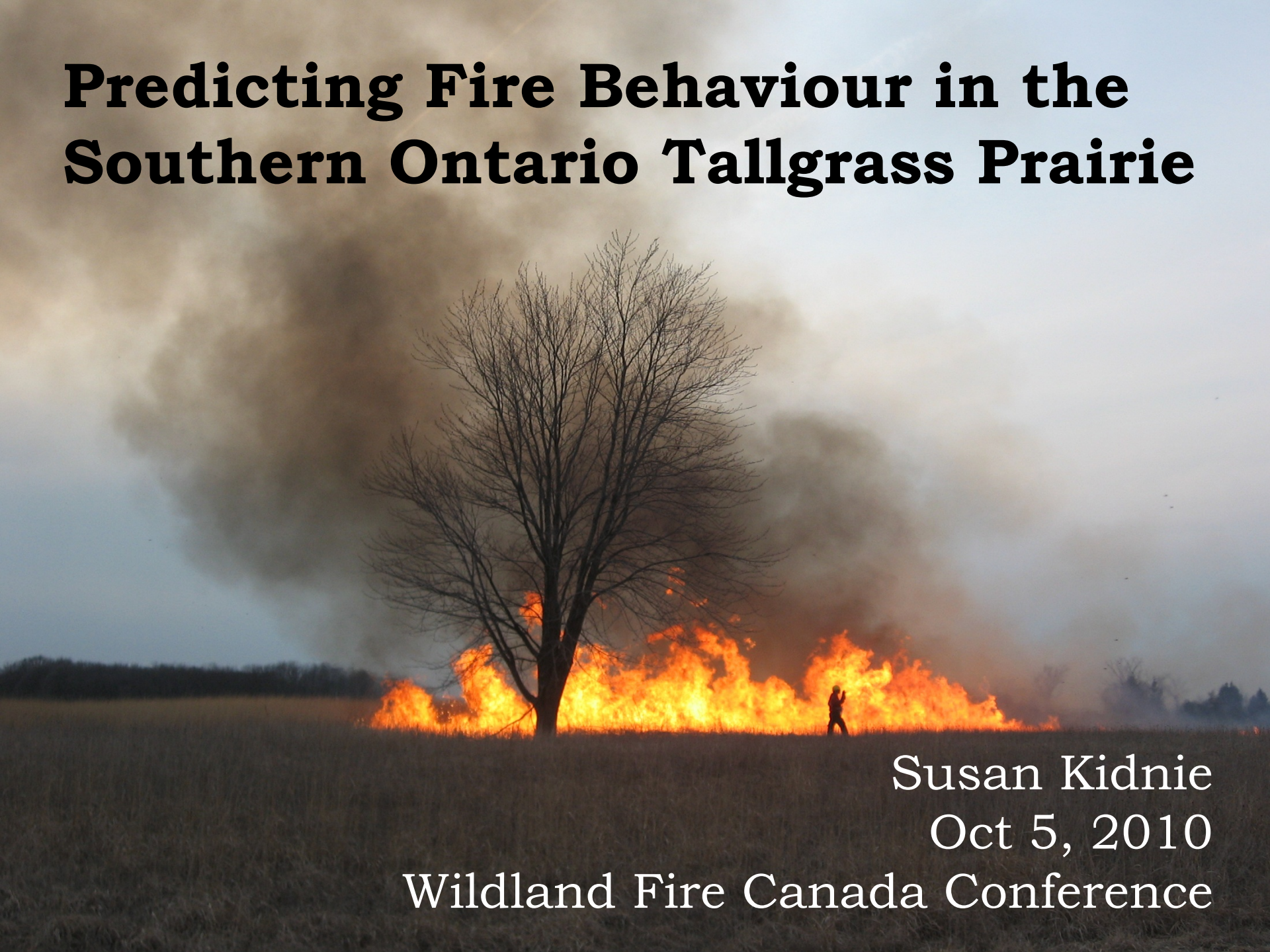
Predicting Fire Behaviour in the Southern Ontario Tallgrass Prairie



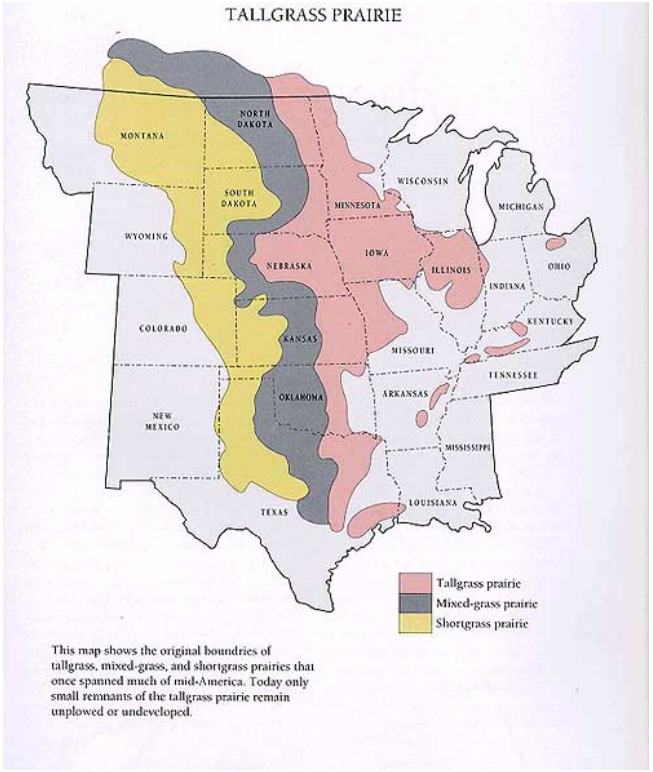
Susan Kidnie

Oct 5, 2010

Wildland Fire Canada Conference

The Tallgrass Prairie Ecosystem

- The tallgrass prairie was once a widespread ecosystem found throughout the central US and southern Canada
  - Home to 100's of species of grasses, forbs, animals, birds and insects (including endangered species)
- Its existence is the result of a delicate environmental balance – fire, drought and herbivory



http://www.museum.state.il.us/exhibits/midewin/grasslandmap.html

Tallgrass Prairie Species

Warm-season grasses

Cool season grasses and forbs

Fire and the Tallgrass Prairie

- Fire is essential component in:
  - Maintaining diversity
  - Preventing invasion of woody/invasive species

- How does fire impact tallgrass community structure?
  1. Alters conditions at soil surface
  2. Excludes non-TGP and woody species
  3. Alters nitrogen availability

Fire and the Tallgrass Prairie

- Removing fire removes these benefits
- Prescribed burning is used in the restoration of tallgrass prairie sites
  - One of the most economical habitat management tools available but also carries responsibilities on the part of the practitioners
  - Low Complexity Burn Program in Ontario

Objectives

Byram's Fireline Intensity Equation:

$$I = H \times W \times R$$

Where: I= Fireline intensity (kW/m)

H=Heat of combustion of fuel consumed (kJ/kg)

W= Load of the Fuel Consumed (kg)

R= Rate of spread (m/s)

Objectives

Byram's Fireline Intensity Equation:

$$I = H \times W \times R$$

H= Heat of Combustion

1. Do differences in heats of combustion of different tallgrass prairie species contribute to variability observed in fire intensity?

Objectives

Byram's Fireline Intensity Equation:

$$I = H \times W \times R$$

W= Fuel Load

2. Develop a rapid fuel load assessment technique to assist prescribed burn managers in estimating fuel load.

Objectives

Byram's Fireline Intensity Equation:

$$I = H \times W \times R$$

R= Rate of Spread

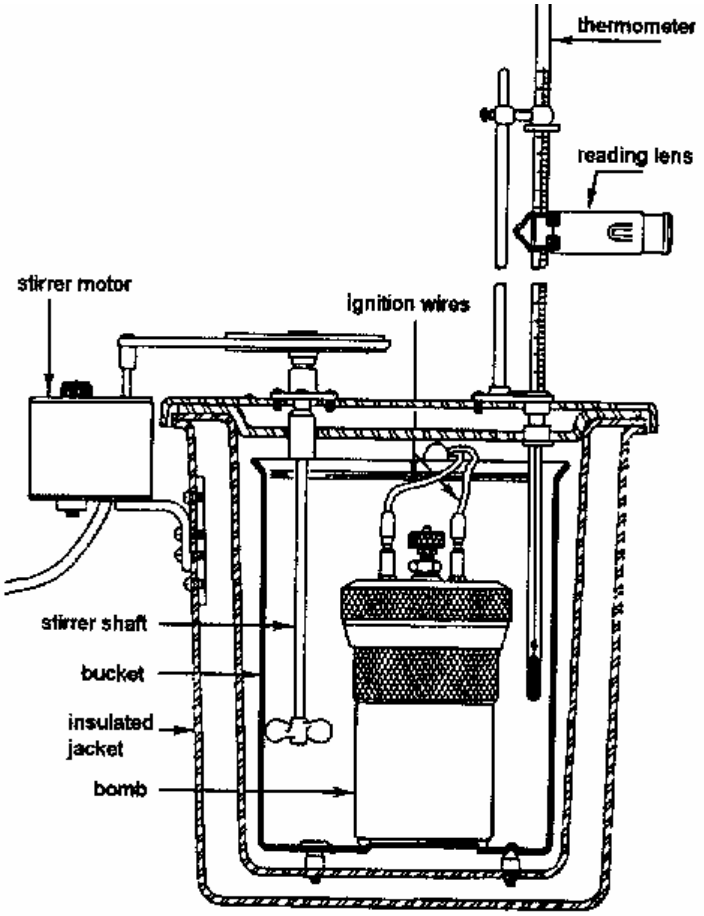
3. Assess the accuracy of different fire behaviour prediction models in predicting rate of spread in the southern Ontario tallgrass prairie.

1. Heat of Combustion

- *Do different tallgrass species release significantly different amounts of energy (per unit mass) (and hence lead to different fireline intensities)?*
  - *Generally in fire behaviour modelling, a constant value is used and thought to be a good assumption*
    - *Canadian FBP System uses 18,000 kJ/kg*
    - *American BehavePlus uses 18,622 kJ/kg*
  - *Compare: warm season grasses, cool season grass and forbs*

1. Heat of Combustion

- Methods
  - Collected grass samples from field (in the fall)
  - Dried and ground samples in lab
  - Used a PAR 1341 Oxygen Bomb Calorimeter to determine heat of combustion



Oxygen Bomb Calorimeter

1. Heat of Combustion

Results

Species	Mean (kJ/kg)	Std Dev	Minimum (kJ/kg)	Maximum (kJ/kg)	N
Big Bluestem	17,779	488	17,124	18,686	10
Little Bluestem	17,787	339	17,326	18,226	5
Indian Grass	17,351	446	16,788	17,919	9
Switchgrass	17,601	67	17,553	17,649	2
Forbs	18,244	936	17,266	19,312	4
Kentucky Bluegrass	17,162	1307	16,238	18,087	2
Brome Grass	15,419	25	15,402	15,437	2

1. Heat of Combustion

- Statistical Analysis
  - Individual hypothesis testing between each species to determine statistical significance existed between means of species

1. Heat of Combustion

- Results cont.
  - Difference in means between brome grass and all other grass except Kentucky bluegrass (another cool season grass)
  - Average difference in means of 13% between brome grass and other grasses and forbs

Photo source: http://www.fao.org/ag/AGP/AGPC/doc/gallery/pictures/bromusin.htm

1. Heat of Combustion

- Discussion
  - Relatively small absolute difference in means of brome grass and other species (average of13%)
  - Compared to variability of rate of spread and fuel load- very small difference, probably not affecting fire intensity significantly

2. Fuel Load

- Fuel load is critical in determining fire intensity
  - Greater the fuel load, the more intense the fire
  - Important factor to consider when developing a prescribed burn plan for a site
- There is a wide range of fuel loads in tallgrass prairie systems
  - no real guides or tools available to objectively estimate these load

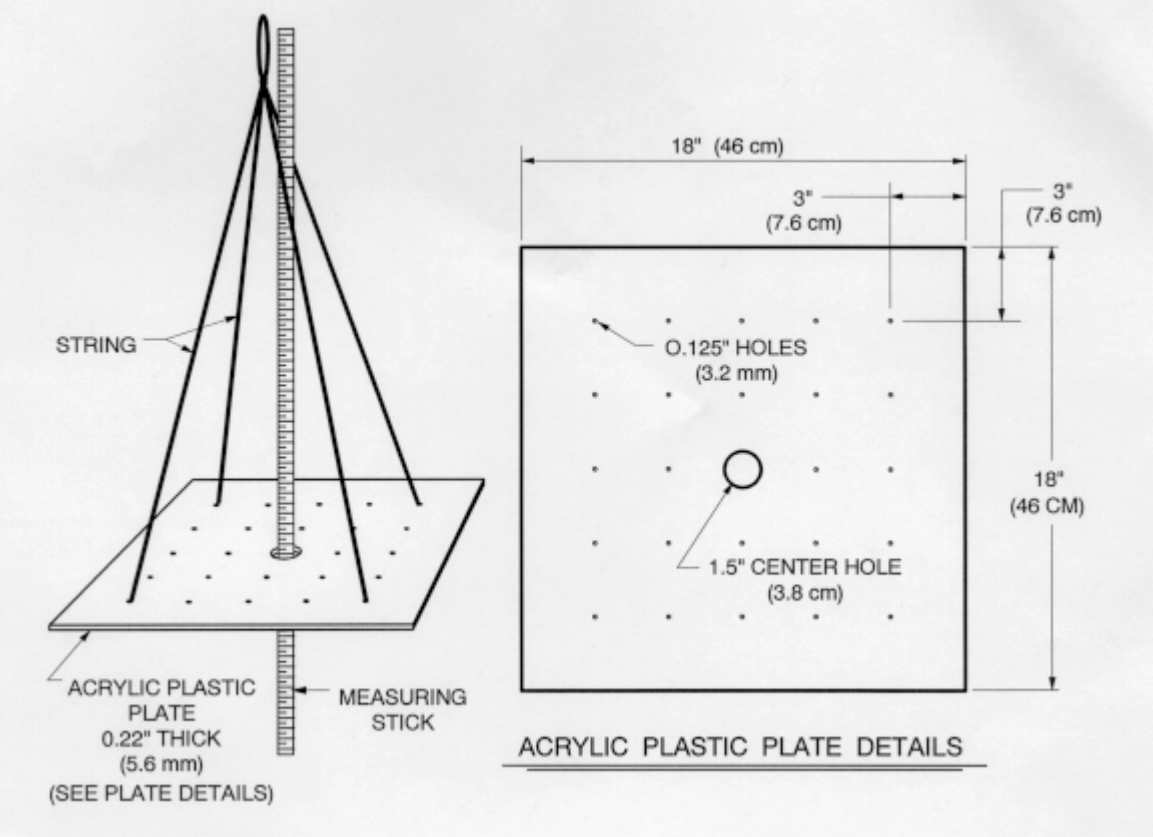
2. Fuel Load

- Fuel load collection from fall 2007 and fall 2008
  - Over 400 samples
- Sampling area ranged from Windsor to Barrie to Peterborough area

2. Fuel Load

- Goal of rapid fuel load assessment is to develop a regression relationship between a known amount of standing vegetation and a predictive variable
  - Plant height
  - Vegetation density
  - Cover
  - Visual obstruction
- Necessary to calibrate models to specific fuel types
- Testing 3 techniques- falling plate meter, Robel pole and grass height

2. Falling Plate Meter



Rayburn and Lozier, 2003

2. Falling Plate Meter

2. Robel Pole/Visual Obstruction

Robel pole being used to estimate fuel load

2. Fuel Load

- Analysis
  - Linear regression models
    - Individual species and site averages
  - Box-Cox Test (Box and Cox 1964) to determine if transformations were necessary

2. Results

Falling Plate Meter Linear Regression Model

Fuel Type	RMSE	Adjusted r2	n
All Observations	0.17	0.37	309
Site averages	0.21	0.56	28
Big bluestem and Indian grass	0.16	0.27	178
Little bluestesm and switch grass	0.15	0.75	34
Mixed grasses	0.17	0.37	95

Robel Pole Linear Regression Models

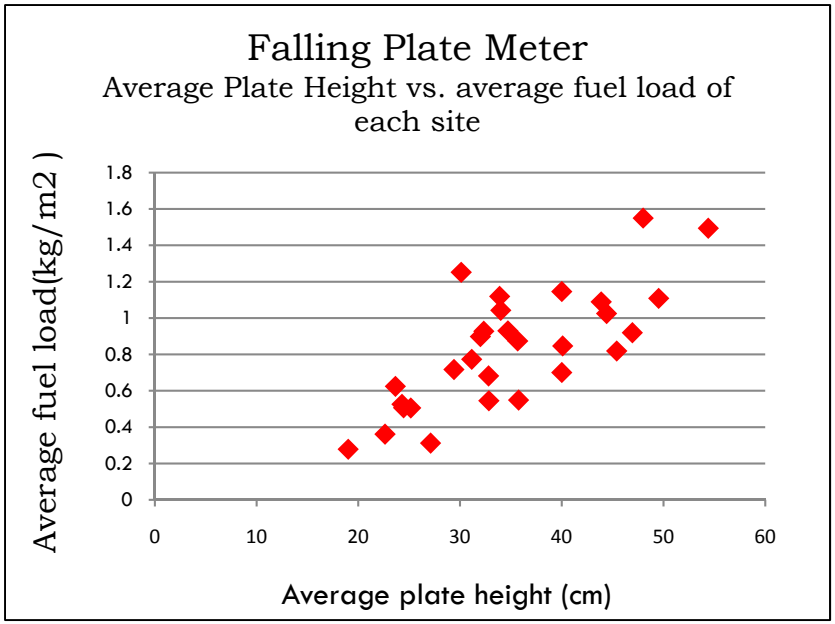
Fuel Type	RMSE	Adjusted r2	n
All Observations	0.28	0.38	179
Site averages (all species)	0.2	0.61	17
Big bluestem	0.28	0.16	49
Little bluestesm	0.25	0.76	13
Indian grass, Switch grass and Mixed grasses	0.29	0.3	111

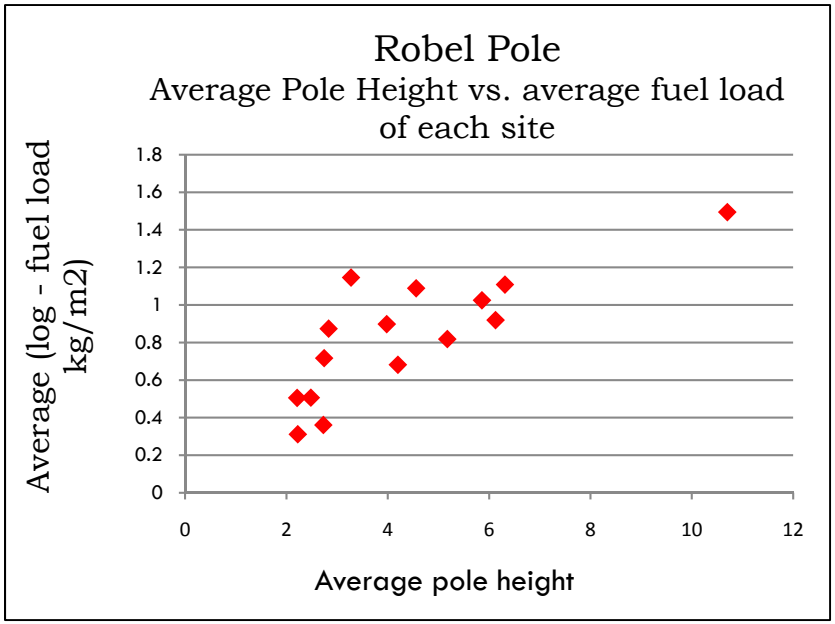
Grass Height Linear Regression Models

Fuel Type	RMSE	Adjusted r2	n
All Observations	0.19	0.21	300
Site averages	0.15	0.37	27
Big bluestem, little bluestem and mixed grass (sandy soils)	0.16	0.48	150
Big bluestem, little bluestem and mixed grass (clay soils)	0.19	0.054	78
Indian Grass	0.1	0.58	64

2. Results

- Robel Pole and Falling plate meter
  - Site average model

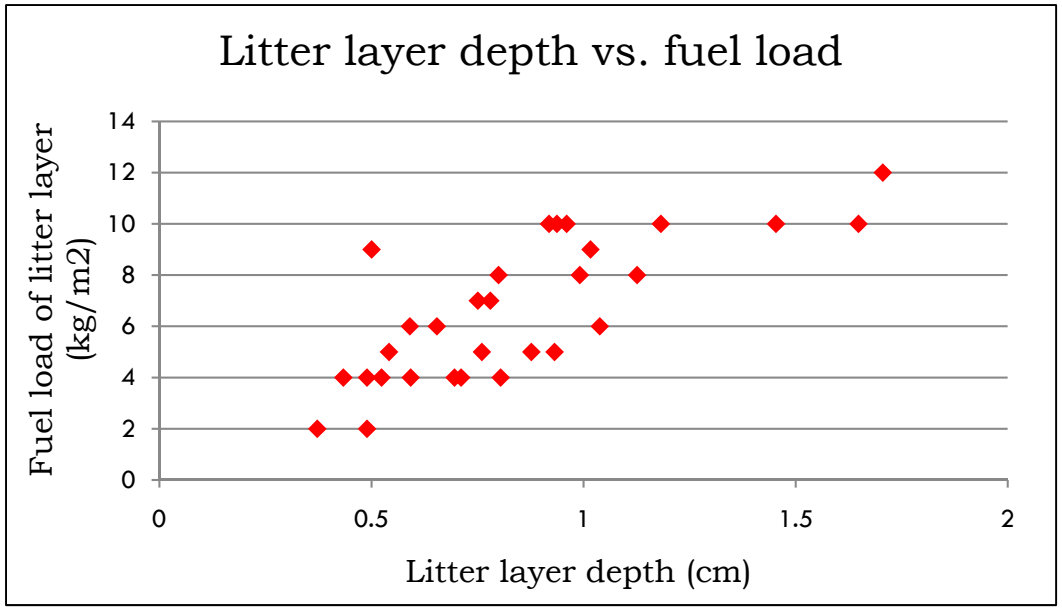




2. Results

- Default FBP grass fuel load: 0.3 kg/m^2
- Average fuel load from this study: 0.6 kg/m^2

- Litter layer linear regression model



3. Rate of Spread

- FBP has 17 fuel types
  - 2 grass fuel types: standing and matted grass
  - Experimental data from Australian grass fires
    - *How well does this model predict fire behaviour in tallgrass prairie?*

3. Fire Behaviour

- Spring 2008 field season – 6 burns
- Spring 2009 field season – 5 burns

3. Rate of Spread

- Measure rate of spread with rate of spread timers
- Measure:
  - Fire characteristics
    - Weather variables during fire
    - Fuel moisture at time of fire
    - Fuel load

3. Fire Behaviour

- Fire Behaviour Models
  - Canadian FBP System (Forestry Canada Fire Danger Group, 1992)
  - American BehavePlus (Rothermel (1972) fire spread model)
  - Australian grass fire spread model (Cheney and Gould, 1997)

- Fuel Moisture
  - Actual fuel moisture
  - Fine Fuel Moisture Code (FFMC) – FBP System
  - Wotton's grass fuel moisture model (Wotton, 2009)

3. Rate of Spread

Results

Model	Fuel Moisture	r2	Adjusted r2	n
FBP - log	Actual	0.003	-0.088	9
FBP – log	FFMC	0.0048	-0.045	15
FBP – log	GFM	0.11	0.03	15
Australian - log	Actual	0.54	0.5	9
Australian - log	FFMC	0.18	0.14	15
Australian - log	GFM	0.23	0.19	15
BehavePlus (FM3) – log	Actual	0.62	0.58	9
BehavePlus (FM3) – log	FFMC	0.15	0.11	15
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3. Rate of Spread

- FBP – very poor relationship between observed and predicted rates of spread
- Australian grass fire spread model and BehavePlus preformed similarly well
  - Recommendation is Australian grass fire spread model
- Need to develop a tallgrass prairie specific fuel moisture model

Applications

- Created **Field Guide for Estimating Fire Behaviour in Ontario's Tallgrass Prairie**
  - Includes Robel pole info and photo series
  - New Australian fire spread model
- Similar feel and flow to the Red Book, but different models and no indicies
- Guides are available
  - In depth presentation on how to use the guide at Tallgrass Workshop on Friday
  - Also available October and November for individual consultations

Summary

- Differences in heat of combustion not likely contributing to differences in fire behaviour
- Fuel load in TGP is greater than default value being used
  - Robel pole and falling plate meter models to estimate fuel load
- FBP has weak relationship between observed and predicted ROS, recommend Australian grass fire spread model
  - Need for more accurate grass fuel moisture model

Acknowledgements

Many thanks to the project team: Mike Wotton, Mark Emery, Bill Droog, Bruce Dunning and Pat Payette.

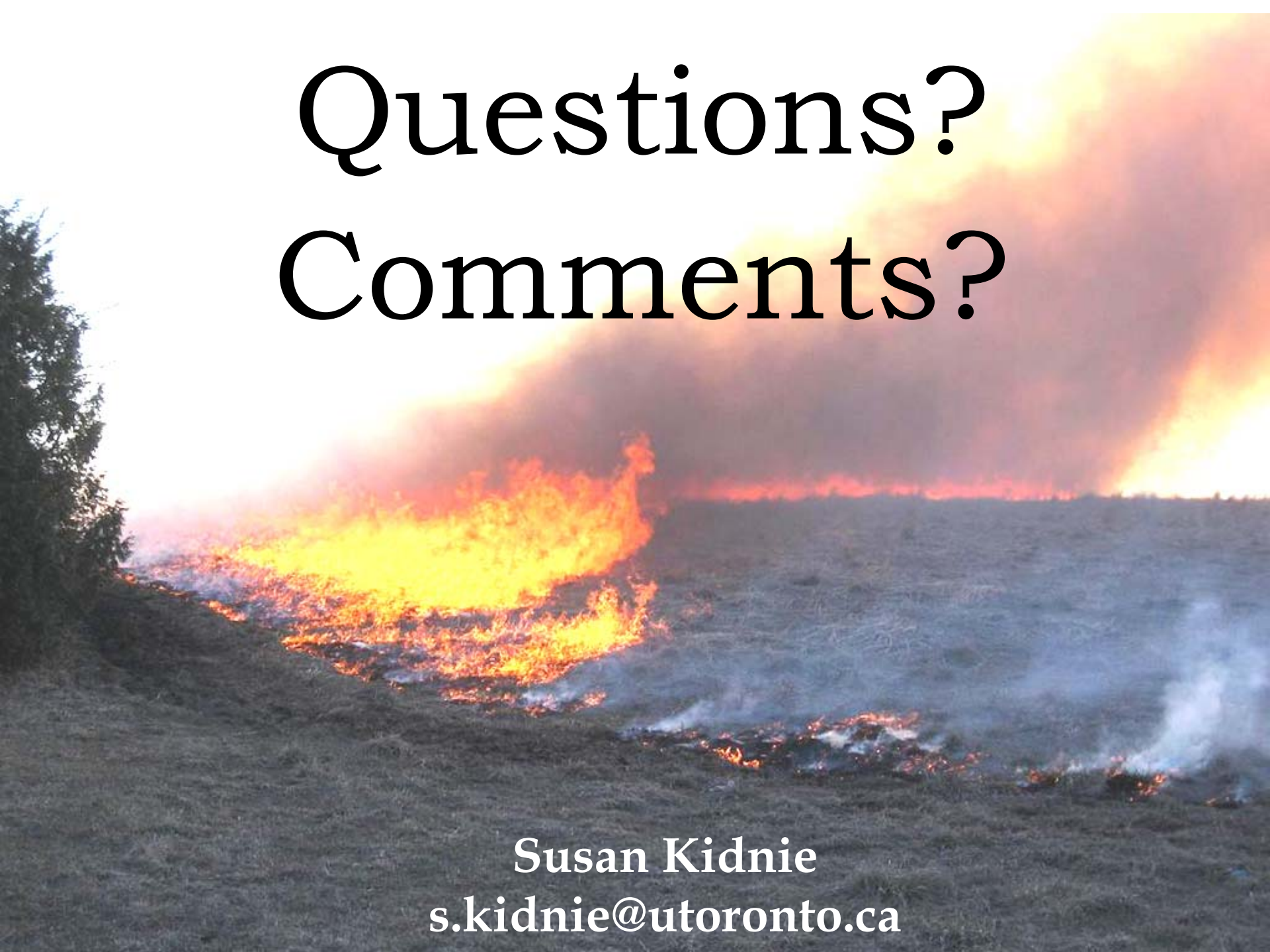
Natural Resources Canada – Canadian Forest Service
The Government of Canada Habitat Stewardship Program for Species at Risk

Ontario Ministry of Government Services-Ontario Public Service Innovation Fund
Ontario Ministry of Natural Resources-Aviation and Forest Fire Management
Ontario Ministry of Natural Resources-Ontario Stewardship Opportunity Fund
Ontario Ministry of Natural Resources-Species at Risk Stewardship Fund

Elgin Stewardship Council

Faculty of Forestry, University of Toronto

Questions?
Comments?



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