Does spruce budworm increase fire risk?

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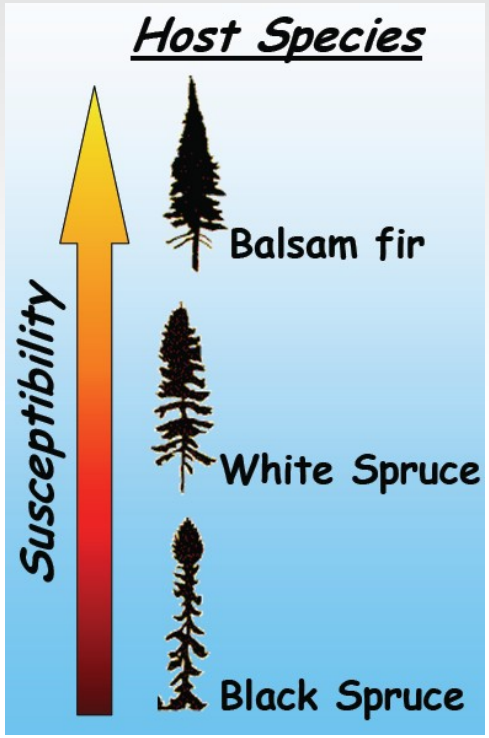
Forest Disturbances

- Integral feature of boreal and mixed-wood forest dynamics.
- Affect spatial patterns in forest age and composition at multiple scales.
- Have important ecological and economic consequences
- Have uncertain interactions.

Eastern Spruce Budworm

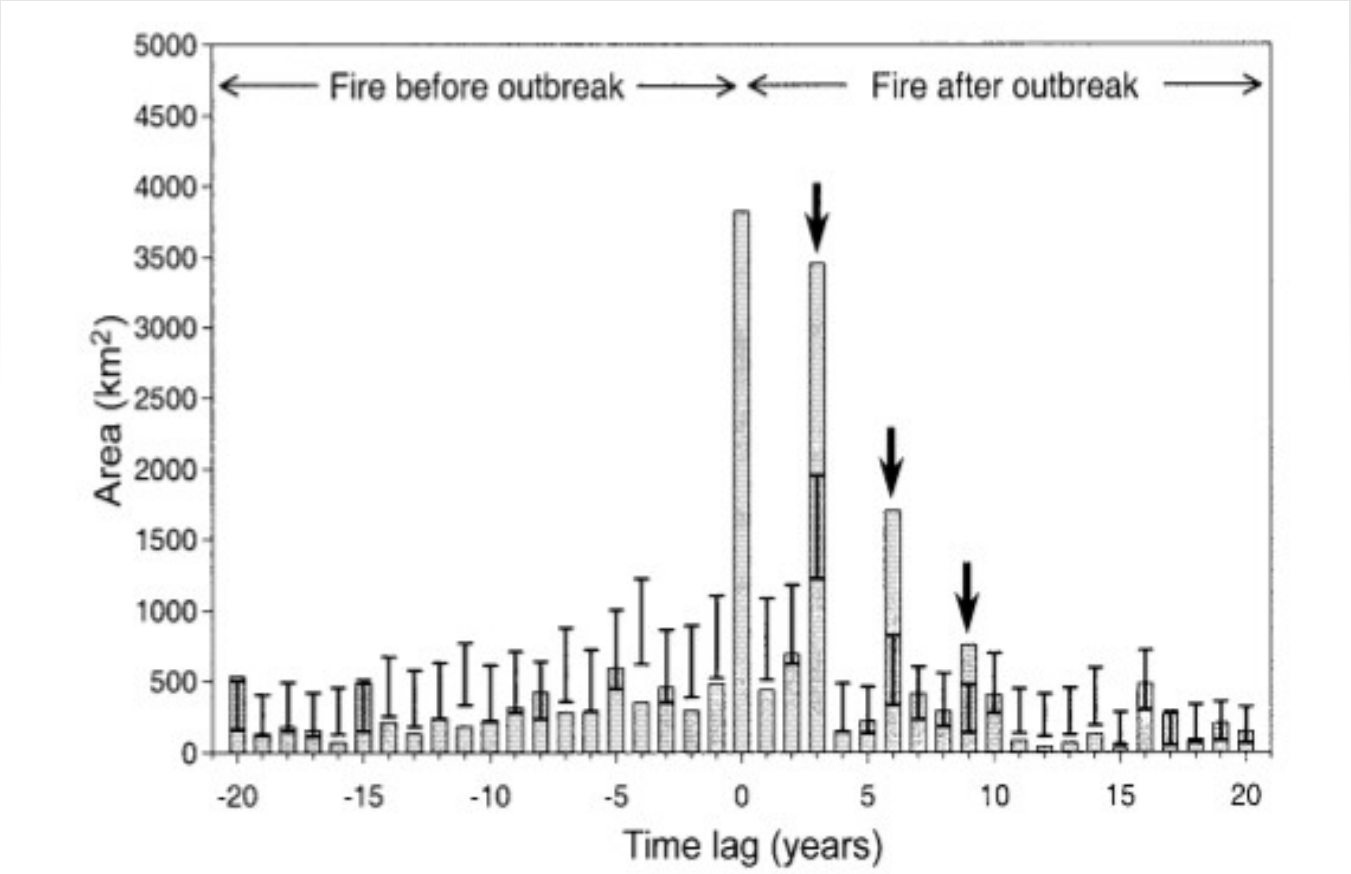


- Dispersal >25km
- Kills host within 5-6 years of severe defoliation
- Create pattern of widespread mortality
- Recurrence Interval: 25-40 years
- Duration: 6-12 years

Insect-fire interactions

- Trees killed by insects represent an increased fire risk, an idea suggested by many. (Baskerville, 1975 ; Stocks, 1982)
- Timing is important (Flemming et al. 2002)

More fires after outbreak?



- 6-10 years after SBW defoliation (Fleming 2002).

Post-SBW fire risk

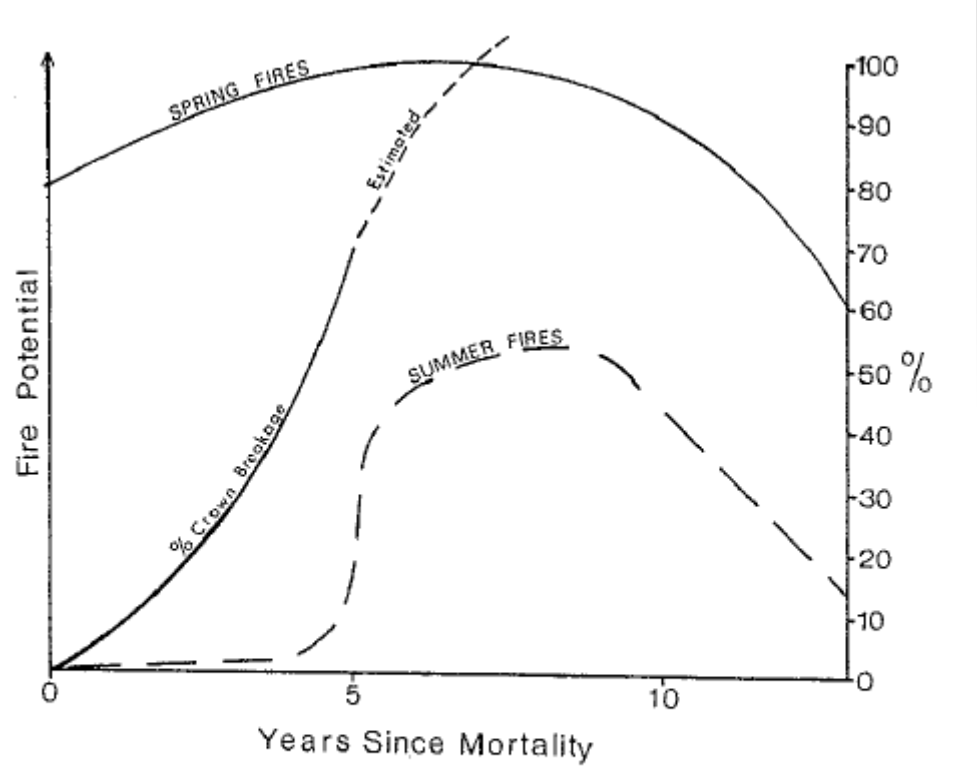


Figure 5. Schematic representation of spring and summer fire potential in Ontario spruce budworm-killed balsam fir stands, as influenced by surface fuel accumulation and understory vegetation.

- Fire potential varies depending on seasons (Stocks 1987)

Contradictory results in other system

Area burned in the western United States is unaffected by recent mountain pine beetle outbreaks

Sarah J. Hart[a,1], Tania Schoennagel[a,b], Thomas T. Veblen[a], and Teresa B. Chapman[a]

Hart, Sarah J., et al. "Area burned in the western United States is unaffected by recent mountain pine beetle outbreaks." Proceedings of the National Academy of Sciences 112.14 (2015): 4375-4380.

Do mountain pine beetle outbreaks change the probability of active crown fire in lodgepole pine forests?

Martin Simard,[1,3] William H. Romme,[2] Jacob M. Griffin,[1] and Monica G. Turner[1]

“Our results suggest that mountain pine beetle outbreaks in Greater Yellowstone may reduce the probability of active crown fire in the short term by thinning lodgepole pine canopies. “

Simard, Martin, et al. "Do mountain pine beetle outbreaks change the probability of active crown fire in lodgepole pine forests?." Ecological Monographs 81.1 (2011): 3-24.

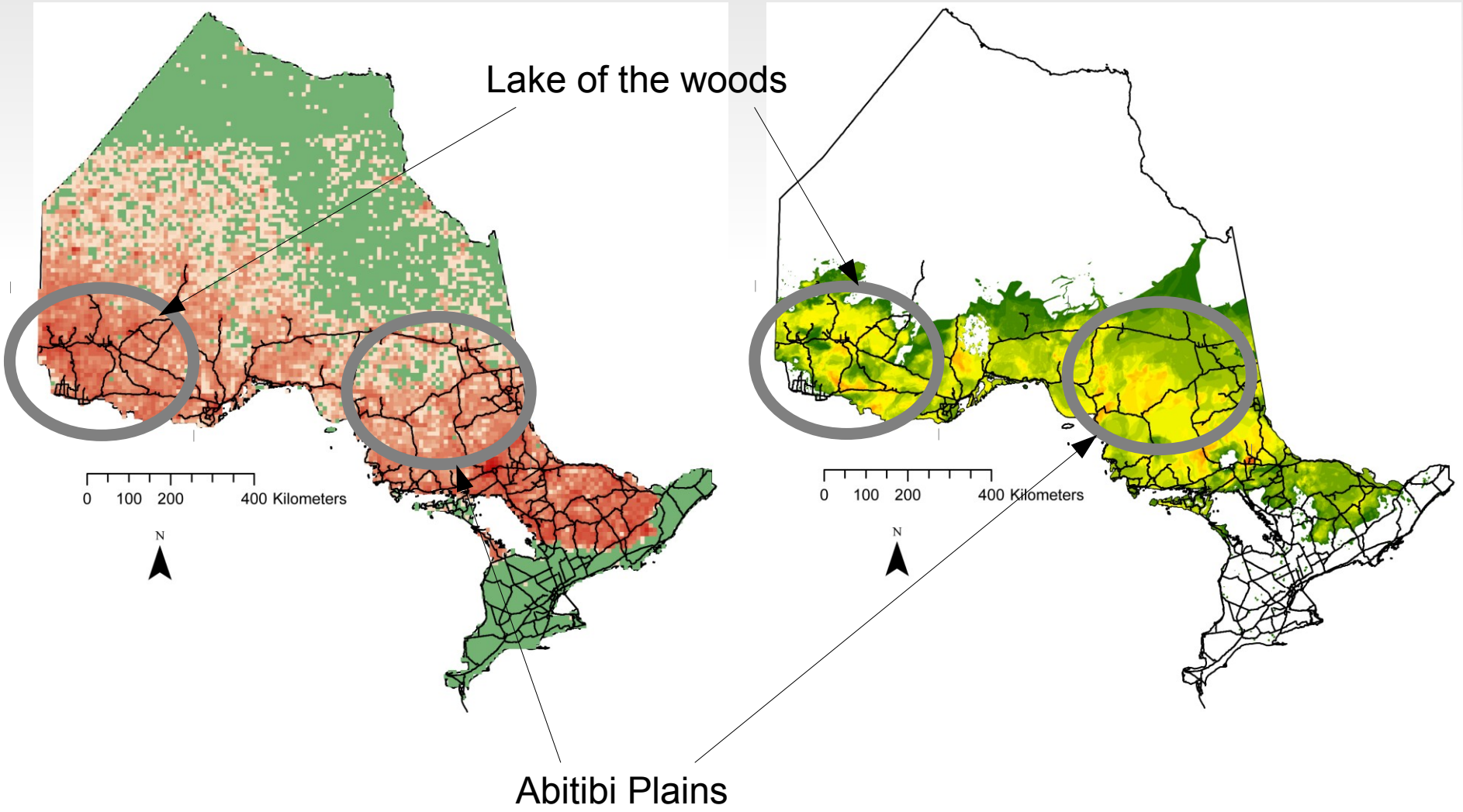
Objectives

- Looking at the probability of ignition in relation to cumulative SBW defoliation.
- **Does the inclusion of cumulative spruce budworm defoliation data increase our ability to predict the probability of ignition ?**
- **How important is SBW relative to other factors?**
- **Can we detect differences in ignition probability relative to season (i.e. spring and summer)?**

Fire and SBW in Ontario

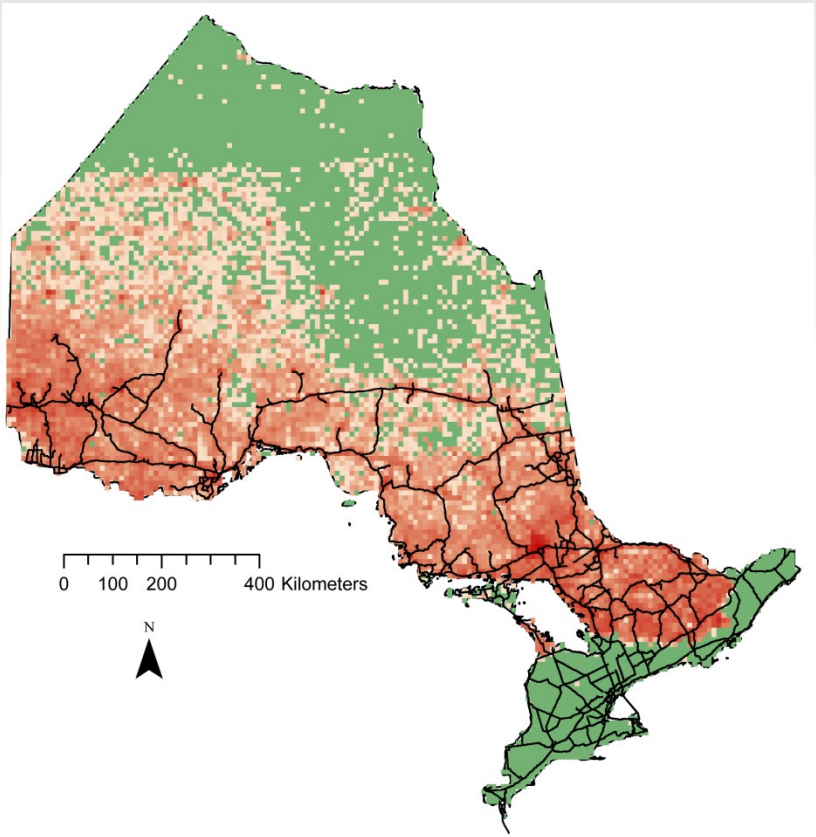
Fires – 1960 - 2004

Cumulative SBW – 1960 - 2004



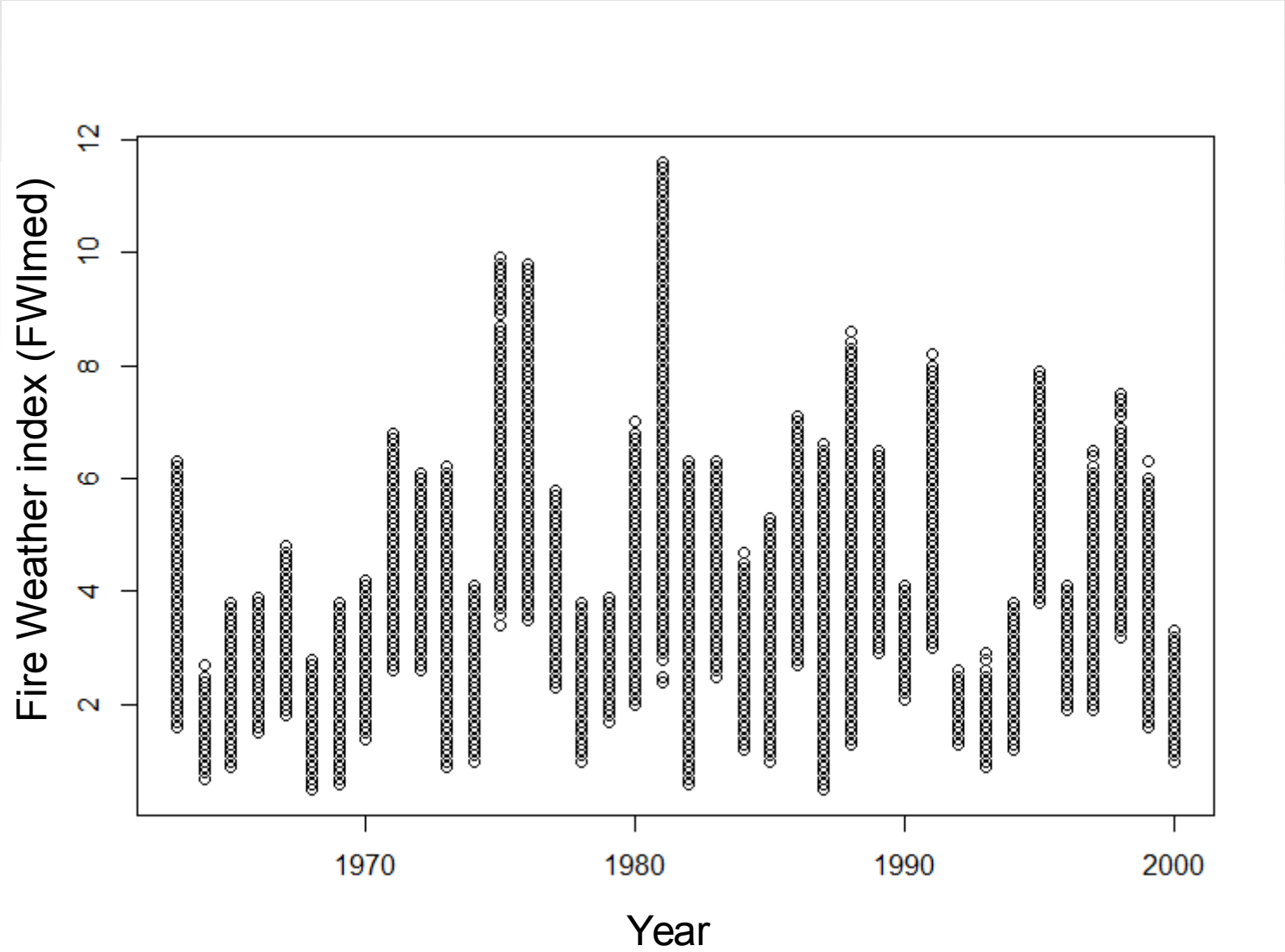
Fire data

Fires – 1960 - 2004



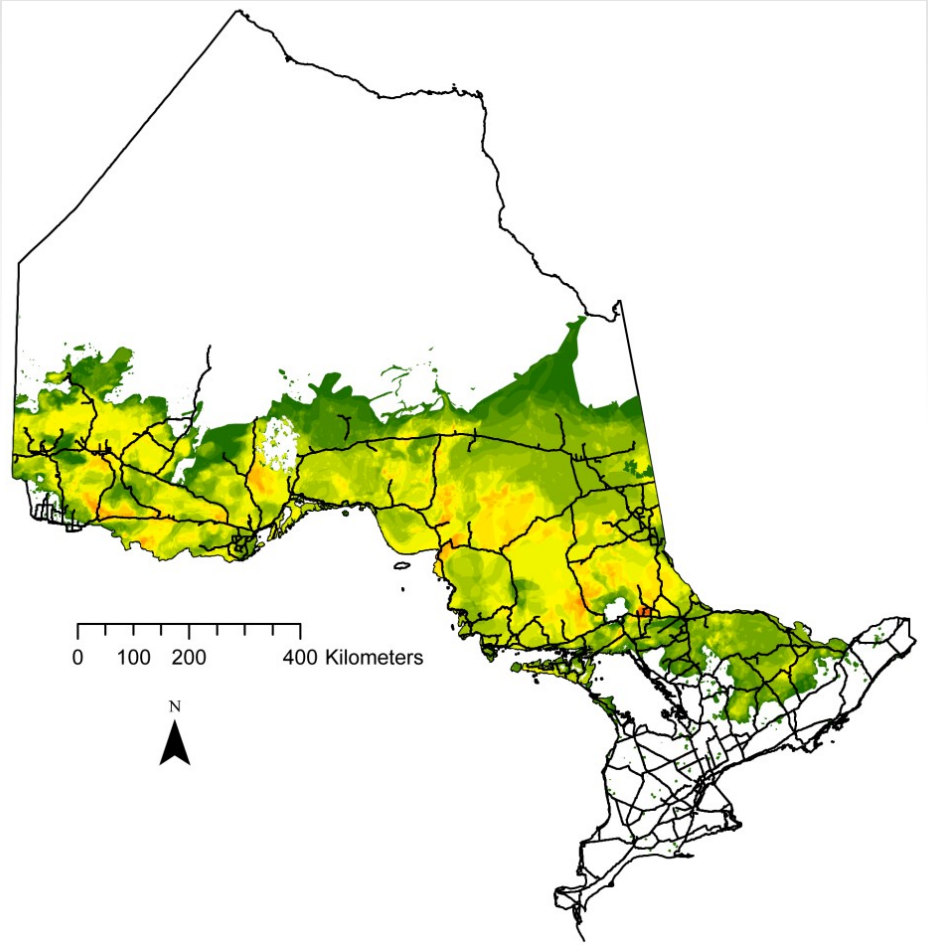
- Canadian Forest Fire Database
- All ignitions (1960-2004 including <200 ha), fire weather, average lightning count
- Summarized in a 10 km x10 km grid

Fire weather has temporal pattern

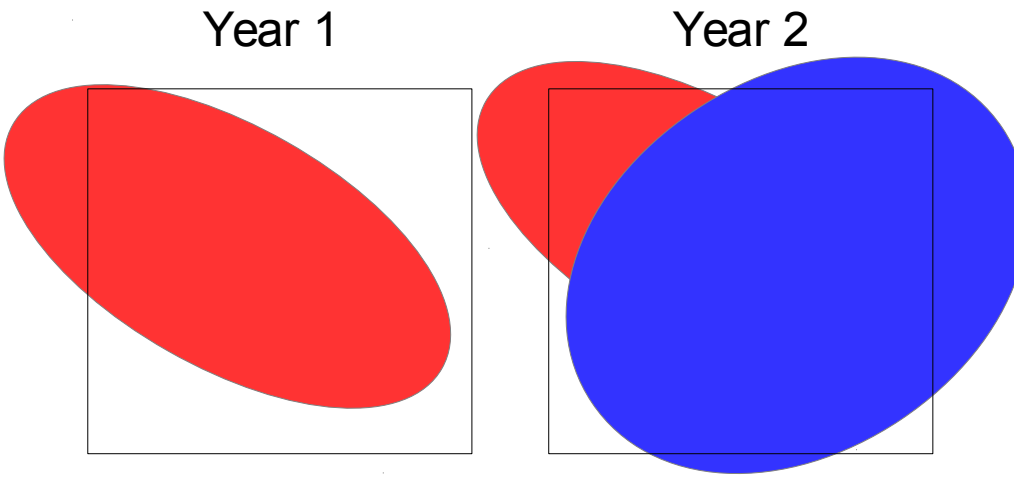


SBW data

Cumulative SBW – 1960 - 2004



- Grid size 10 km
- Proportion defoliated, moderate/highly
- Calculate from t= 0 to t=-10 years



Predictors

- Response Variable:
  - Presence-Absence of fires / 1 year / 10km cell
- Predictors
  - Cumulative defoliation (1 – 10 years)
  - Average lightning strike (yearly)
  - Seasonal Median:
    - Fine-fuel moisture
    - Drought code
    - Drought moisture code
    - Build-up Index
    - Fire weather index
    - Initial spread index

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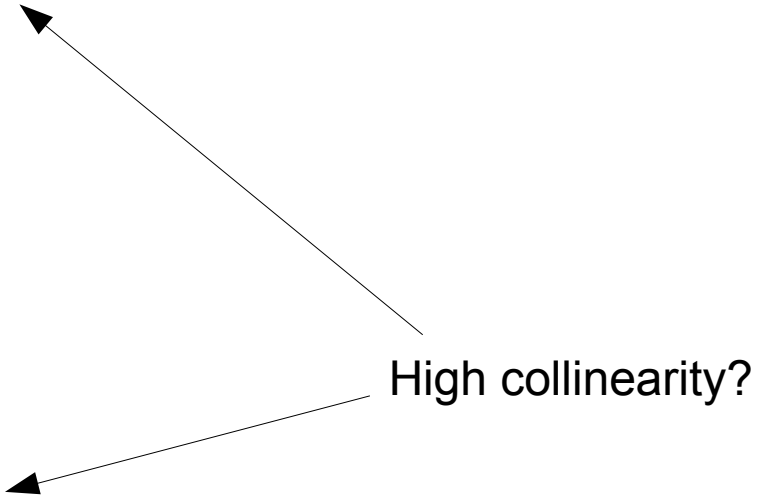
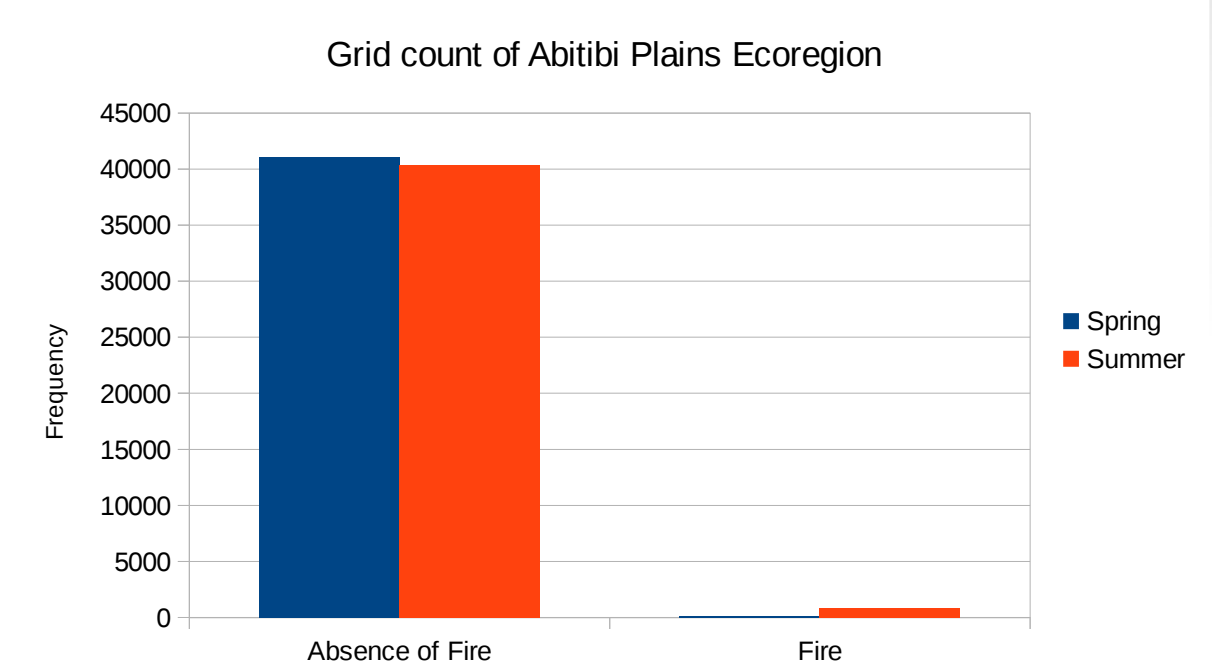


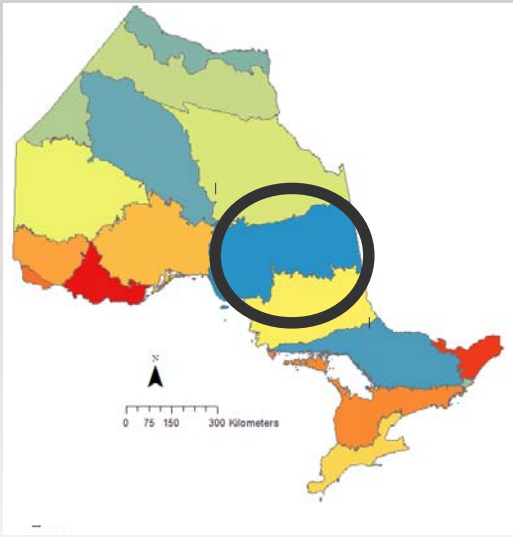
Too many zeros...



Data analysis

- Analysis restricted to:
  - Lightning caused ignitions
  - Intensive Fire Management Zone (2 ecoregions East-West gradient)
  - Spring vs. summer fires
  - Grid that had at least 1 fire during the time period
- Method:
  - Logistic Regression
  - General additive model (GAM) (to reduce temporal autocorrelation (Zuur 2009))
  - Selection process by AIC

Model : Abitibi Plains



Spring: Model explain well, adding SBW data is less important

Data		Best model				Deviance Explained (%)	Delta AIC: (Fire and Defoliation) – (Fire model)
Number of 0	Number of 1	Name	Coefficient	P-value		(~R2 adj)	
5898	182	Intercept	-4.52	***		22.1	-3.757
		Cumulative Defoliation (8 years)	0.27	**			
		Fine-Fuel Moisture Code (median)	0.79	***			
		Build-up Index (median)	-0.44	***			

Summer: Mode explain well, adding SBW data *increase* prediction of model

Data		Best model				Deviance Explained (%)	Delta AIC: (Fire and Defoliation) – (Fire model)
Number of 0	Number of 1	Name	Coefficient	P-value		(~R2 adj)	
19320	896	Intercept	-3.53	***		9.9	-26.024
		Cumulative Defoliation (1 year)	-0.26	***			
		Cumulative Defoliation (8 years)	0.30	***			
		Fine-Fuel Moisture Code (median)	0.60	***			
		Drought Code (median)	0.49	***			

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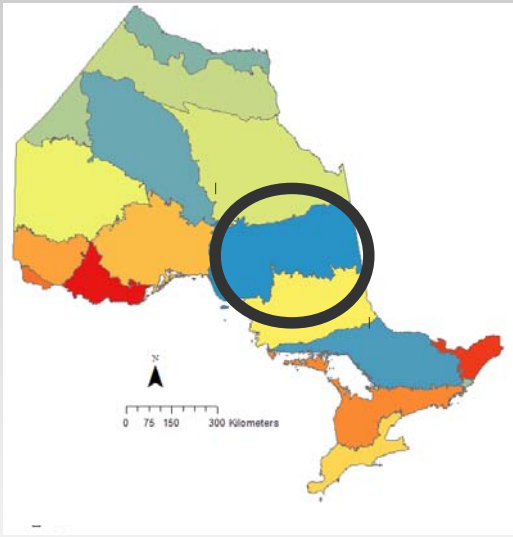

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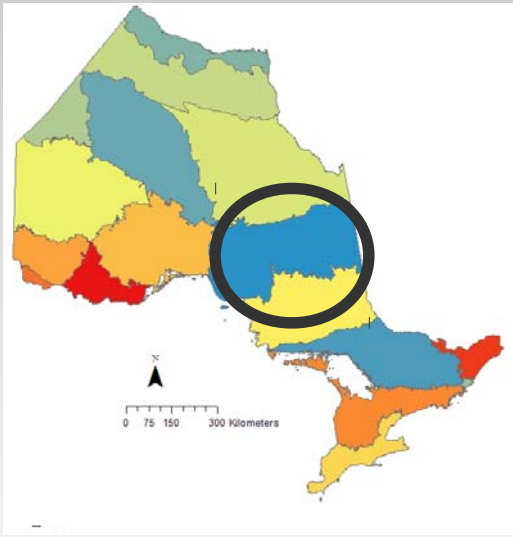

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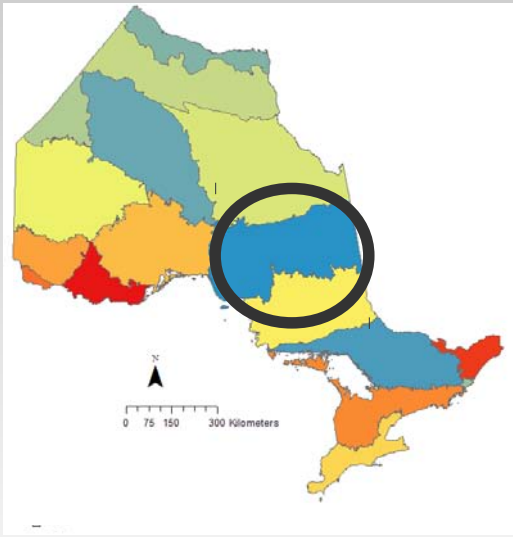
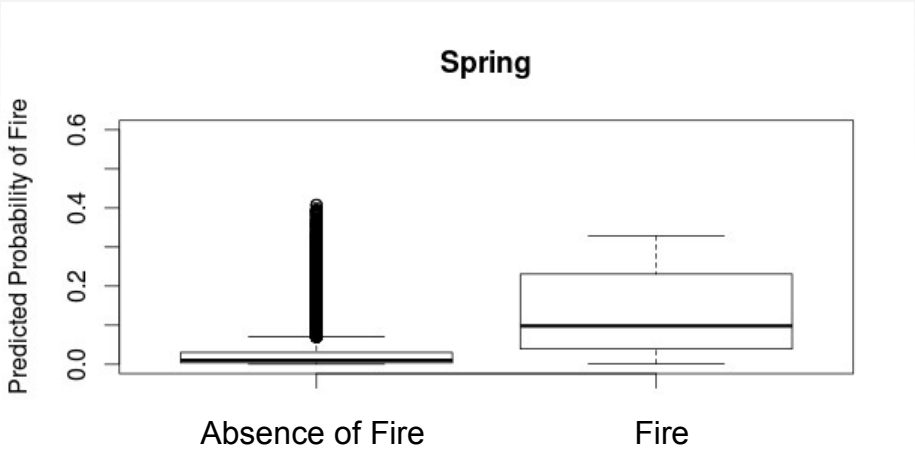
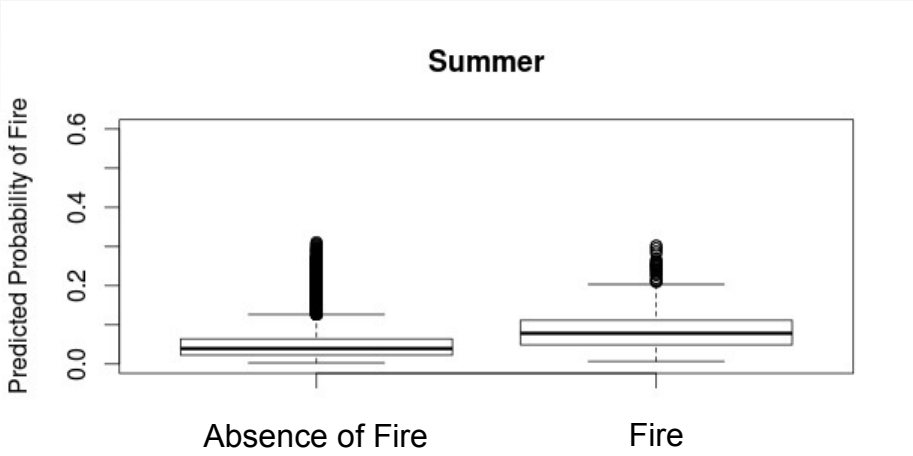
Model : Abitibi Plains Good Separation







ROC:Auc: Spring → 0.84
Summer → 0.76

Model : Lake of the Woods

Spring: Model explain well, adding SBW data is less important

Data		Best model			Deviance Explained (%)	Delta AIC: (Fire and Defoliation) – (Fire model)
Number of 0	Number of 1	Name	Coefficient	P-value	(~R2 adj)	
7041	293	Intercept	-4.08	***	26.2	-4.341
		Cumulative Defoliation (8 years)	0.31	**		
		Build-up Index (median)	0.78	***		
		Drought Code (median)	0.23	**		

Summer: Model explain well, adding SBW data *slightly increase* prediction of model

Data		Best model			Deviance Explained (%)	Delta AIC: (Fire and Defoliation) – (Fire model)
Number of 0	Number of 1	Name	Coefficient	P-value	(~R2 adj)	
9346	1902	Intercept	-1.84	***	10.2	-7.926
		Cumulative Defoliation (10 years)	0.14	**		
		Fine-Fuel Moisture Code (median)	0.47	***		
		Build-up Index (median)	0.51	***		

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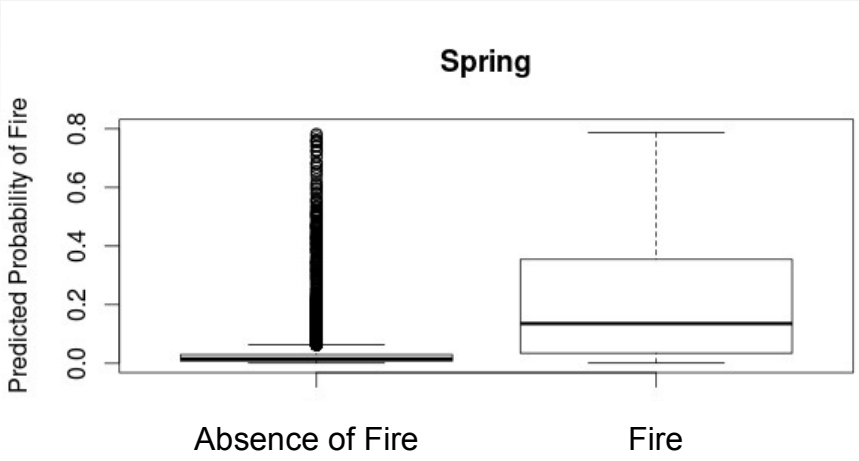
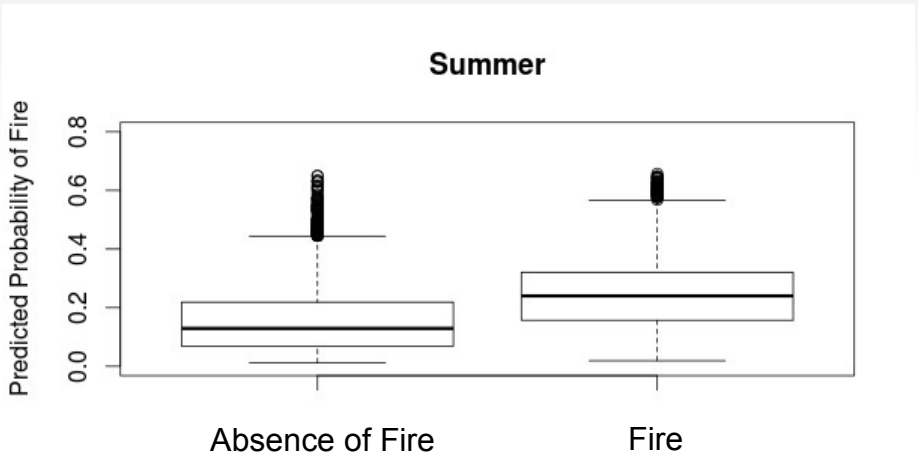
Model : Lake of the woods
Good separation





ROC:Auc: Spring → 0.84
Summer → 0.73

Comparison between sites

	Lake of the Woods	Abitibi Plains
Climate	Drier, more fires	More humid, less fires
Spring	Defoliation is less important	Defoliation is less important
Summer	Defoliation slightly increases prediction	Defoliation increases prediction

Summary

- **Does the inclusion of cumulative spruce budworm defoliation data increases our ability to predict the probability of ignition ?**

  → Yes, in areas less prone to fire and in the summer

- **How important is SBW relative to other factors?**

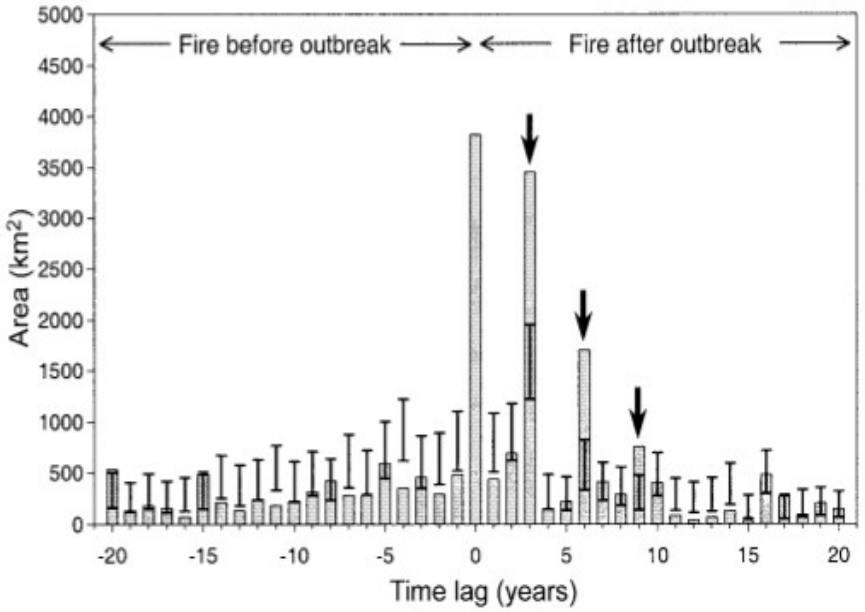
  → Dependent on season, less important in spring more important in summer

- **Can we detect differences in ignition probability relative to seasonality (i.e. spring and summer)?**

  → Yes model vary as function of season

What does this all mean?

- Adding SBW defoliation increases the prediction of fire but is highly dependent on spatial context
- Support for the literature (Increased probability during a 6-10 years window) but not everywhere
- Contrasting conclusion with Mountain pine beetle system



Acknowledgement

- Mike Wotton, University of Toronto
- Fonds de Recherche Nature et Technologies

Fonds de recherche Nature et technologies Québec

Questions?

References

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