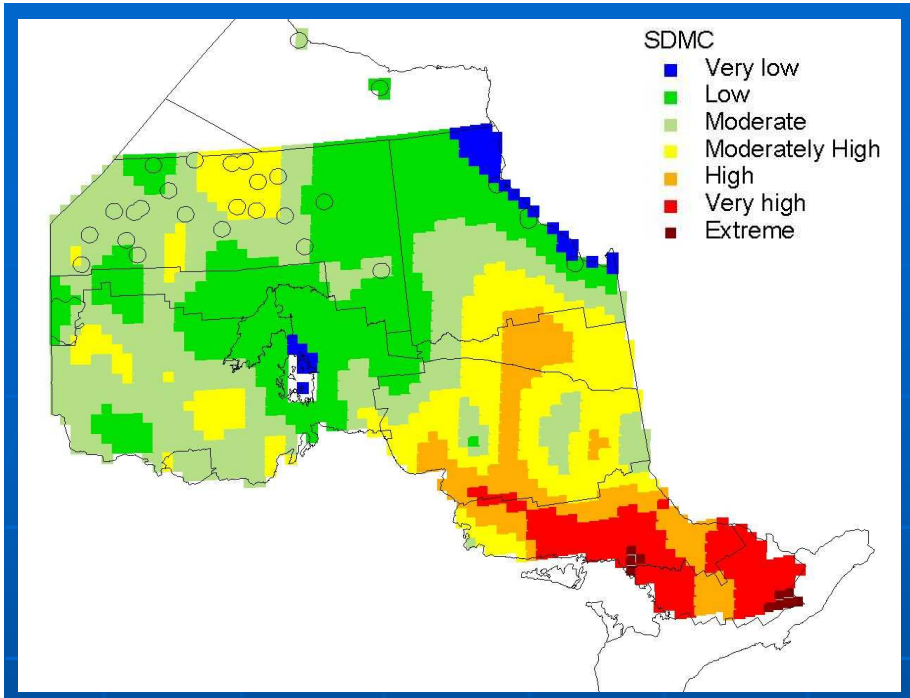

July 21, 2001

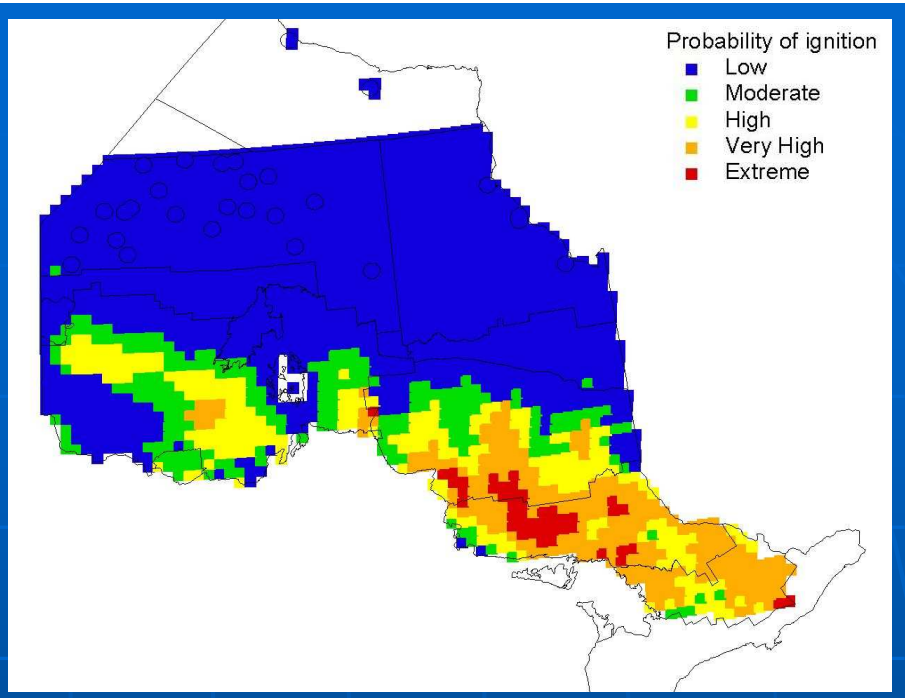
**Sustainable Ignitions**

Observed = 52

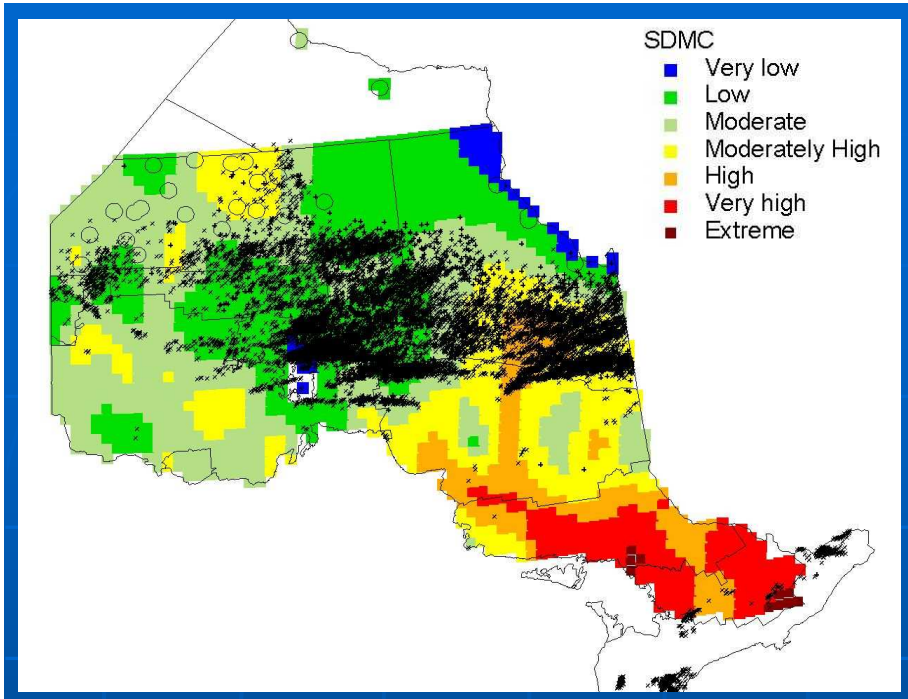
Predicted = 31 to 52

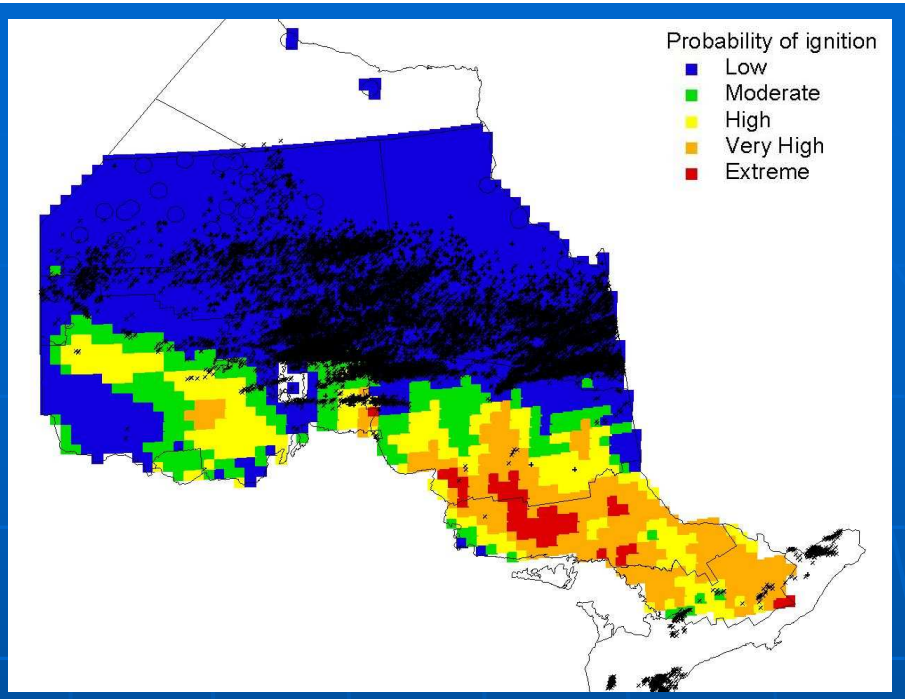



SDMC
Very low
Low
Moderate
Moderately High
High
Very high
Extreme

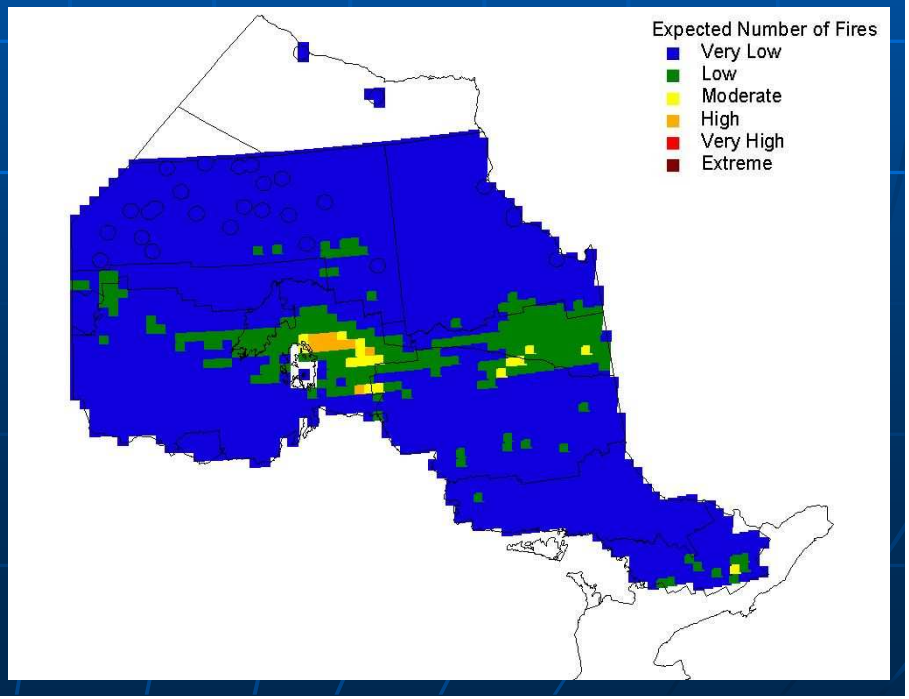

Probability of ignition
Low
Moderate
High
Very High
Extreme

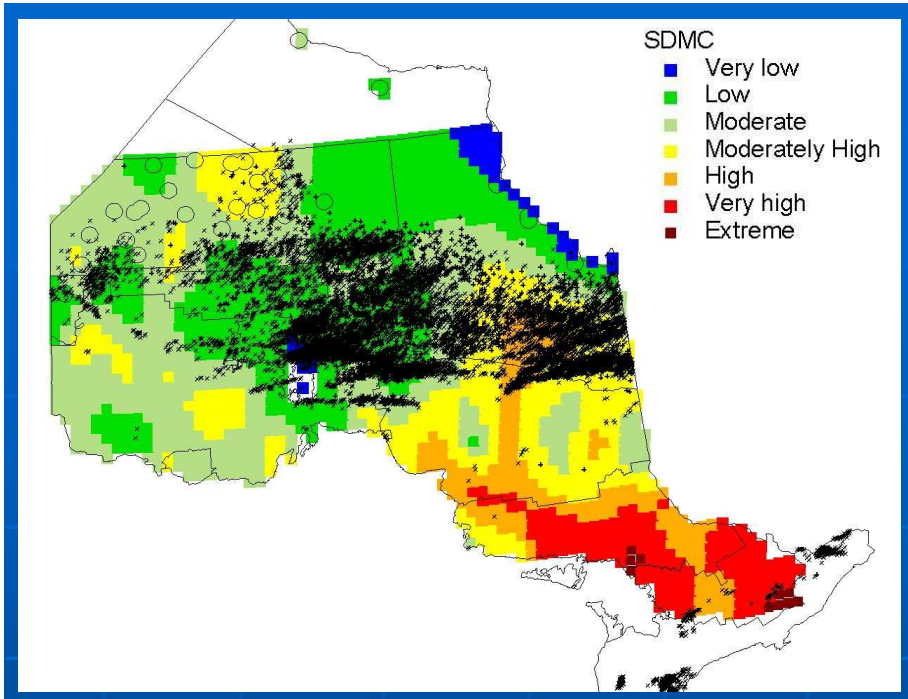
July 23, 2001

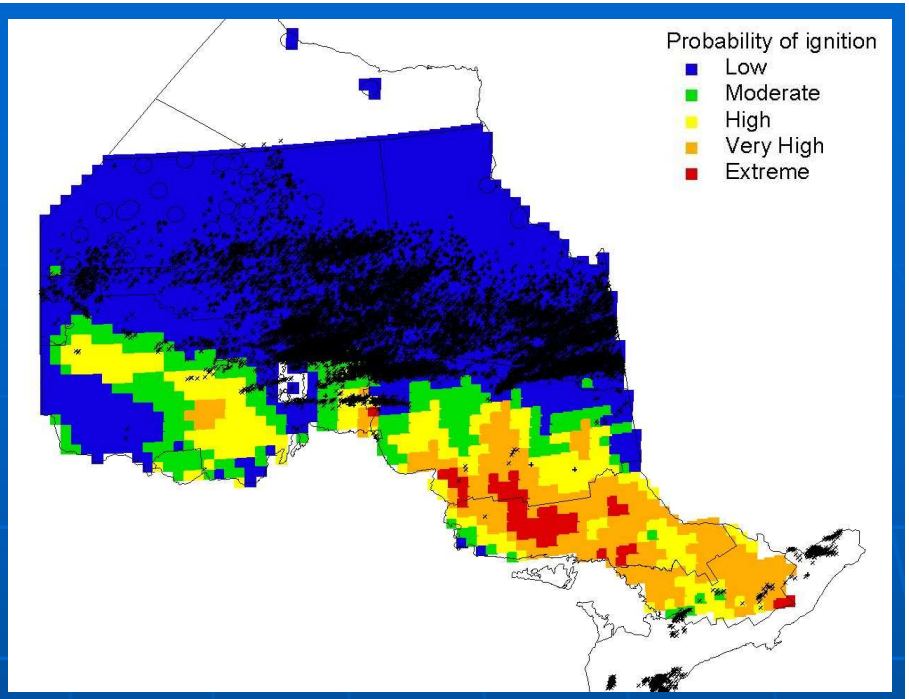

SDMC
Very low
Low
Moderate
Moderately High
High
Very high
Extreme


Probability of ignition
Low
Moderate
High
Very High
Extreme

July 23, 2001


Expected Number of Fires
Very Low
Low
Moderate
High
Very High
Extreme



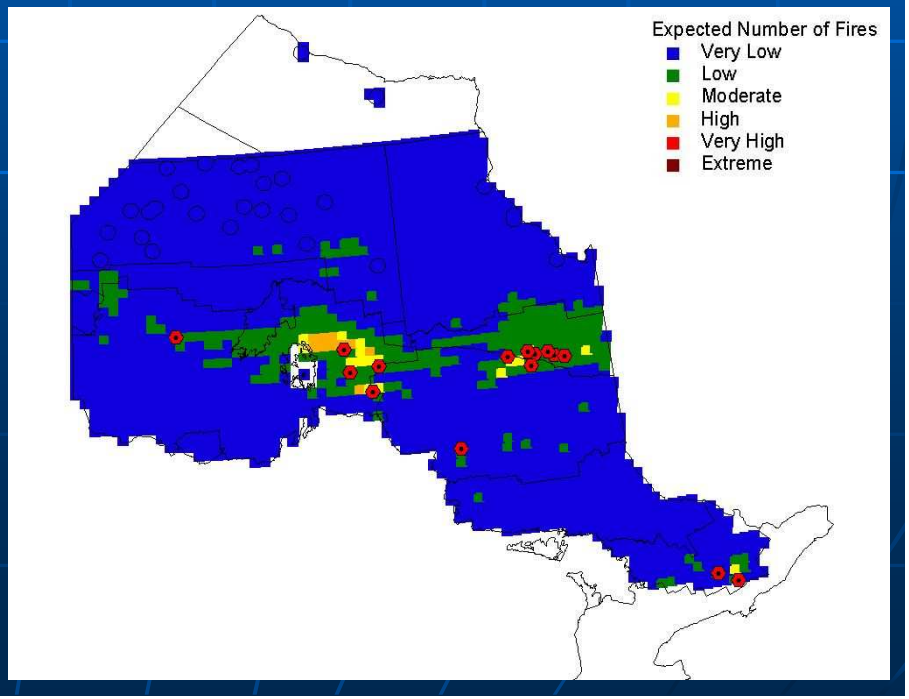




July 23, 2001

**Sustainable Ignitions**

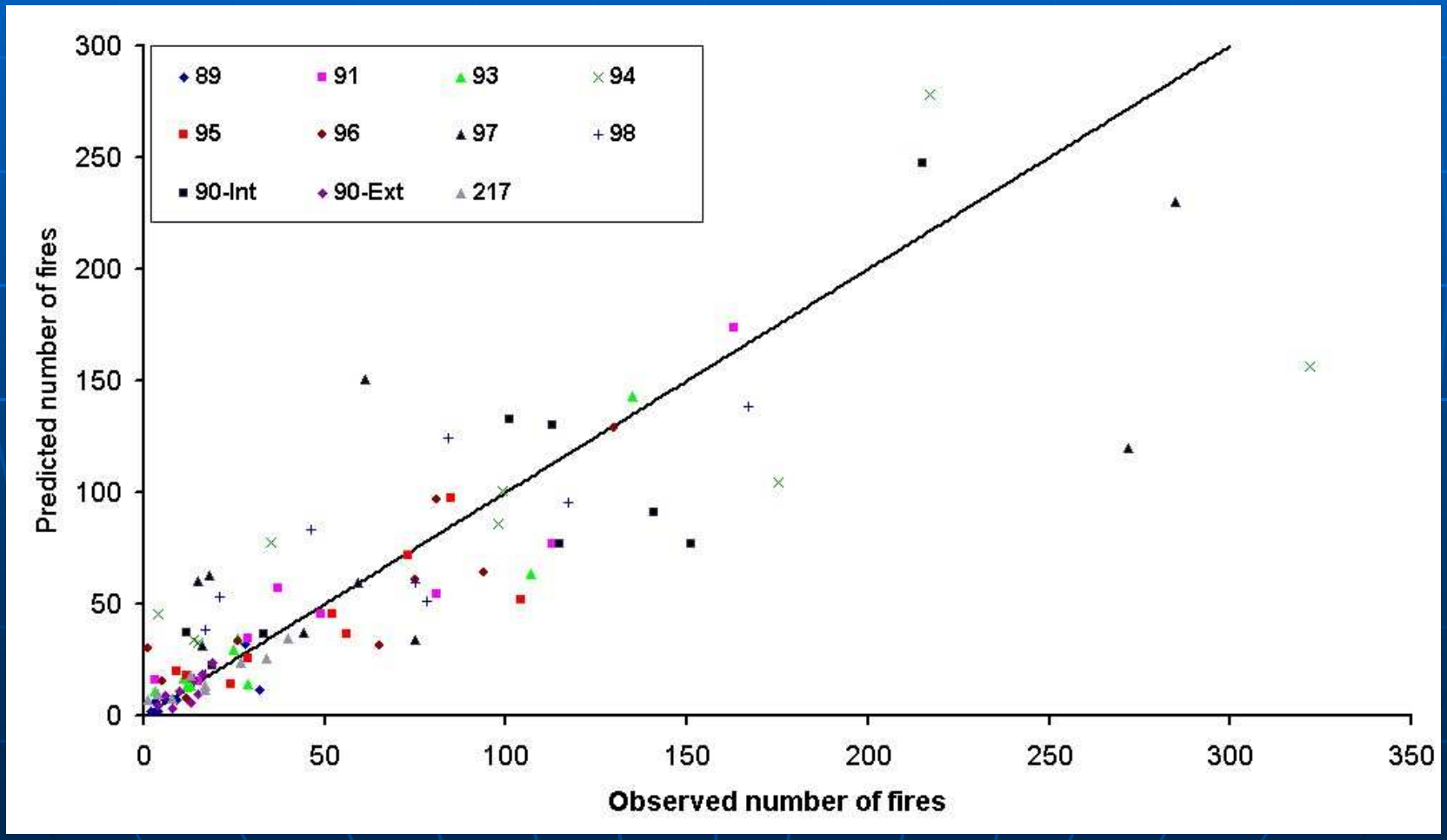
Observed = 14

Predicted = 16 to 34



# Ignition models

**Annual predictions – for each Ontario ecoregion**



# Lighting-caused fire

- Future
  - Currently implementing daily ignition and arrival models operationally in Ontario Response Centres
  - Developing similar models across ecoregions of Alberta and Saskatchewan