The Fire Monitoring, Accounting and Reporting System (FireMARS) in support of National Forest Carbon Accounting

NRCan Initiative
Earth Science Sector (ESS)
Canadian Forest Service (CFS)

Presented by - Timothy J. Lynham (CFS)

With assistance from…

Canadian Space Agency (CSA)
- **$1.5 million over 5 years**

Canadian Fire Management Agencies
- **logistic support from NWT, AB, SK, MN, ON**

Fire Monitoring, Accounting and Reporting System

Daily processes

- collect hotspot data
- flag potential satellite images
- flag fire wx data for fire events

End of fire season processes (immediate)

- acquire coarse res. national satellite data (SPOT-VGT, MODIS)
- acquire fine res. satellite data for selected fires (LANDSAT)
- request fire polygons from fire mgt. agencies (LFDB)

End of fire season processes (annual)

- coarse res. national fire mapping by year end
- calibration of coarse res. burned area from fine res. burned area
- prepare National Burned Area Composite (NBAC)
- apply CanFIRE to calculate fuel consumption & tree mortality
- estimate direct & post-fire emissions with Carbon Budget Model (CBM-CFS3)

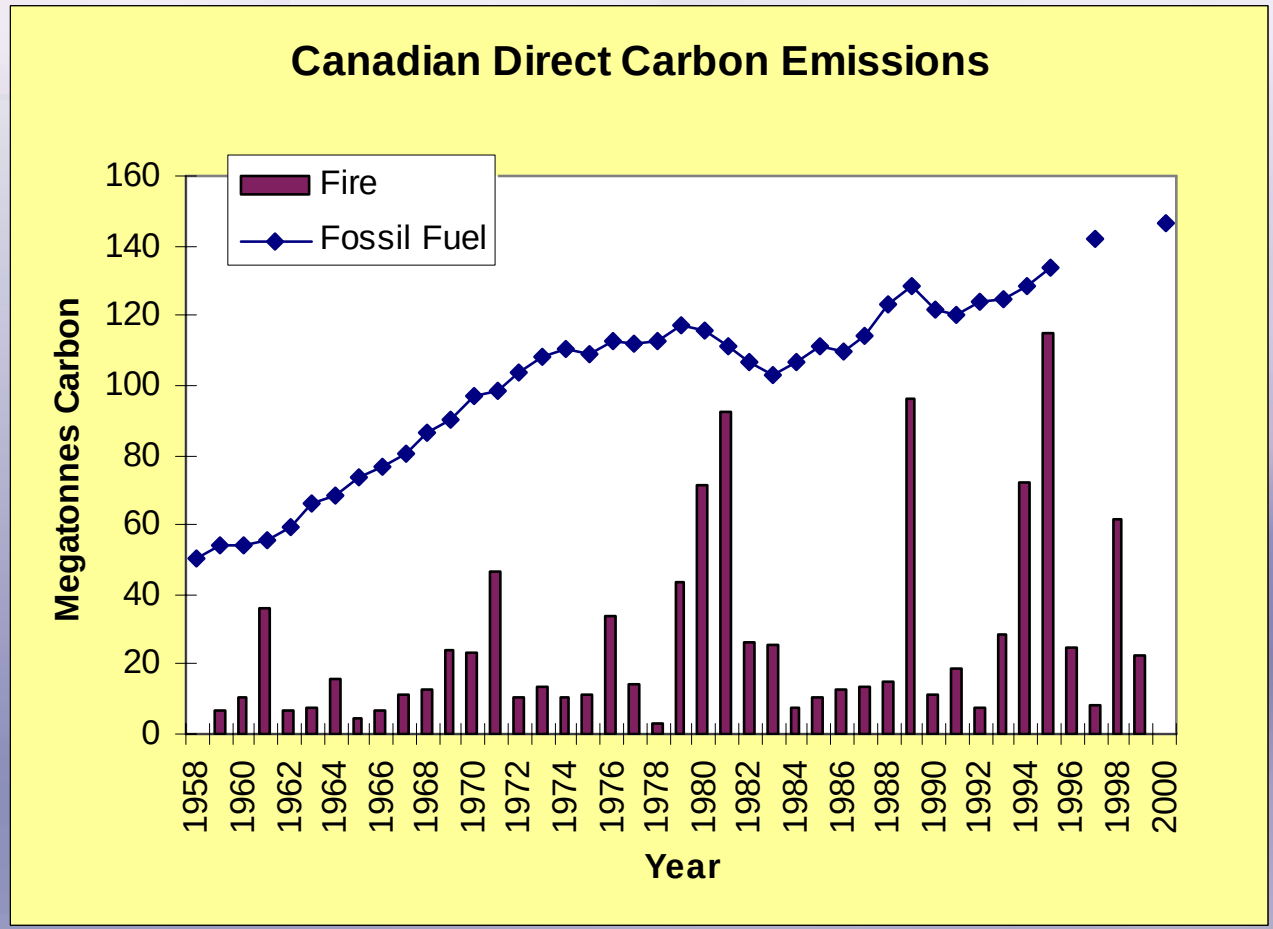
The Canadian Wildland Fire Information System

- **A kitbag of fire management tools**
  - **spatial data & maps for weather, fire weather, fire behavior and hotspot monitoring**
  - **fire occurrence prediction models**
  - **regional satellite images**
  - **database for Canadian weather network**
  - **large fire database for Canada**

FireMARS adds:

- **satellite data acquisition/archiving and fire mapping**
- **carbon emissions reporting system for wildfires**
- **wildfire data warehouse (National Forest Fire Facility)**
- **a web portal for accessing fire statistics & information**

Why are Wildfire Emissions Important?



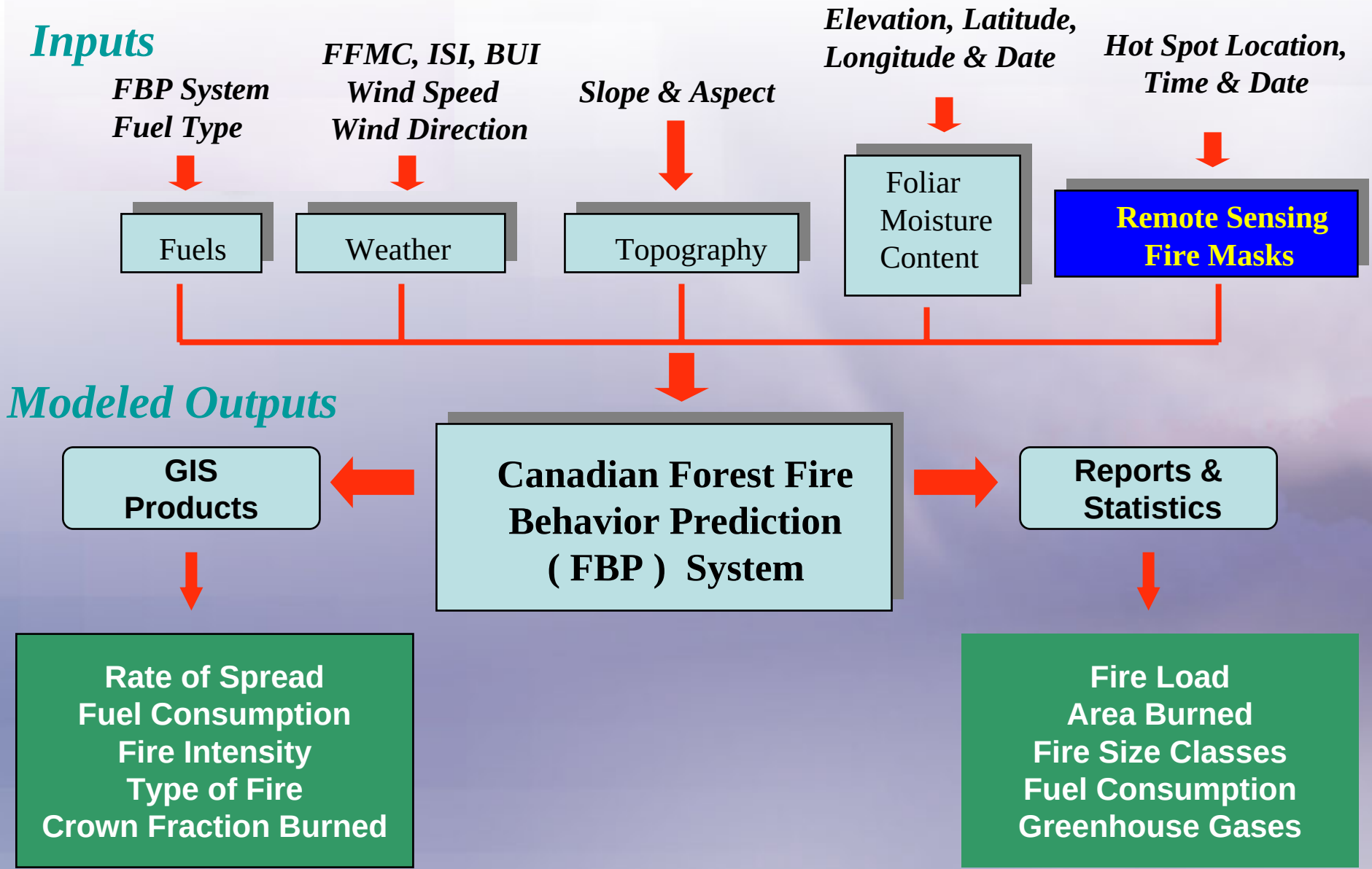
Sources:
Fossil fuels: www.nrcan.gc.ca/es/ceo/update.htm
Fire: Amiro, B.D. *et al.* 2001. Can. J. For. Res. 31: 512-525

Why use Earth Observation data for fire detection, mapping, and reporting?

- the product is nationally consistent
- it's internationally defensible
- it's timely for annual, operational reporting
- it provides an estimate of national burned area by Sept. 15 of the following year
- updates to the estimates are possible in later years as additional data become available

Some History – Part A

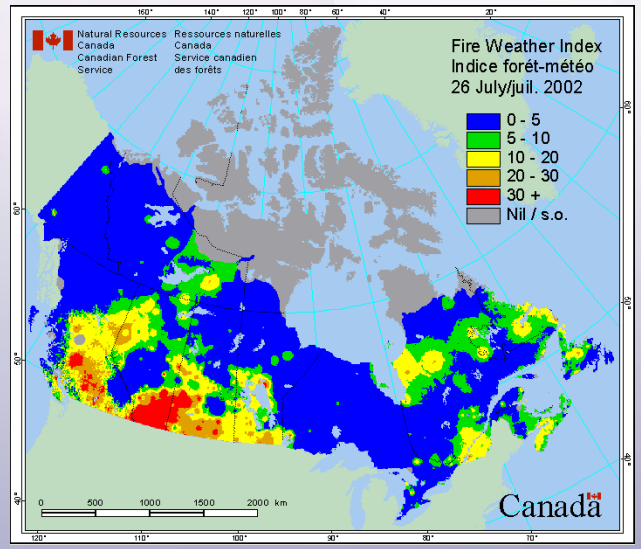
- 1989 - CFS released the Fire Behavior Prediction (FBP) System

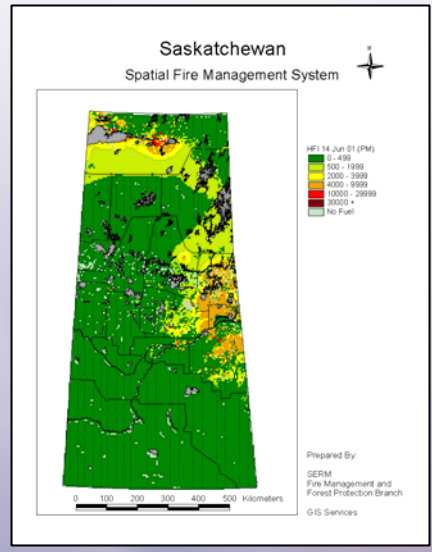

Inputs
FBP System
Fuel Type
FFMC, ISI, BUI
Wind Speed
Wind Direction
Slope & Aspect
Elevation, Latitude,
Longitude & Date
Hot Spot Location,
Time & Date
Fuels
Weather
Topography
Foliar
Moisture
Content
Remote Sensing
Fire Masks
Modeled Outputs
GIS
Products
Canadian Forest Fire
Behavior Prediction
(FBP) System
Reports &
Statistics
Rate of Spread
Fuel Consumption
Fire Intensity
Type of Fire
Crown Fraction Burned
Fire Load
Area Burned
Fire Size Classes
Fuel Consumption
Greenhouse Gases

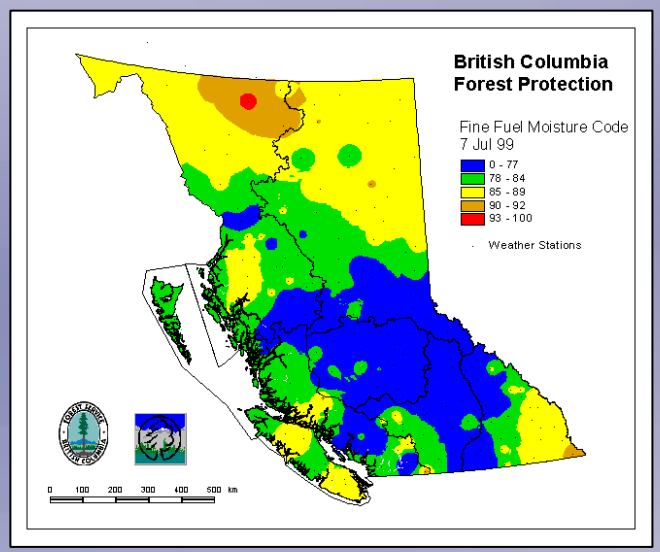
Some History – Part B

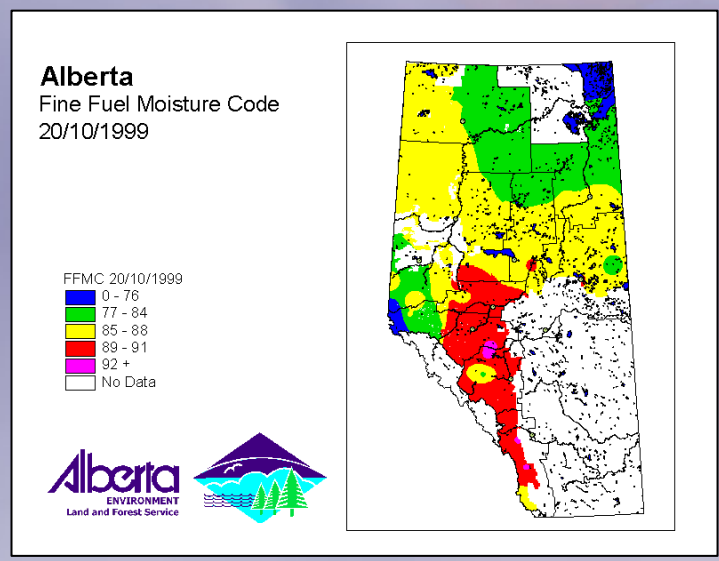
- *1990s – CFS (NoFC) developed the spatial Fire (sFMS) Management System and Canadian Fire Effects Model (CanFIRE)*

sFMS Canadian Implementations

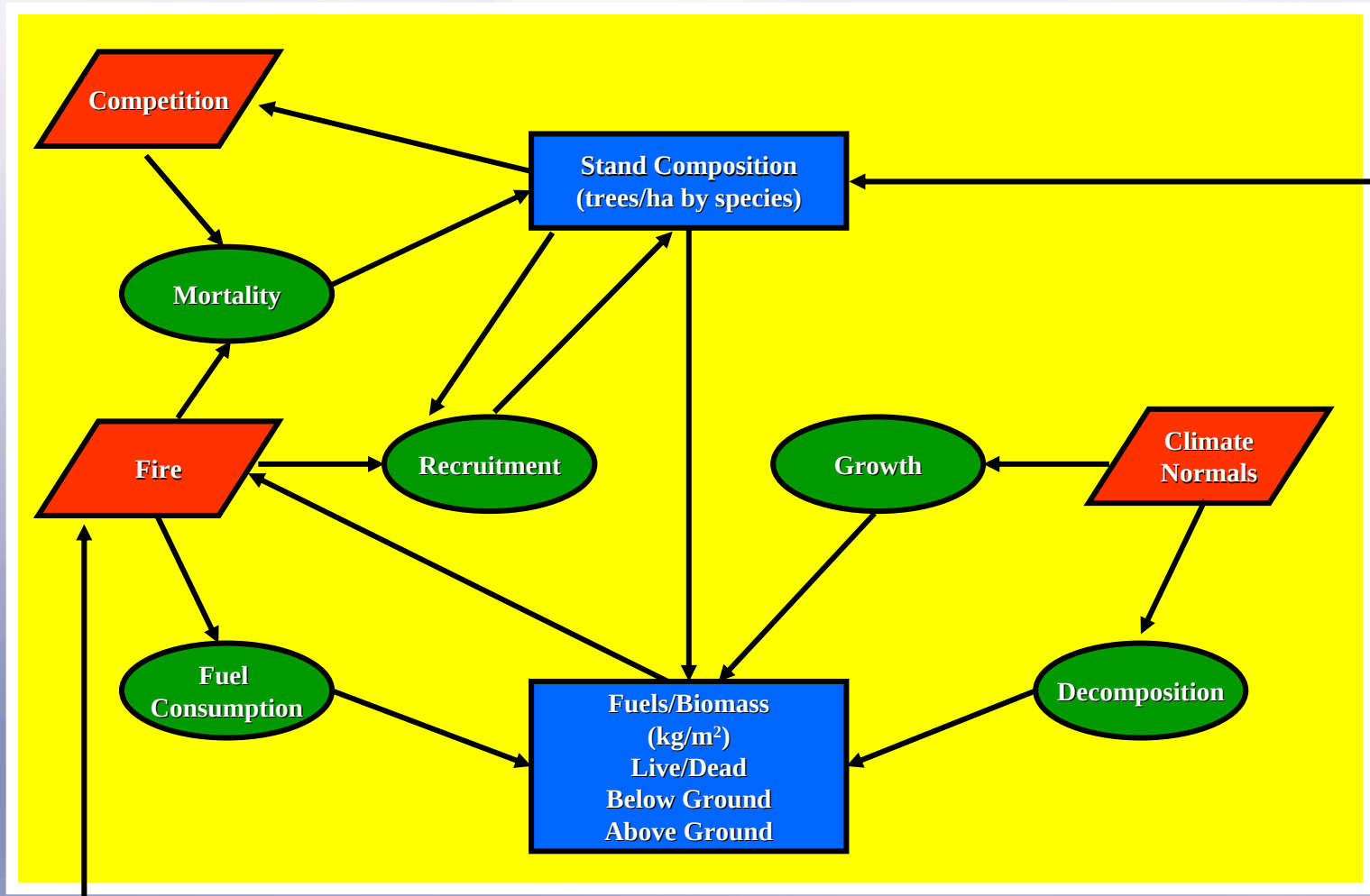








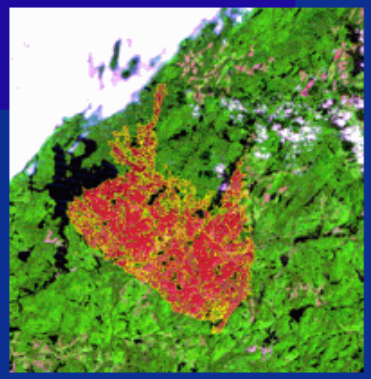
CanFIRE Model Structure

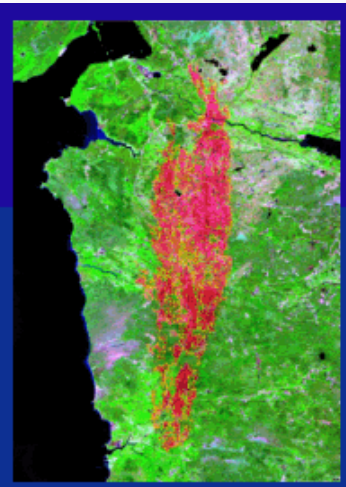


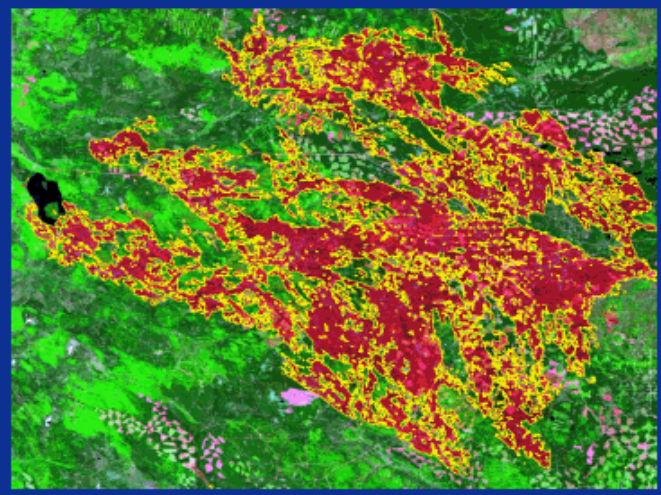
Some History – Part C

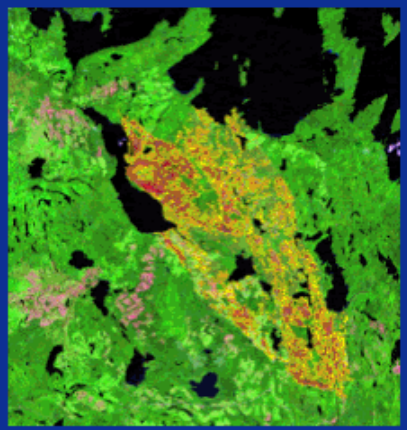
- 1990s – Earth Sciences Sector (CCRS) developed, with the help of Forest Industry, a fire mapping tool using LANDSAT satellite data
- The LANDSAT burned area estimates were within 2% of the estimates from colour aerial photography.

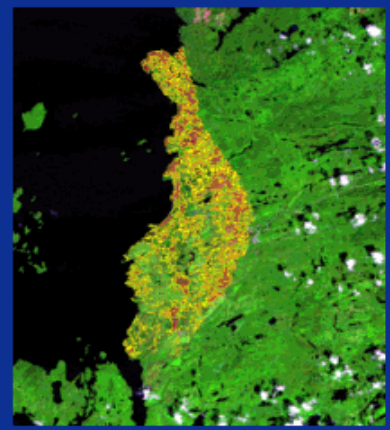
Satellite-based Mapping Benefits Forest Products Companies











Domtar

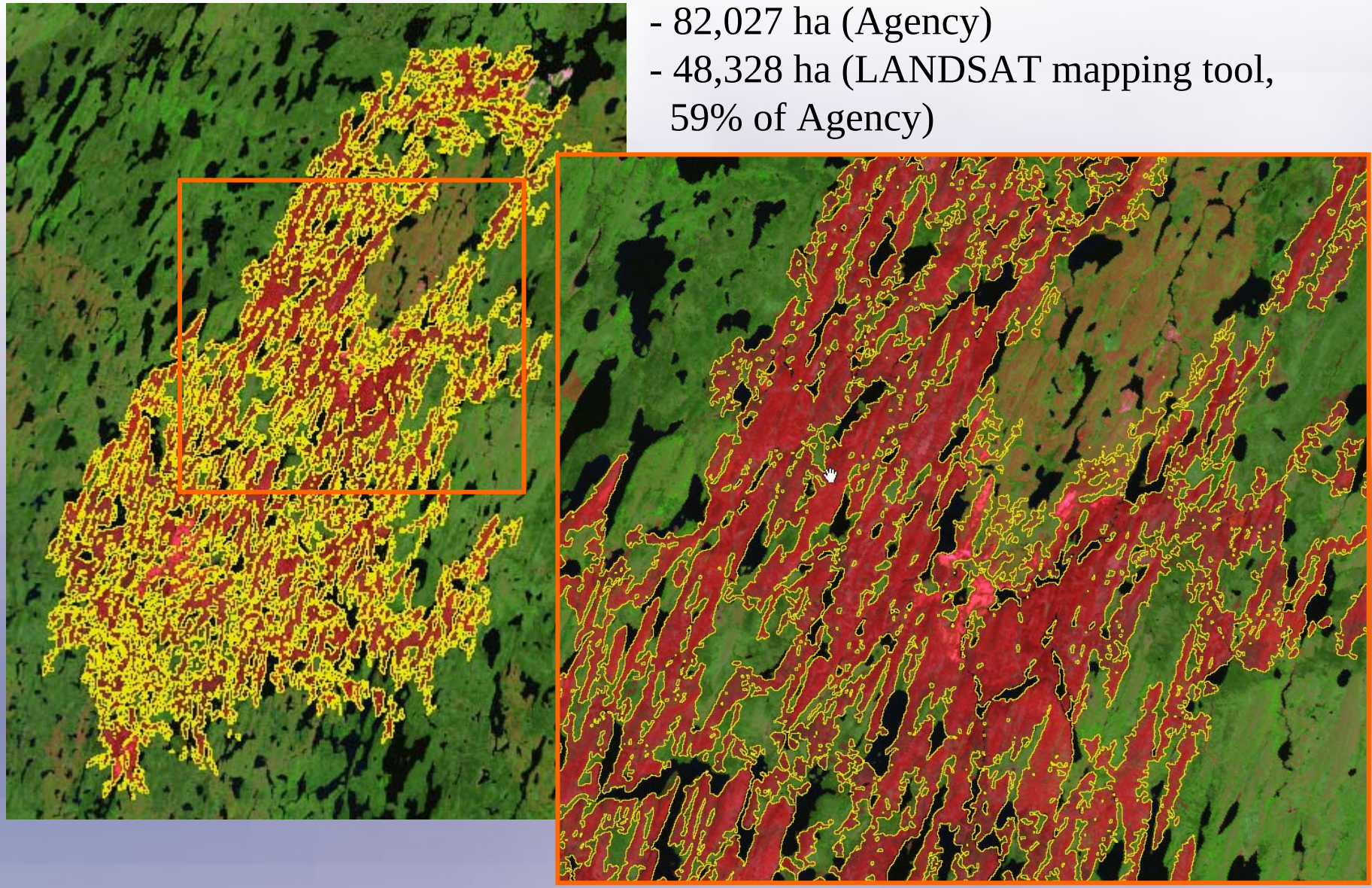
PFPC

RANGER
Blue Ridge Lumber (1981) Ltd.

MILLAR WESTERN

BOWATER

Domtar

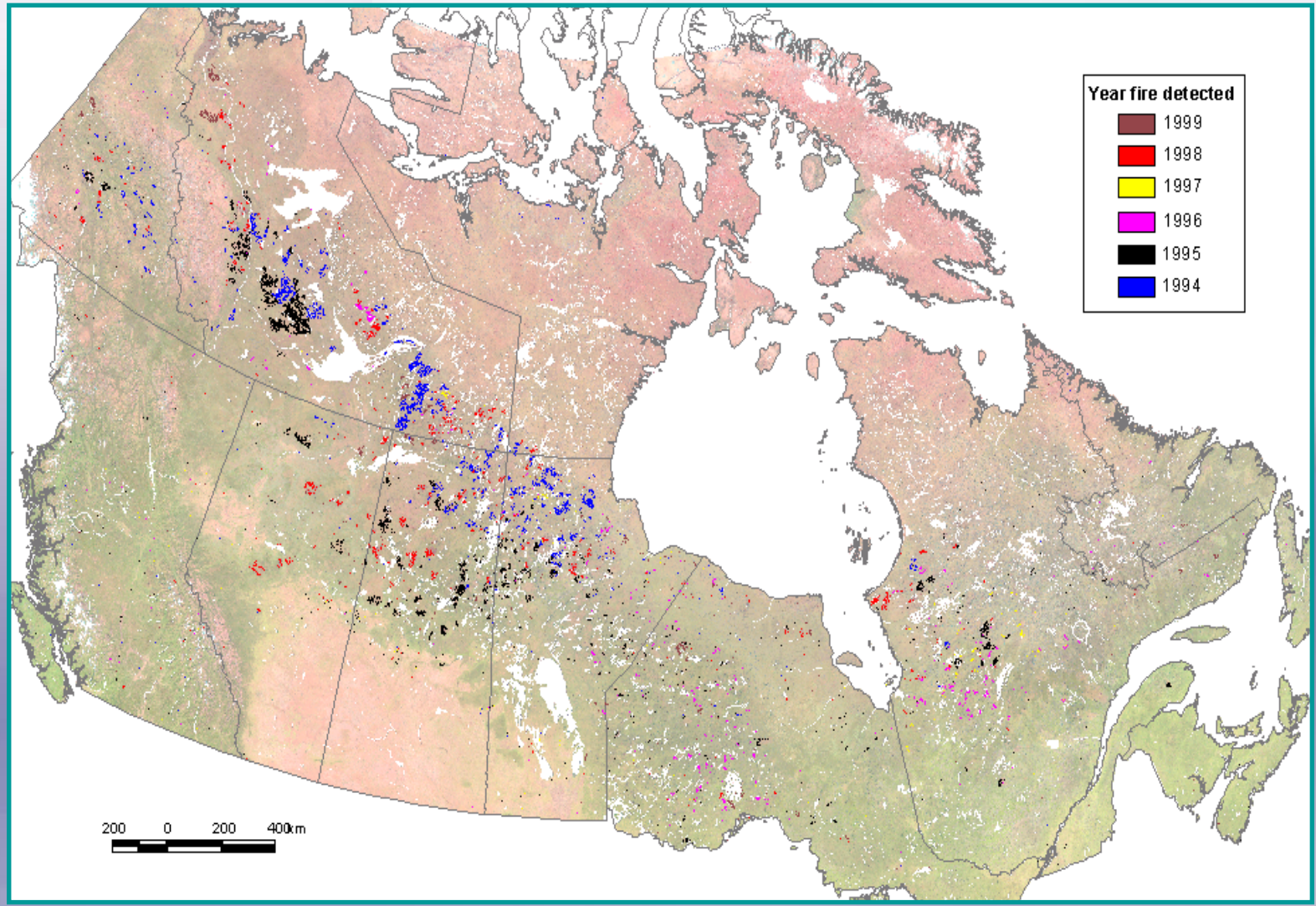


- 82,027 ha (Agency)
- 48,328 ha (LANDSAT mapping tool, 59% of Agency)

Some History – Part D

- *1997 – ResSources (ESS & CFS), an NRCan knowledge mgt. program, funded the development of the first Canadian satellite hotspot monitoring* system using AVHRR satellite data

Forest fire hotspots detected in Canada



Never Underestimate the Value of a Hotspot

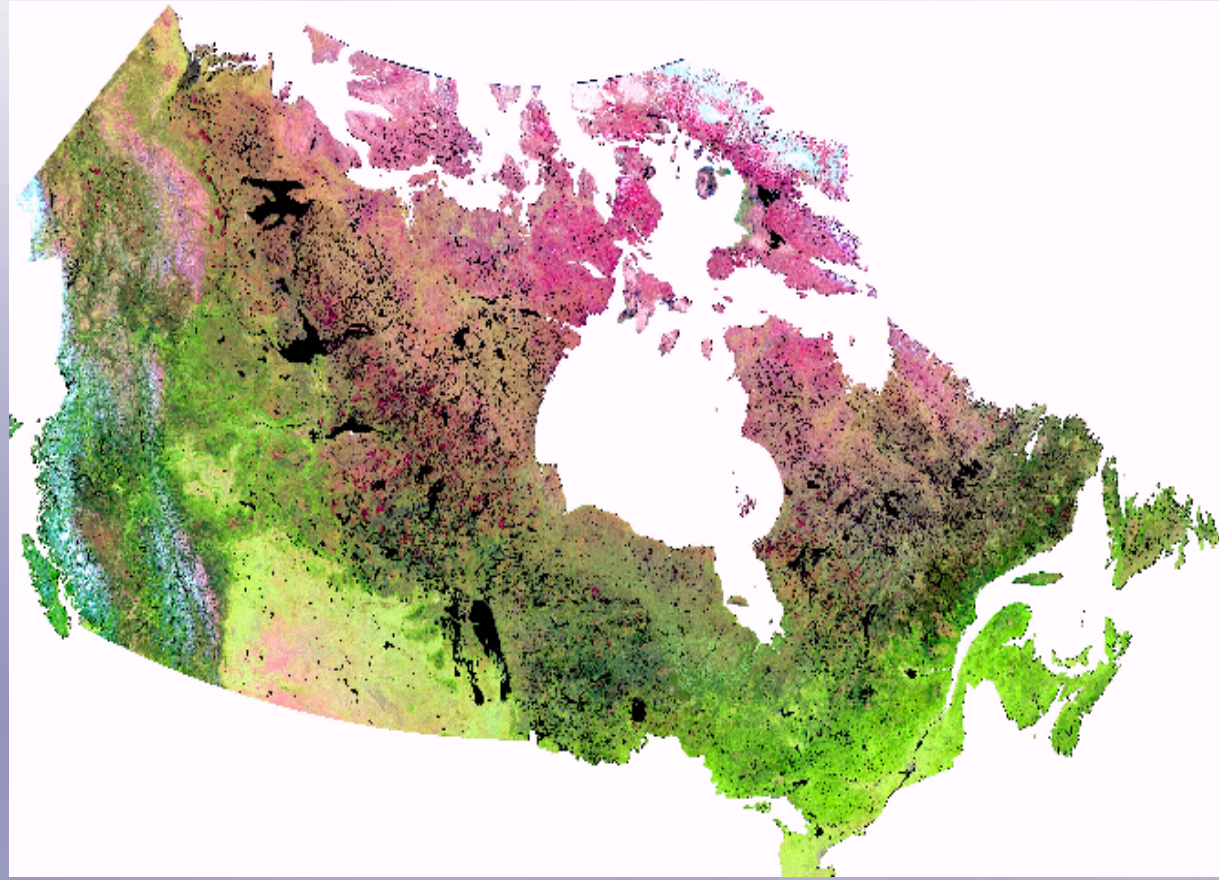
- shows the location of current fires
- used to estimate fire Rate of Spread
- confirms that a disturbance or landuse change is a fire
- places a unique date stamp on burning pixels (required for completing emissions calculations)

Some History – Part E

- 2001 – NRCan's Canada Centre for Remote Sensing [CCRS] developed the first rapid, national wildfire mapping tool (HANDS) that provides burned area polygons (at the end of the fire season) for wildfires that are greater than 200 ha.
- this new product, using data from the French satellite SPOT VGT (1 km resolution), was only possible because the VGT sensor includes a SWIR detector.
- In 2003, HANDS combined with a LANDSAT mapping tool (from CCRS), become instrumental in developing an annual National Burned Area Composite

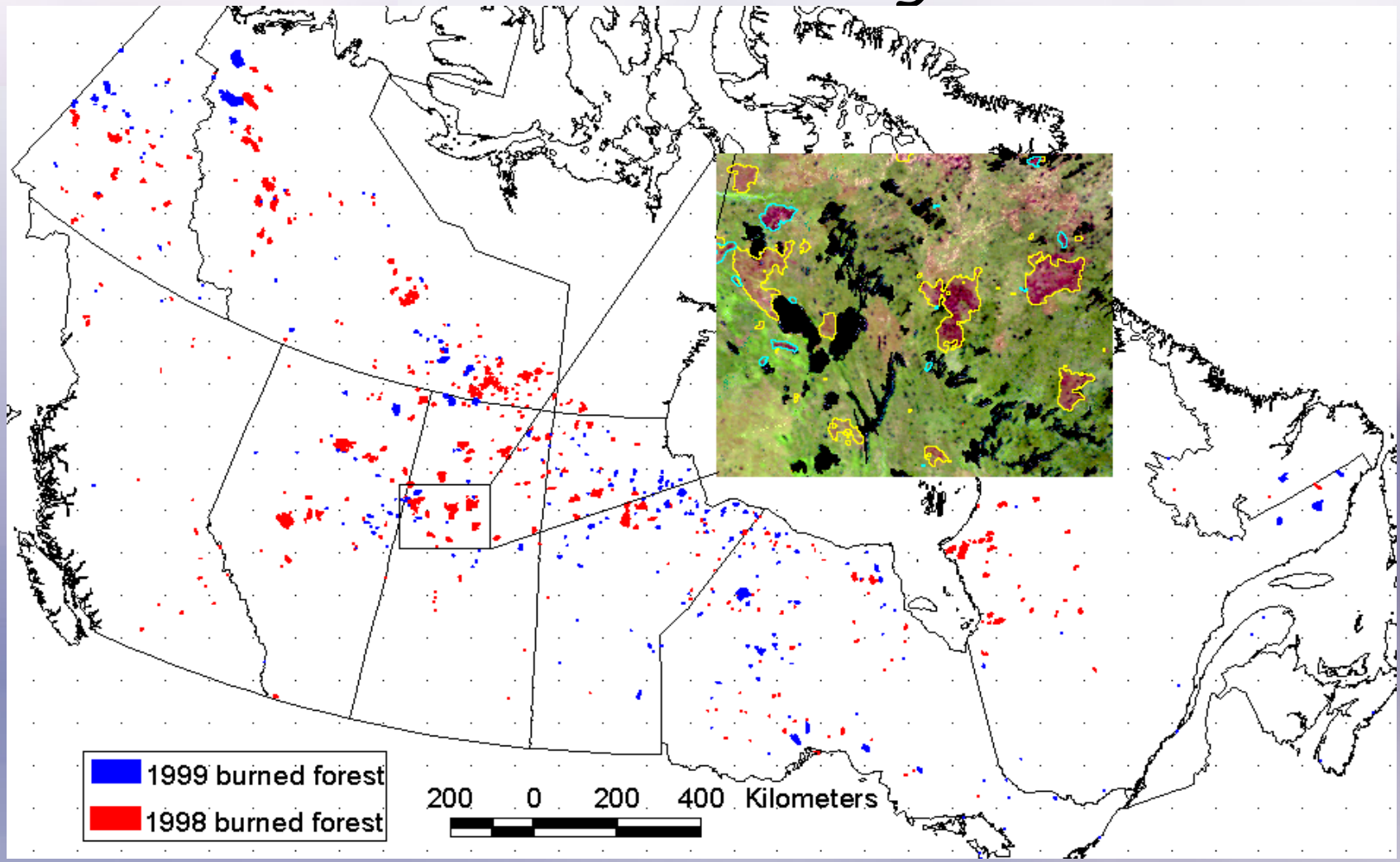
SPOT VEGETATION (VGT) Sensor

- Launched March 1998
- Swath and resolution similar to AVHRR
- Channels designed specifically for veg. monitoring: blue, red, NIR, SWIR
- 10-day composites



SWIR,NIR,Red=RGB

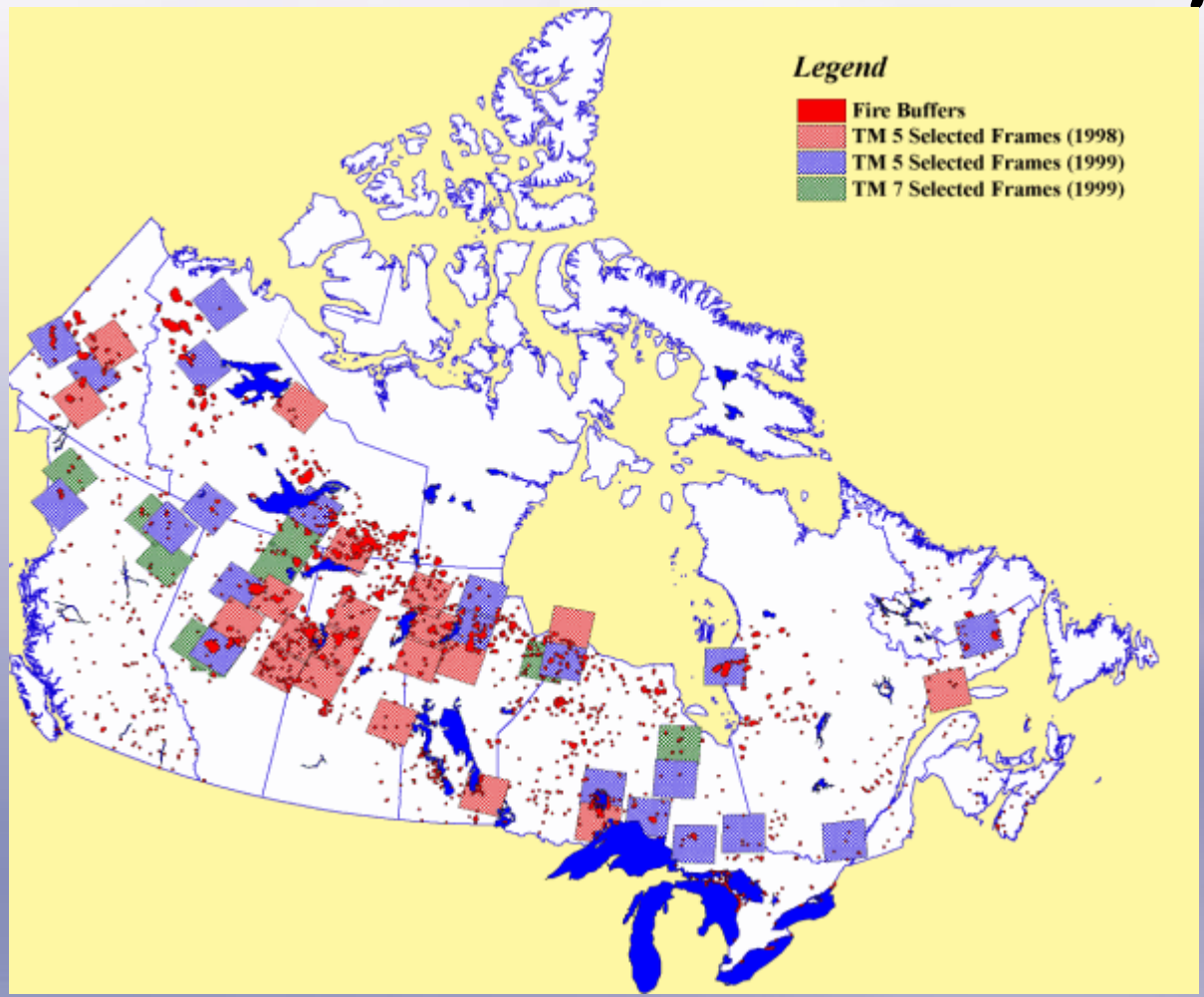
Forest burned in 1998/99 using HANDS satellite algorithm



Question?

- But, how reliable is the HANDS product ?

Burned area validation-Sampling dataset

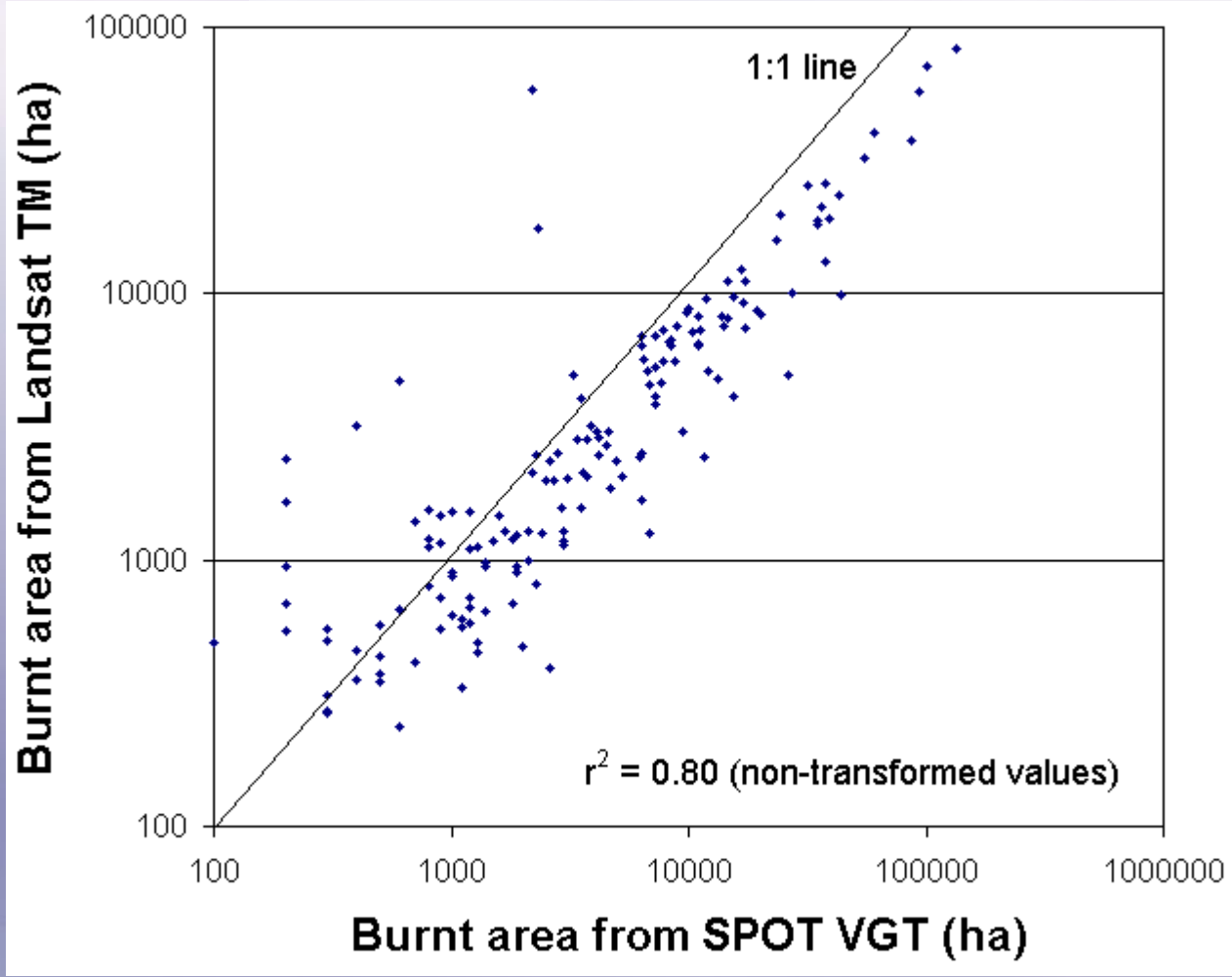


Landsat-TM 1998,1999
- over 55 imagery

Number of fires mapped
- fires over 200 ha.
- 197 fires mapped

Landsat-TM dataset for SPOT-VGT mapping validation

Burned area product validation



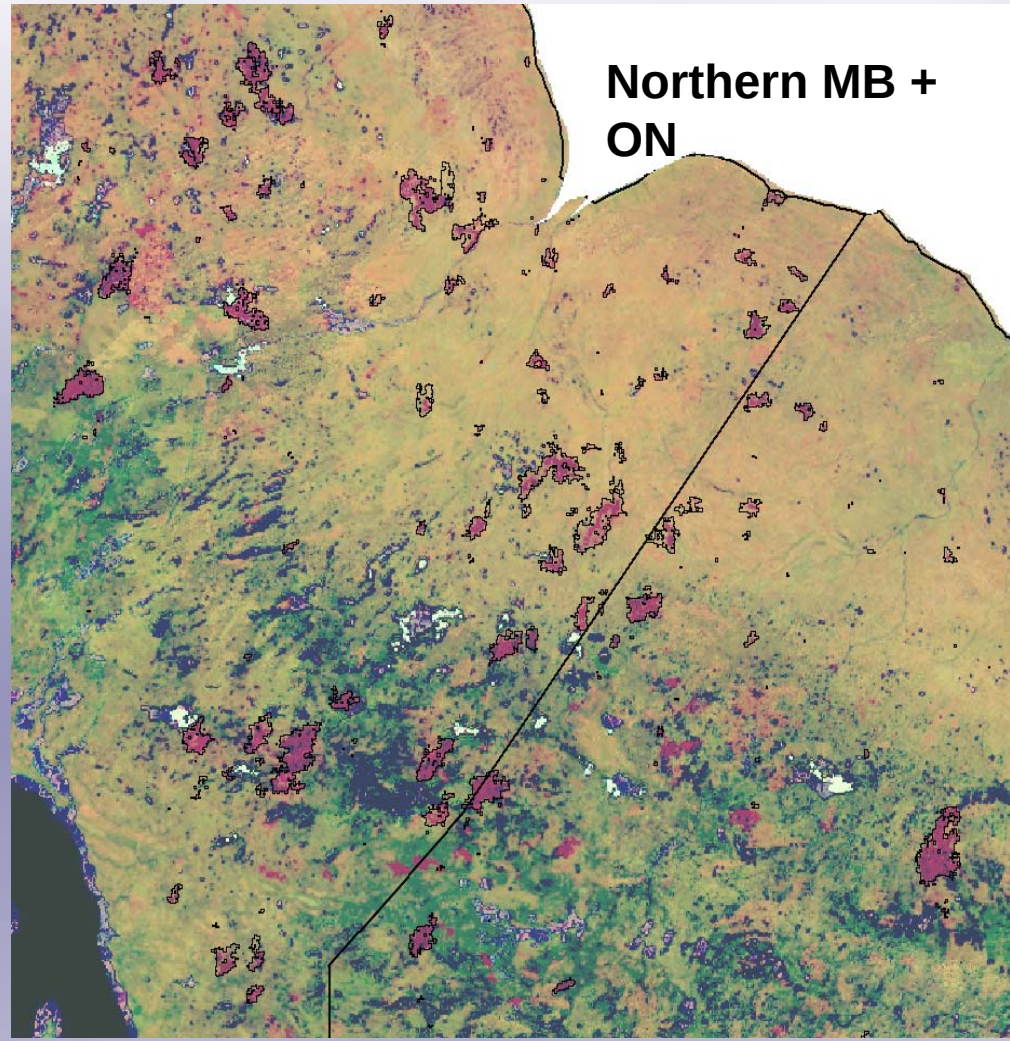
Result

- Since 1999, in 7 out of 8 years, the HANDS national burned area product has been within 2-8% of the national burned area reported by the Canadian Interagency Forest Fire Centre (CIFFC).

- In one year, 2003, HANDS produced a national burned area estimate of 2.3 million ha while CIFFC reported 1.65 million ha. The difference was largely due to about 650,000 ha of wildfire in northern Manitoba and Ontario that was not reported to CIFFC.

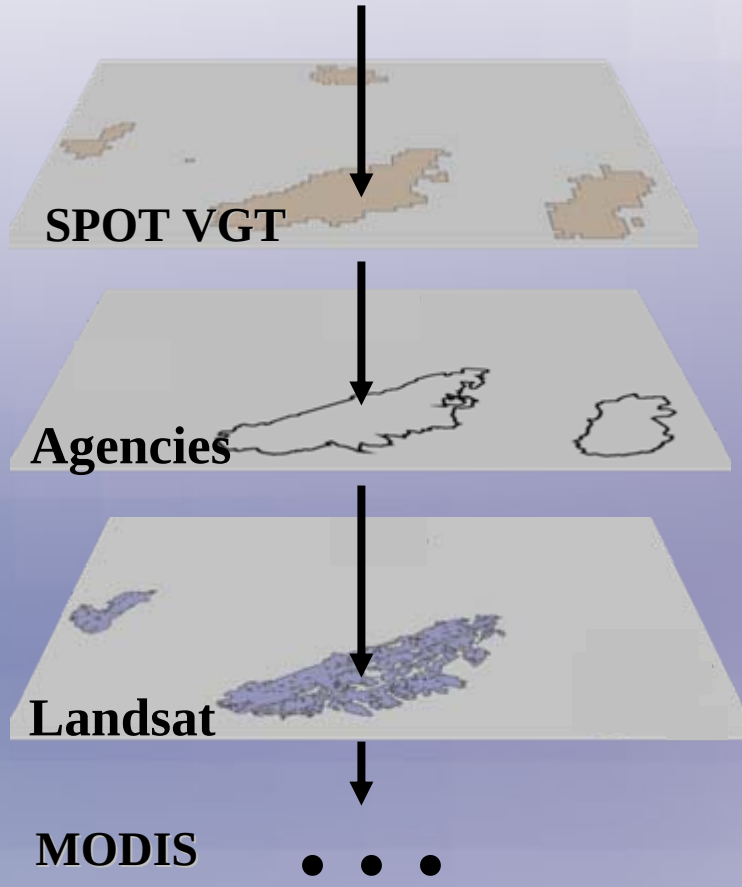
HANDS V2 Results – 2003

Prov	CIFFC 2003 (ha)	HANDS 2003 (ha)
BC	266,412	290,200
YT	49,037	54,100
AB	55,482	60,700
NT	127,821	138,800
SK	126,591	126,200
MB	**430,170**	**903,100**
ON	**314,219**	**434,700**
QC	87,860	101,700
NF	36,533	51,800
NB	237	0
NS	1,257	100
PE	12	0
PC	141,133	132,200
Total	1,636,764	2,293,600
		+ 656,836 (40%)
		+593,411 (MB+ON)

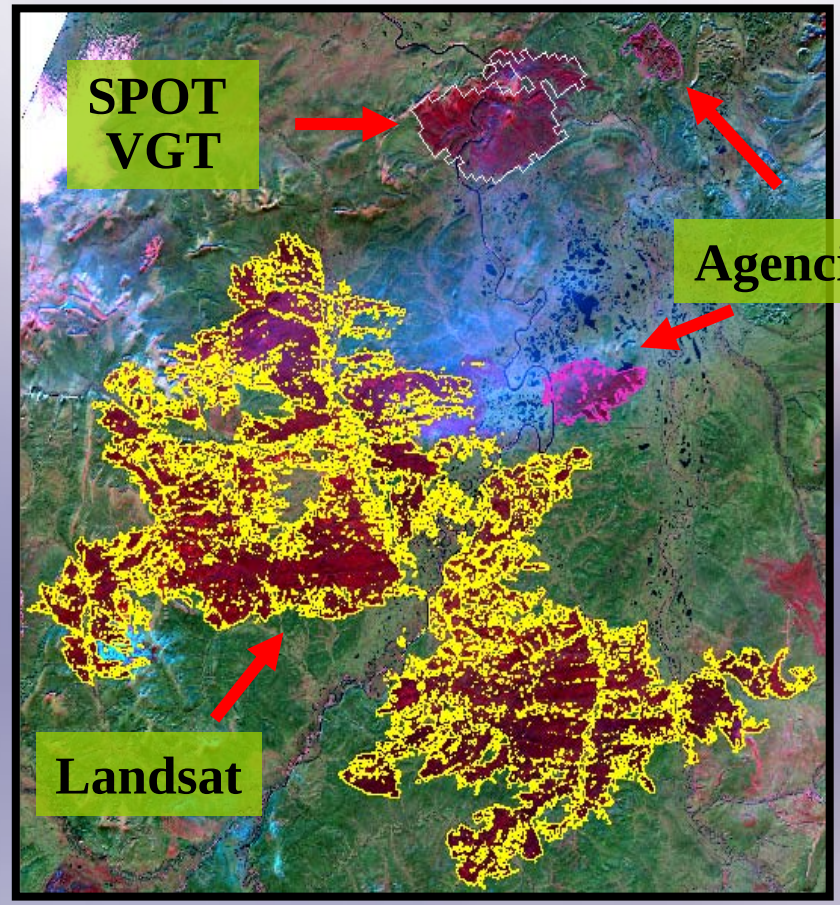


National Burn Area Composite Product
(Ensure the best available burn area products across-Canada at any time)

Access to burn area products from multi-sources, BUT at different times…



Rules



A Missing Link – Fuel Consumption

- A paper by Amiro et al. (2001) has the best published national estimate of carbon emissions released from fires (~27 Tg C/yr). Their model uses the FBP to calculate fuel consumption.
- Based on observations of many large fires that appeared to have fuel consumption that exceeded what would be predicted by FBP, we designed a field study to quantify surface fuel consumption on large fires that burned under extreme drought.
- We determined that fuel consumption was about 35% higher/fire than FBP predicted and we used the CanFIRE model to accommodate the difference.

Wildfires and Fire Radiative Energy

- The radiative component of the energy liberated by burning fuel can be measured by remote sensing, and space-borne fire radiative energy (FRE) measures can potentially provide detailed information on the amount and rate of biomass consumption over large areas.

Wildfires and Radiative Energy (cont'd)

- FRE assessments made via independent hyperspectral and MIR radiance approaches in fact show good agreement, and fires are calculated to radiate 14 ± 3% of their theoretically available heat yield in a form capable of direct assessment by a nadir-viewing MIR imager.

Current Approaches to BB Quantification

Biomass Burnt (M) = Area Burnt × Fuel Load × Burning Efficiency

√ X X

Difficulty in estimating pre-burn fuel load and burning efficiency parameters makes estimates of M (and therefore emissions) subject to large uncertainties *(French et al., 2004)*

KCL working on alternative method, based on measure of fire radiated power.

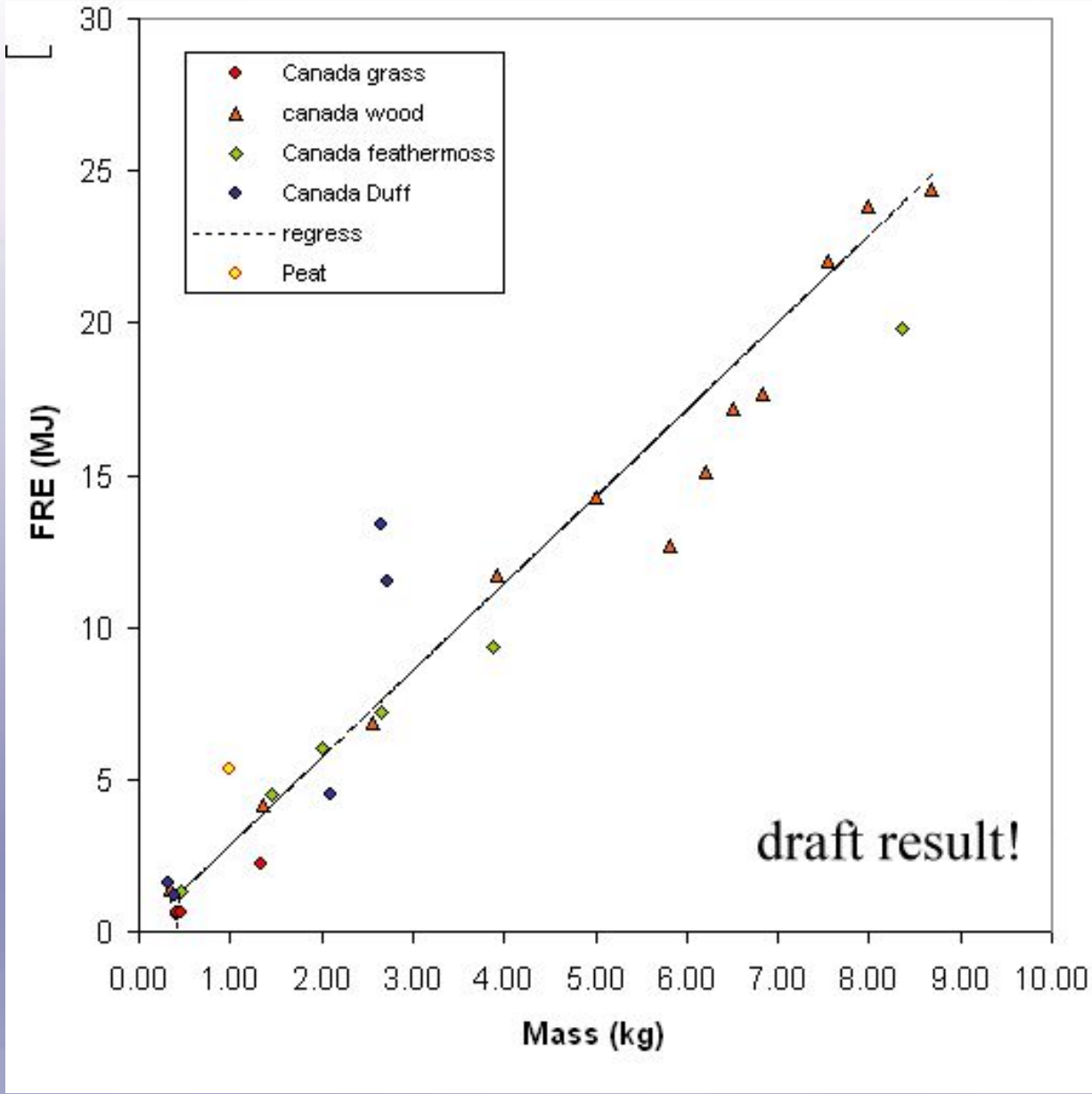

VERSALIFT
2006/06/26

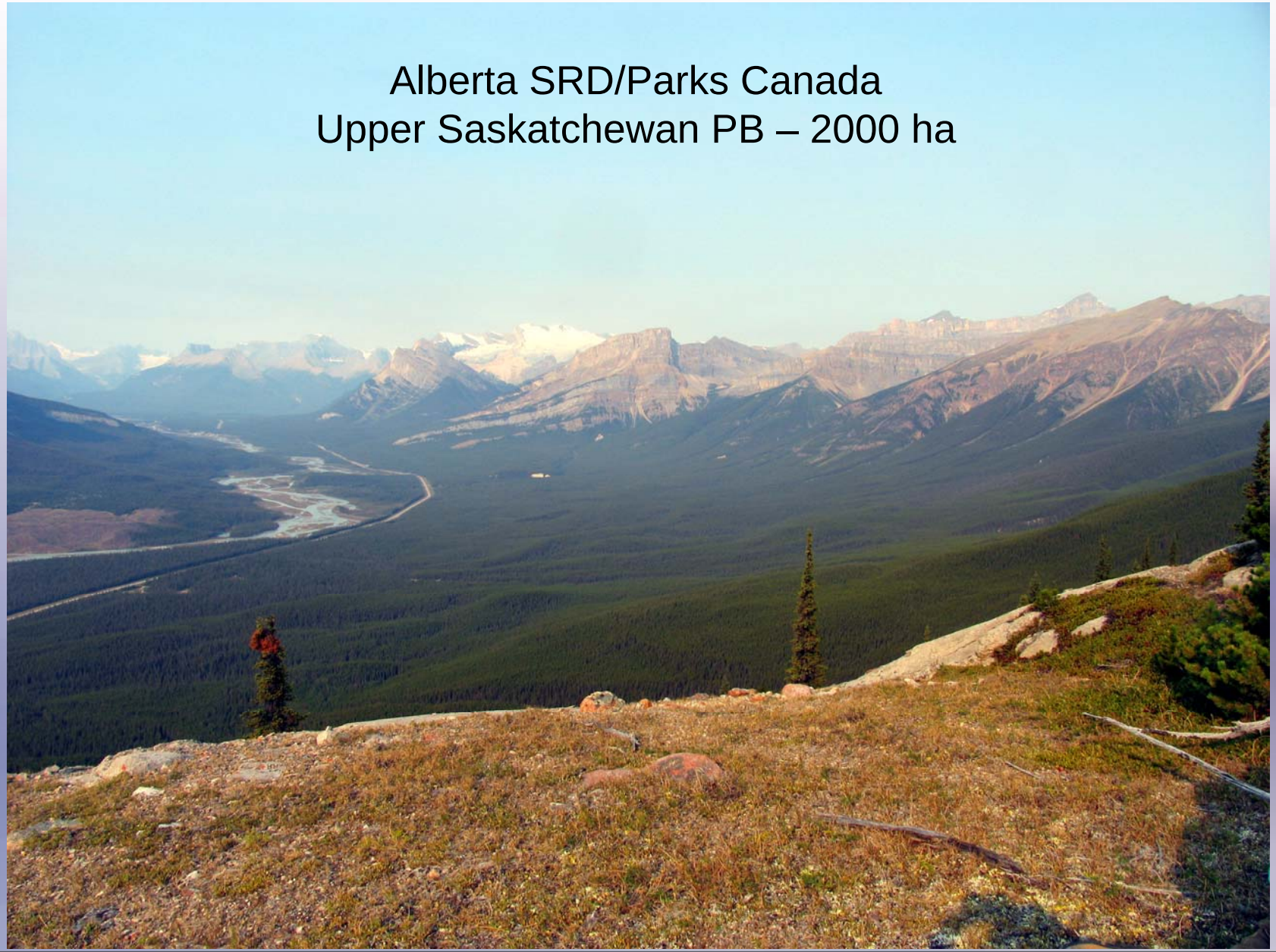

2006/06/29


2006/06/27


2006/06/29

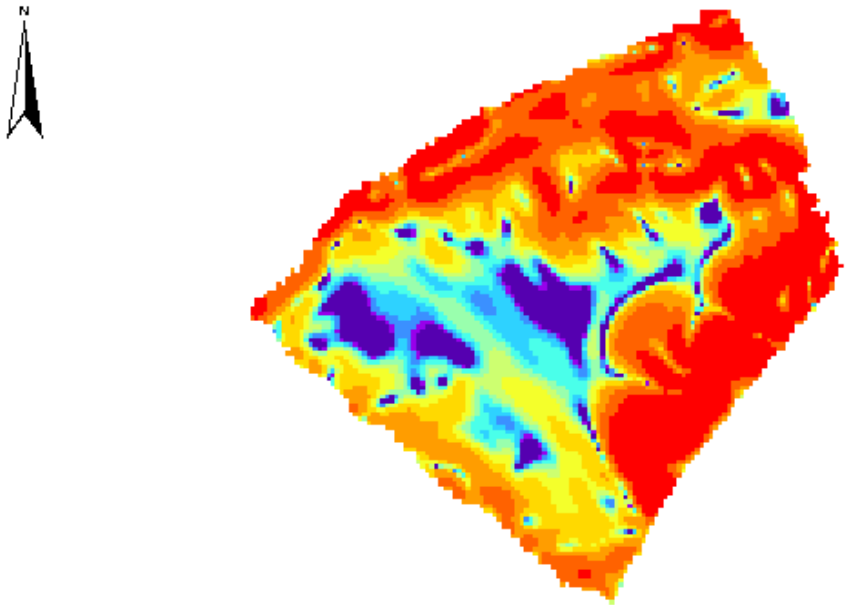

PLAY
SAND
SABLE À JOUER
2006/06/26


Canada grass
canada wood
Canada feathermoss
Canada Duff
regress
Peat
FRE (MJ)
Mass (kg)
0
5
10
15
20
25
30
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
draft result!


Alberta SRD/Parks Canada
Upper Saskatchewan PB – 2000 ha


116°38'10"W
116°38'0"W
116°37'50"W
116°37'40"W
116°37'30"W
52°1'0"N
52°0'50"N
0
70
140
280
Meters
1:3,500
Upper Saskatchewan Unit 6 (CFS Site2)
August 19, 2008
ASRD
Forestry Division
Business Services Branch
Fire Science Unit

Rate of spread (m/min.)
Sharpsand fire in May 13, 2007



Legend

ROS, interval 5 sec.
m/min.

- 1.4 - 8
- 8.0 - 16
- 16 - 32
- 32 - 48
- 48 - 64
- 64 - 80
- 80 - 96
- 96 - 112
- 112 - 128
- 128 - 144
- 144 - 160
- 160 - 4,700

0 20 40 80 Meters

Integrated FRE, KJ/M2
Sharpsand fire, May 13, 2007