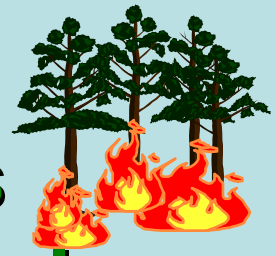


Wildfire Impacts on Carbon Stocks and Exchanges in Forests of Central Siberia: Quantifying Effects of Fire Intensity, Fire Severity, and Burning Conditions

Susan G. Conard, Douglas J. McRae, Galina A. Ivanova, Anatoly I. Sukhinin, and Wei Min Hao

Natural Resources Canada
Canadian Forest Service

Background

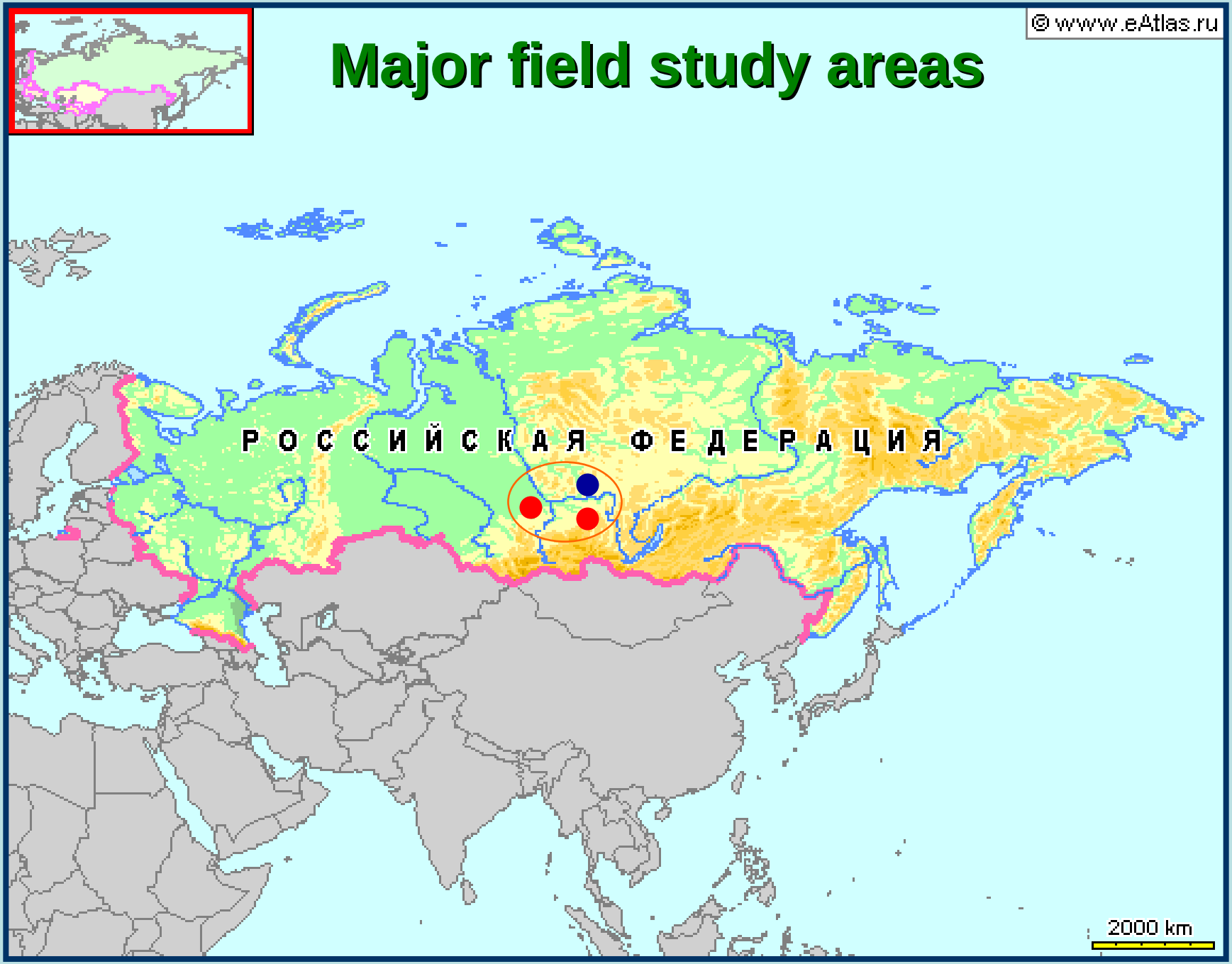
- Over 30% of the global terrestrial biomass is in boreal forests.
- Wildland fire affects some 14 to 15 million ha of boreal forest annually.
- Global climate models predict the most rapid warming in boreal and arctic; warming is predicted to increase fire severity and extent.
- Fire intensity and severity in the Russian boreal vary greatly among years and regions, but there is little information linking fire severity to emissions or ecosystem response and recovery.

Research Goals

- Determine the impact of fire on carbon balance for key forest types of central Siberia.
- Use this information to develop validated estimates of fire areas, fire severity, and emissions.
- Build on our past research efforts in Scots pine forests (2000-2004), while initiating similar research in larch forests.

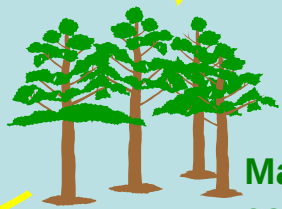
Approach:

Combine experimentally-derived ground data with infrared remote-sensing of active fires to relate fuel condition with fire behavior, ecosystem effects, and carbon cycling in Russian boreal forests.


Major field study areas
© www.eAtlas.ru
РОССИЙСКАЯ ФЕДЕРАЦИЯ
2000 km

FIRE and CARBON CYCLING

CARBON
SINK

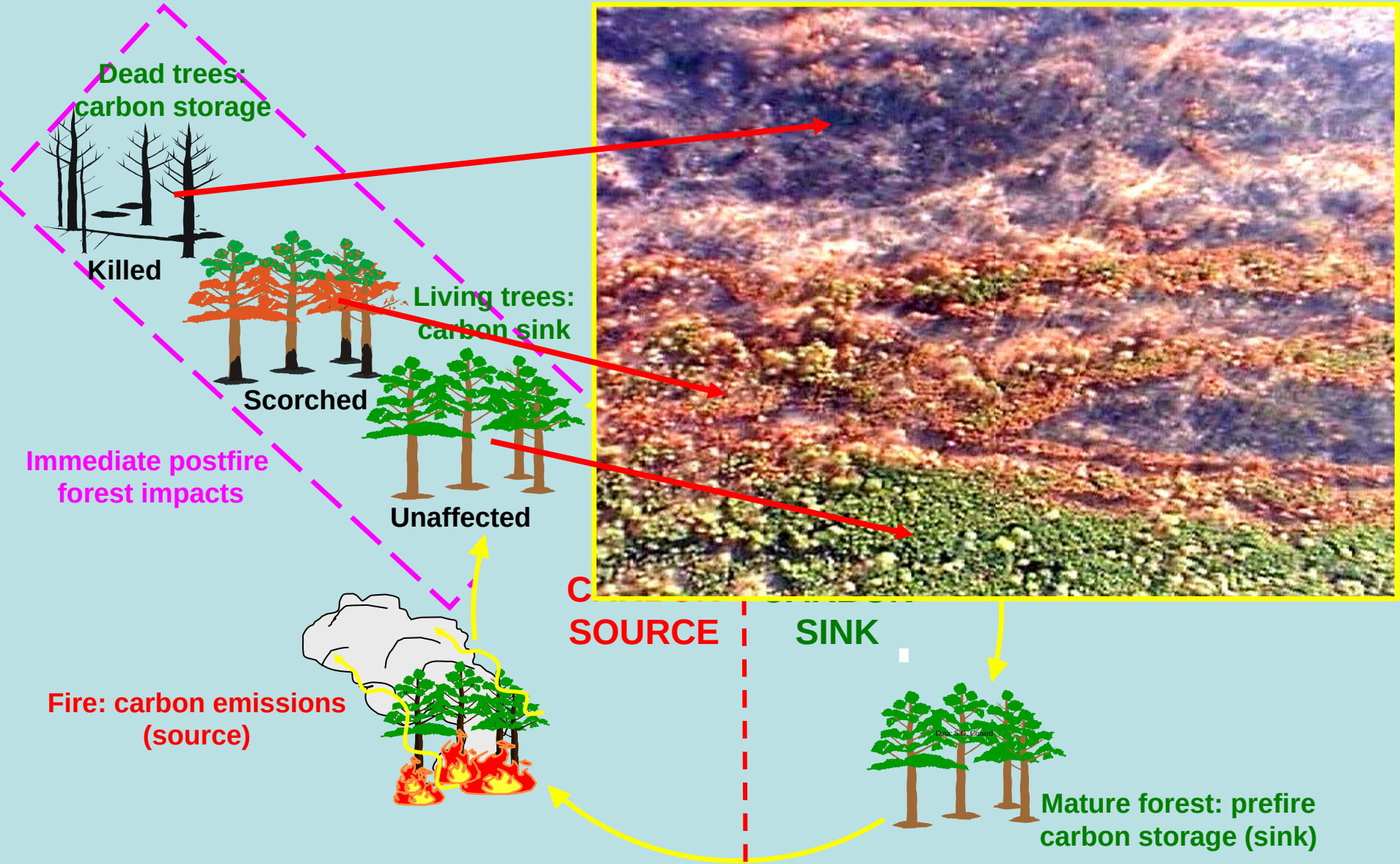


Mature forest: prefire
carbon storage (sink)

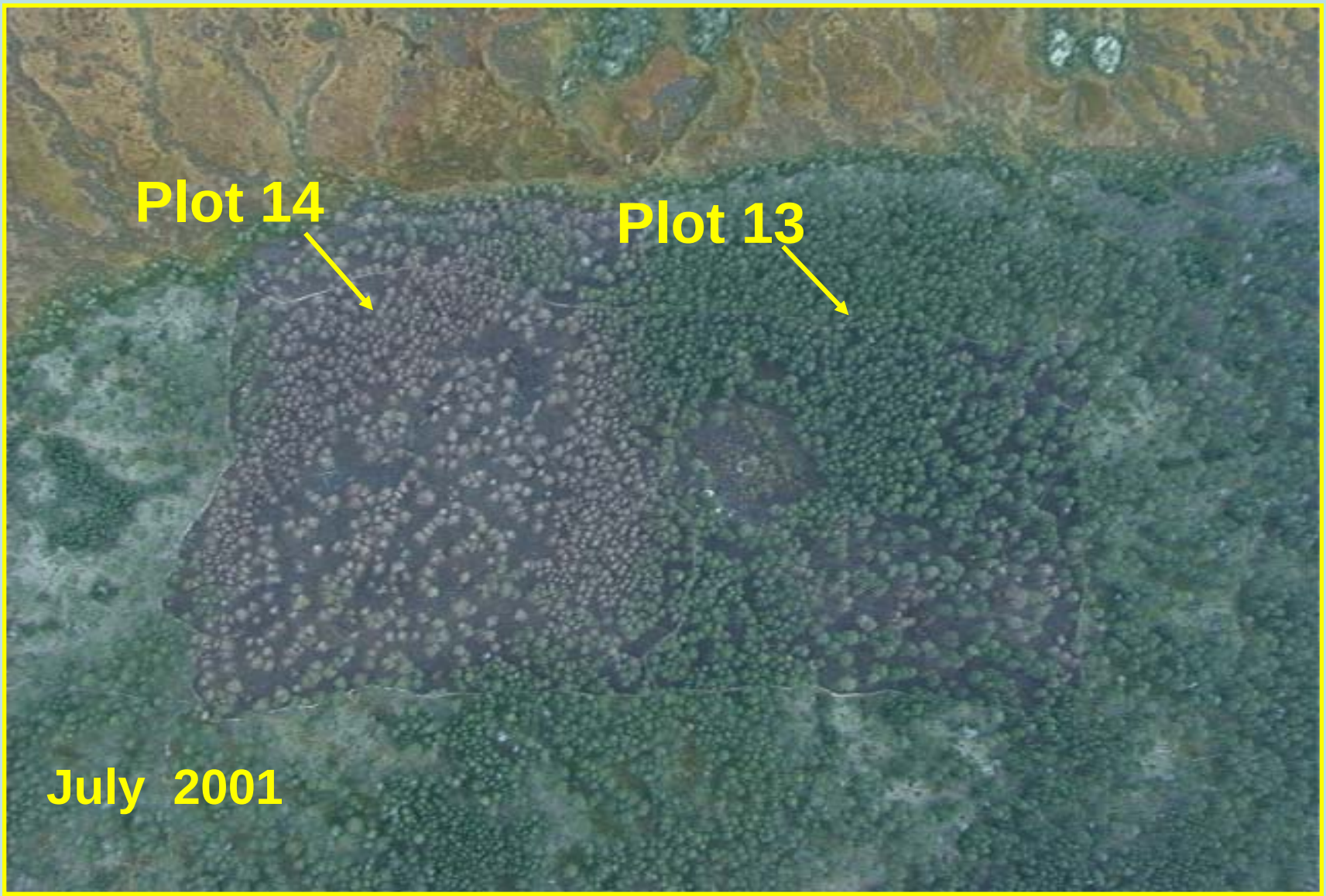
FIRE and CARBON CYCLING

Fire: carbon emissions
(source)

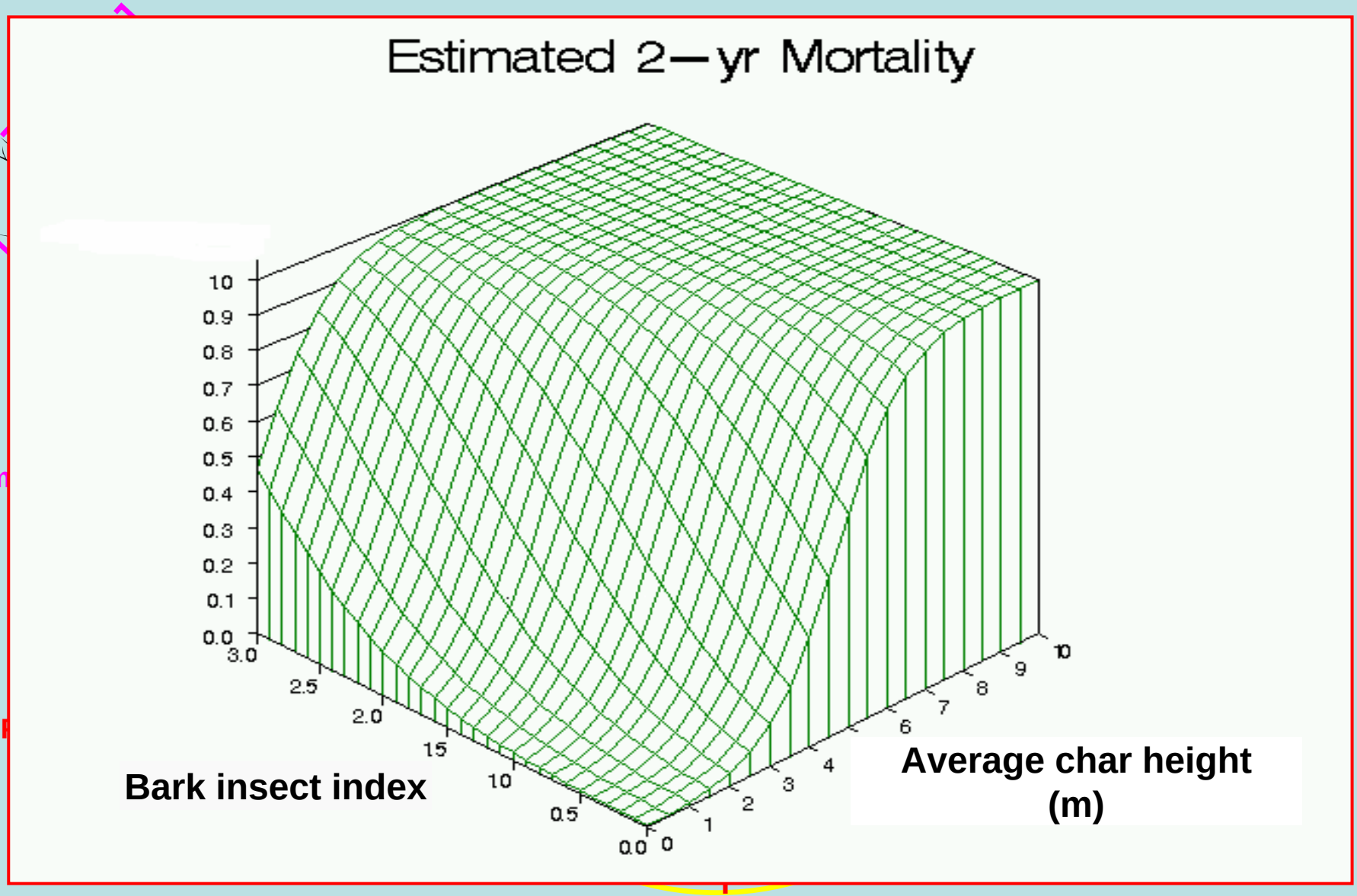
FIRE and CARBON CYCLING



Aerial view of Plots 13 and 14

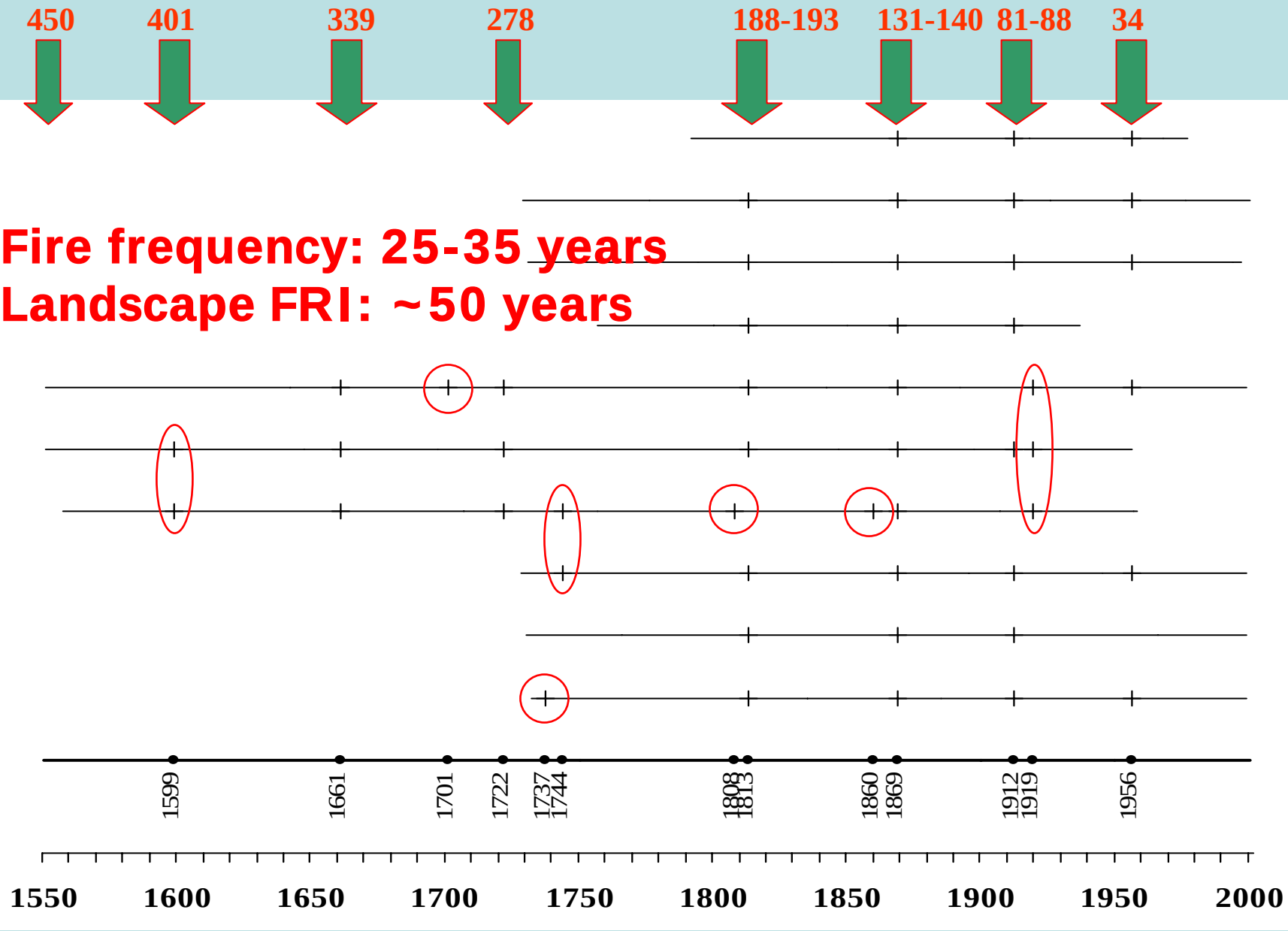


FIRE and CARBON CYCLING



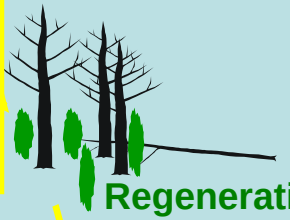
FIRE and CARBON CYCLING

FIRE and CARBON CYCLING



FIRE and CARBON CYCLING

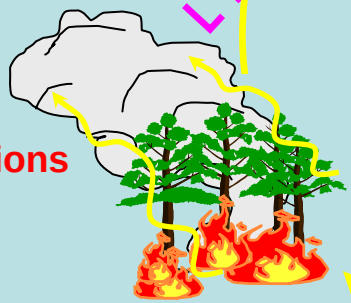
soil respiration:
carbon source



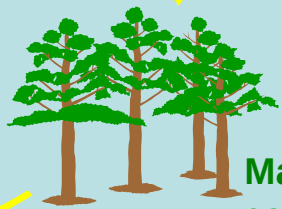
Regeneration: carbon sink

CARBON SOURCE

CARBON SINK



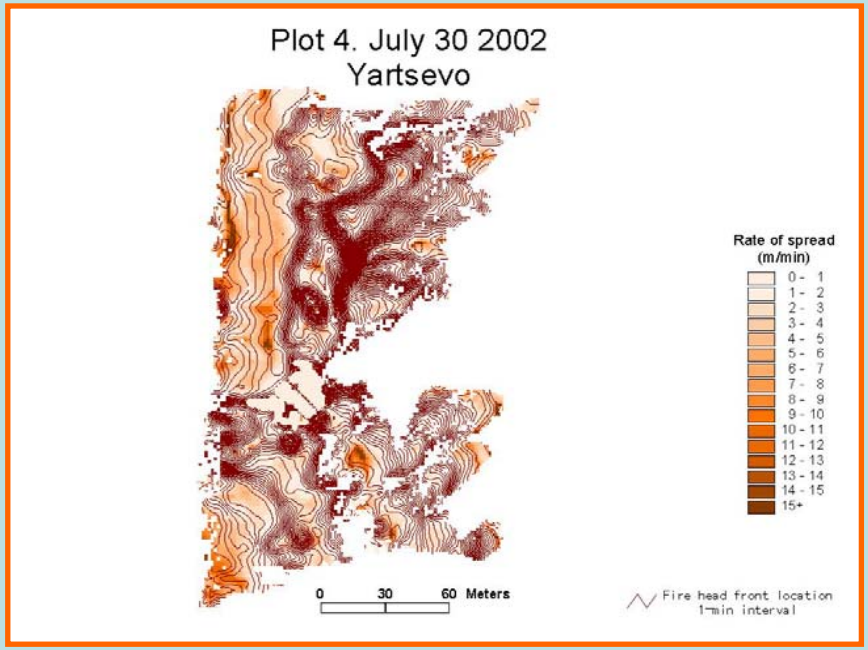
Fire: carbon emissions
(source)

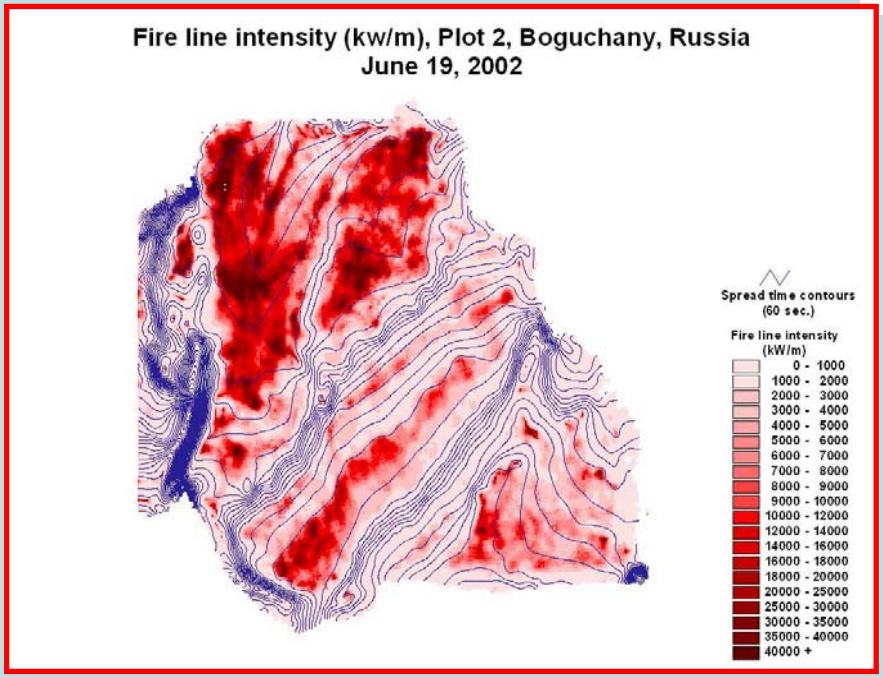


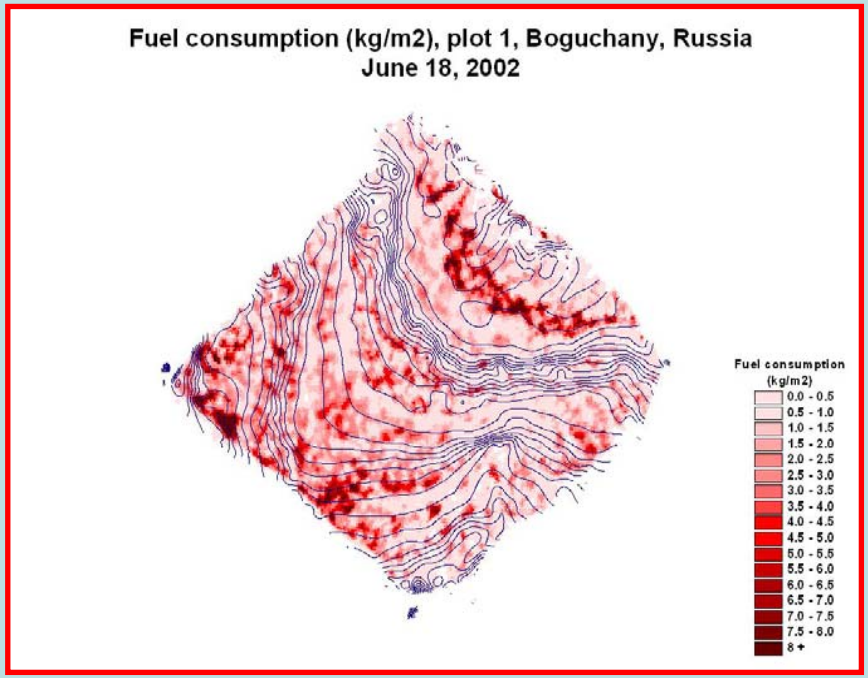
Mature forest: prefire
carbon storage (sink)

50-year fire
return interval

Remote Sensing of Fire Behavior and Thermal Radiance



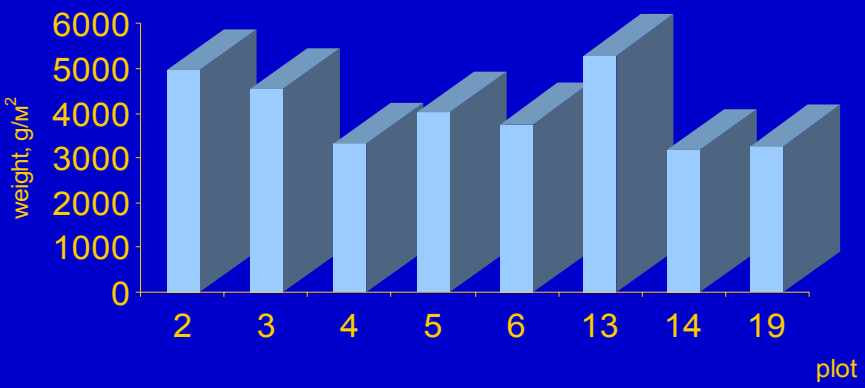




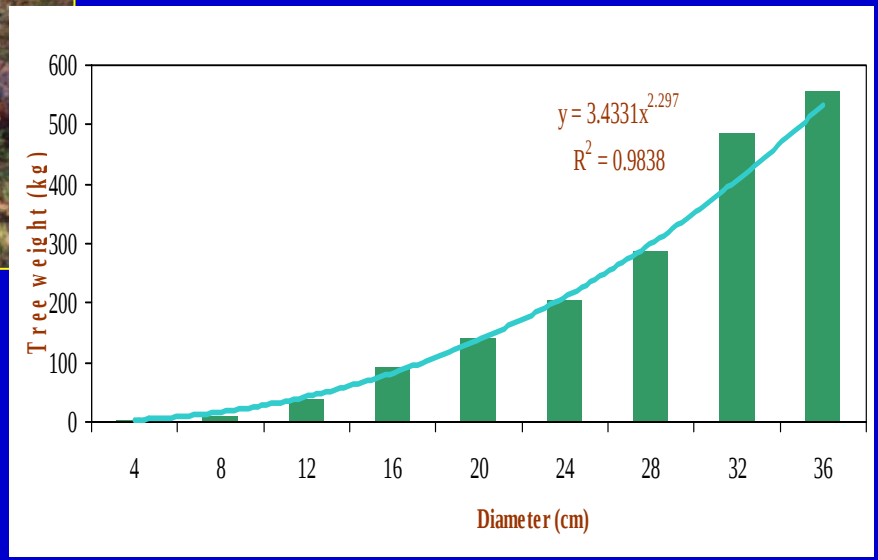
Fuel (carbon) sampling

Fuel Structure and Loading.

Ground fuel



Crown fuel sampling



Fire behavior and fuel consumption

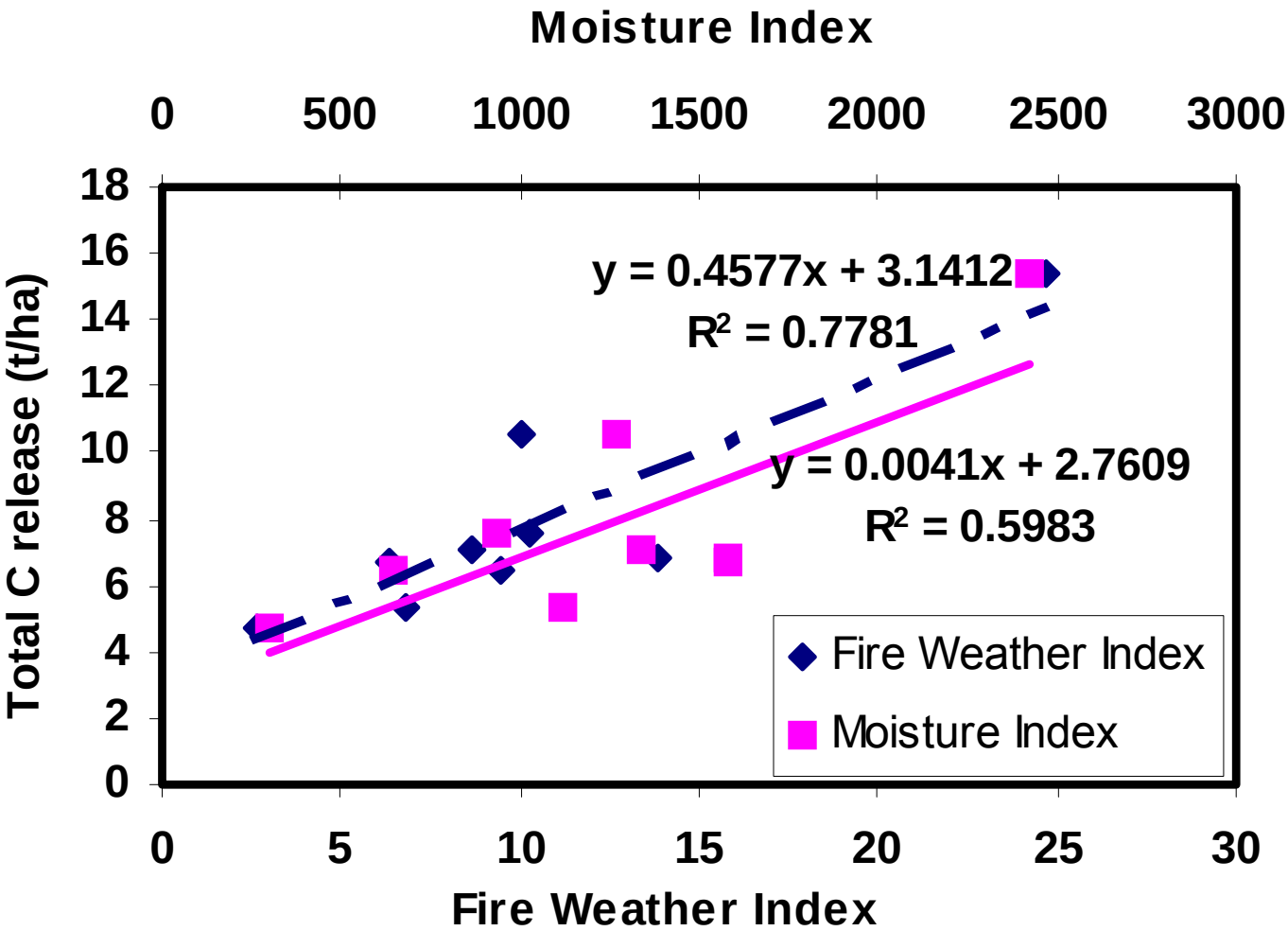
	Fuel consumption and carbon emissions		Fire behavior characteristics		
Fire No.	Consum-ption (kg/m^2)	Carbon emissions (t/ha)	Depth of burn (cm)	Rate of spread (m/min)	Fireline intensity (kW/m)
1	1.35	6.77	4.4	4.9	2140
2	0.95	4.78	3.3	2.5	1156
3	1.29	6.46	4.0	5.9	2473
4	2.10	10.50	4.7	2.0	1067
5	3.07	15.36	6.4	9.0	9018
6	1.08	5.39	3.5	2.9	1016

Fuels burned on dry Scotch pine sites

- **10 – 30 t/ha forest fuels were burned in experimental surface fires**
  - **The amount burned depended on fuel conditions and fire behavior**
  - **Between 75 and 95 percent of this was in the litter and forest floor**

- **An additional 6 - 14 t/ha would be burned in a crown fire**

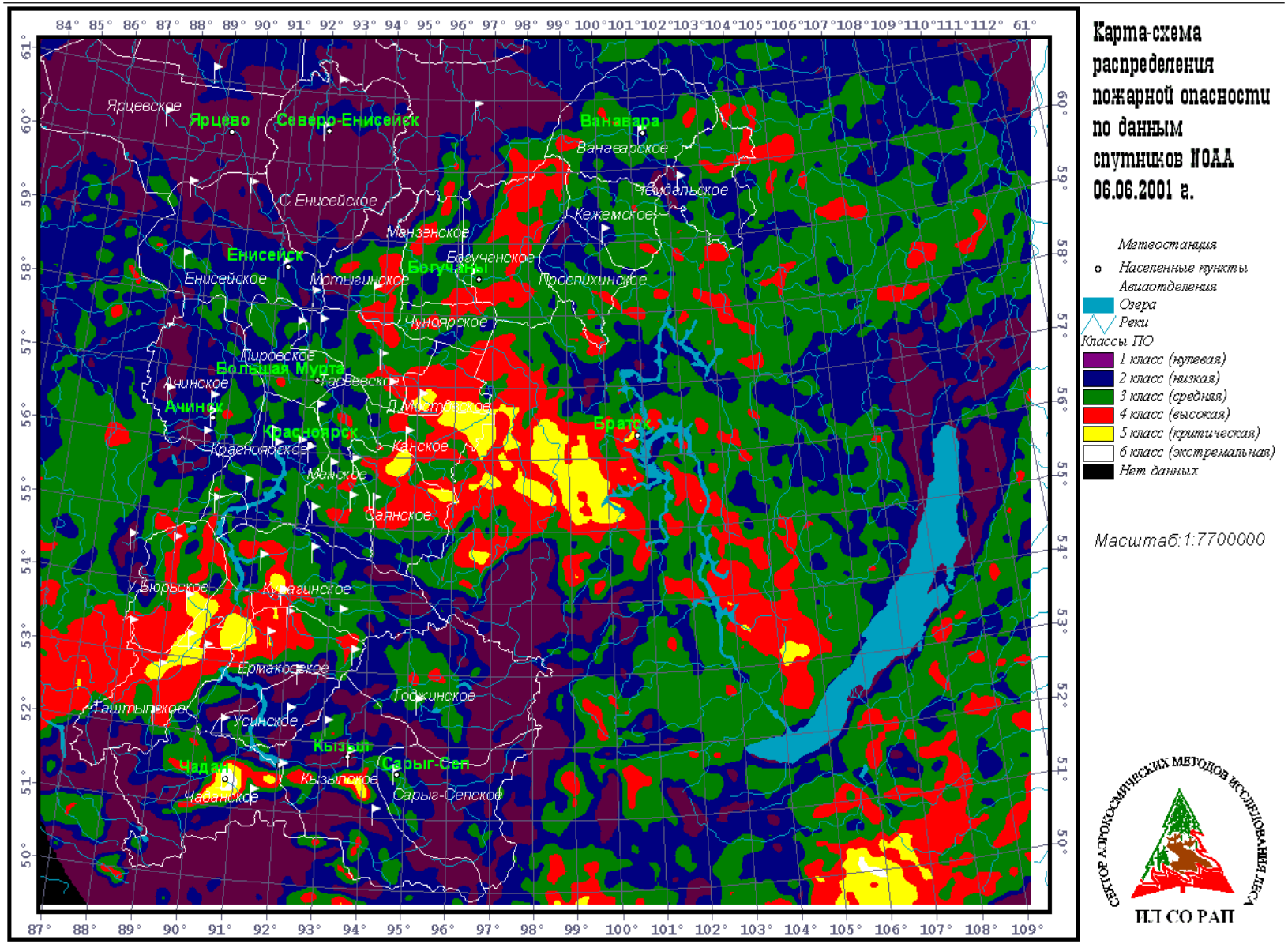
Developing Predictive Models for Carbon Emissions

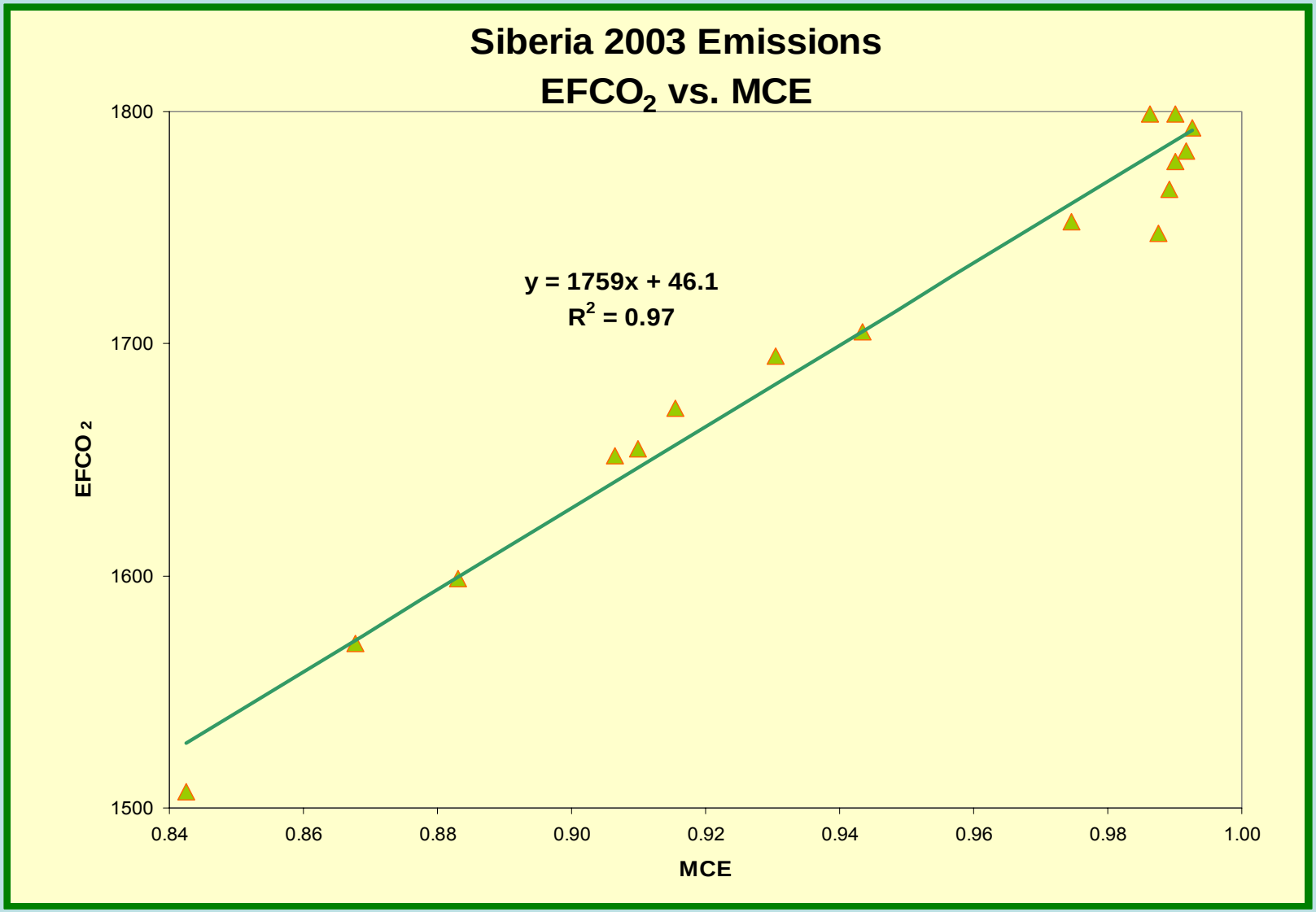


Predictive value of fire hazard indices for fire behavior and fuel consumption

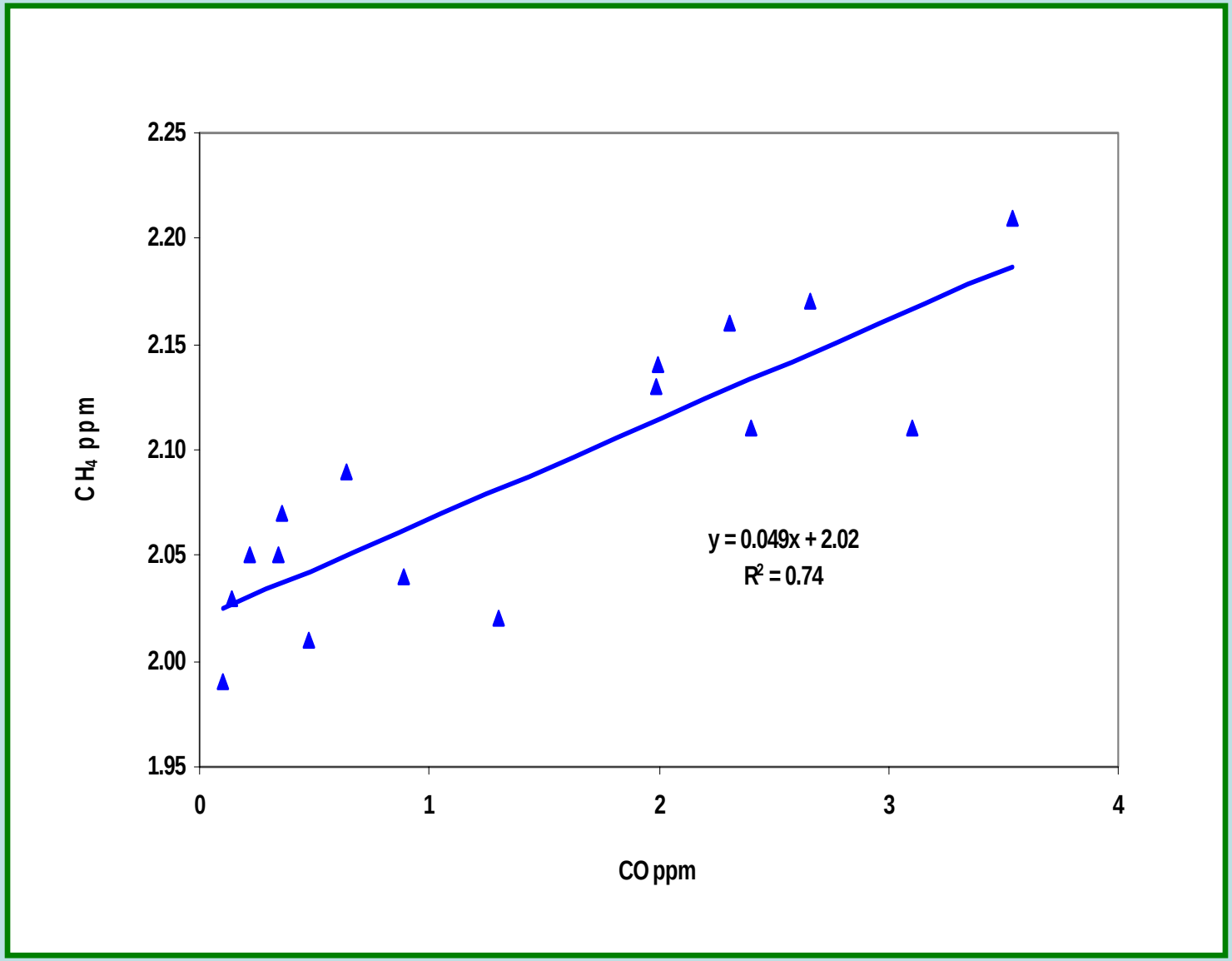
	Russian fire danger systems		Canadian Forest Fire Weather Index System		
Fire parameter	Nesterov Index	Moisture Index	Duff Moisture code	Drought Code	Fire Weather Index
Fuel consumption	0.654	0.842*	0.941*	0.823*	0.941*
Depth of burn	0.763*	0.900*	0.877*	0.681	0.944*
Rate of Spread	0.570	0.672	0.638	0.231	0.824*
Fireline Intensity	0.650	0.782*	0.820*	0.500	0.939*

Fire Weather Danger Index based on NOAA/AVHRR/TOVS data





Relationship between CO_2 emission factor and Modified Combustion Efficiency for emissions collected from 2003 fires by helicopter. This model can be applied to measured or derived Combustion Efficiencies in Siberian Scotch pine fires to predict CO_2 emissions.

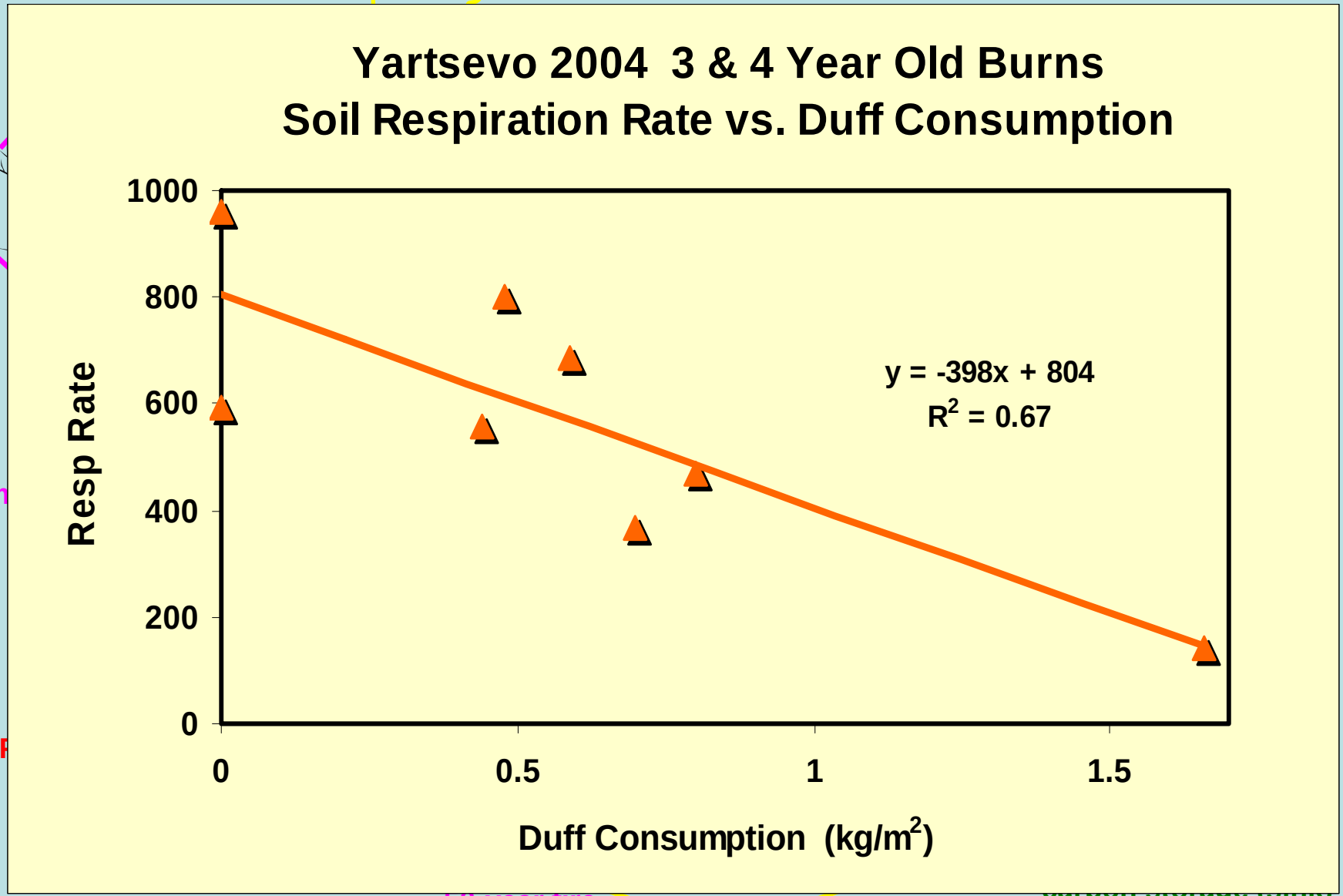


We can combine data on fuel consumption with data on composition of fire emissions to estimate emissions of various gases, including greenhouse gases such as methane.

Emission Factors for Yartsevo Fires (g/kg fuel)					
Plot	Date	MCE	EFCO2	EFCO	EFCH4
3	7/26/2001	0.917	1673	96.1	3.43
19	7/28/2001	0.907	1656	108.5	2.48
6	7/30/2001	0.863	1611	135.3	3.68
20	7/25/2002	0.939	1717	71.2	1.76
21	7/26/2002	0.923	1684	90.0	3.02
4	7/30/2002	0.933	1691	77.3	7.34
Mean		0.914	1672	96.4	3.62
StdDev		0.027	36	23.2	1.95

Integrated emission factors for 2001 and 2002 fires at Yartsevo. These emission factors can be used to predict total emissions of the gases for Siberian Scots pine fires from fuel consumption data.

FIRE and CARBON CYCLING

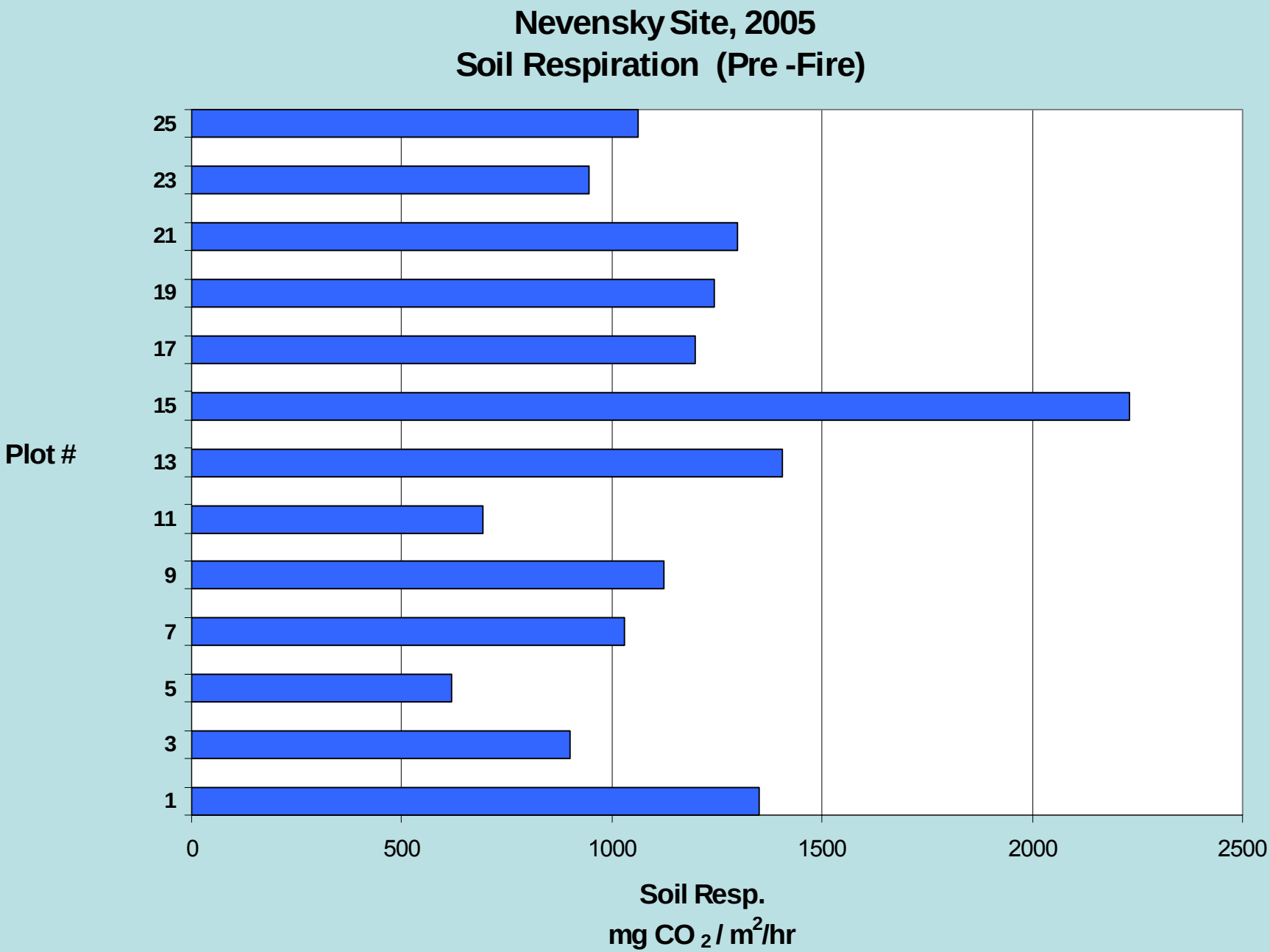


50-year fire return interval

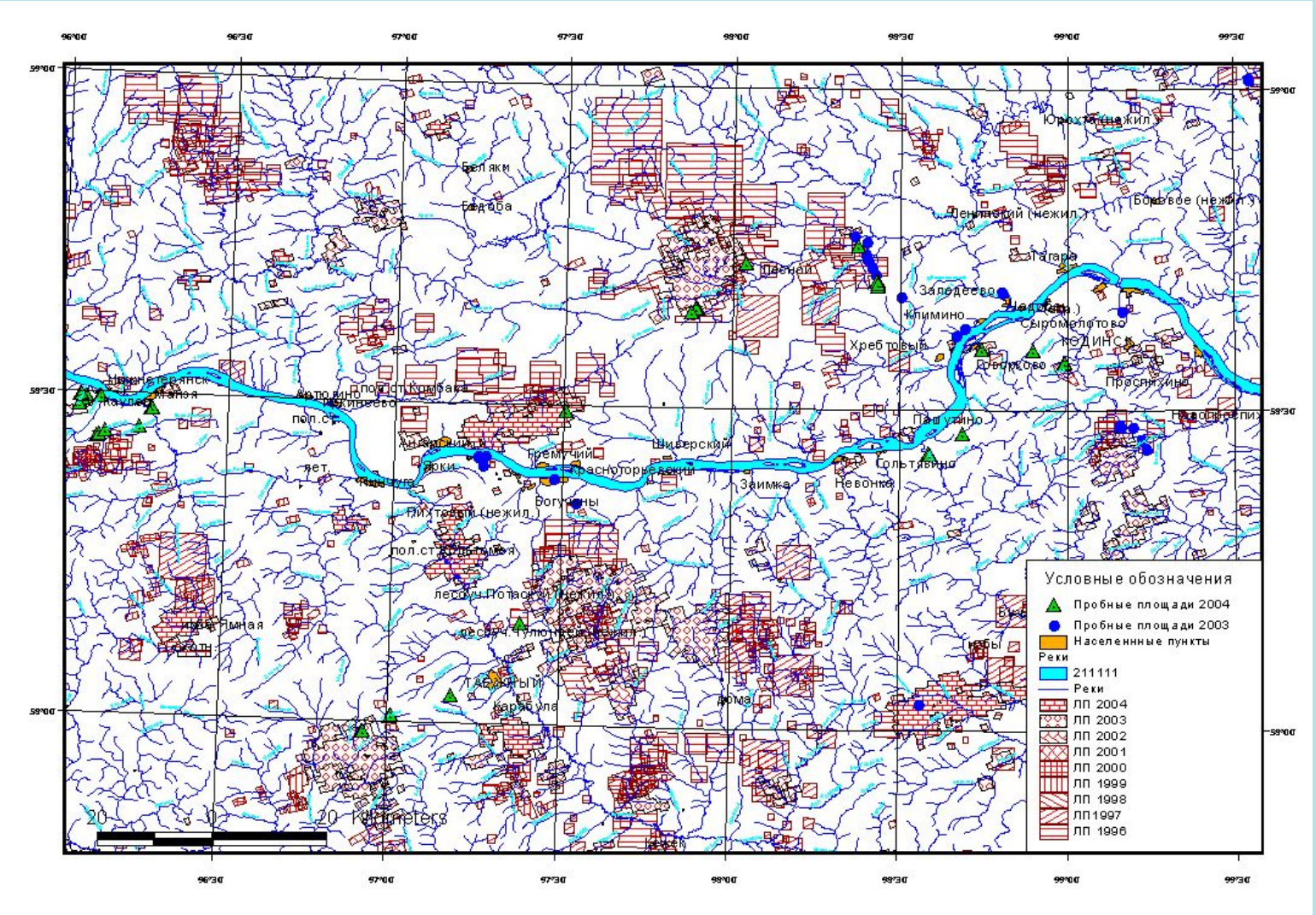
Estimated annual soil respiration following fires of different ages

Year of Fire	Soil Respiration (tC/ha/yr)	Standard deviation
Unburned	4.553	0.368
2-yr. postfire	2.146	0.874
1-yr. postfire	1.496	0.184
Immediate postfire	4.488	0.230

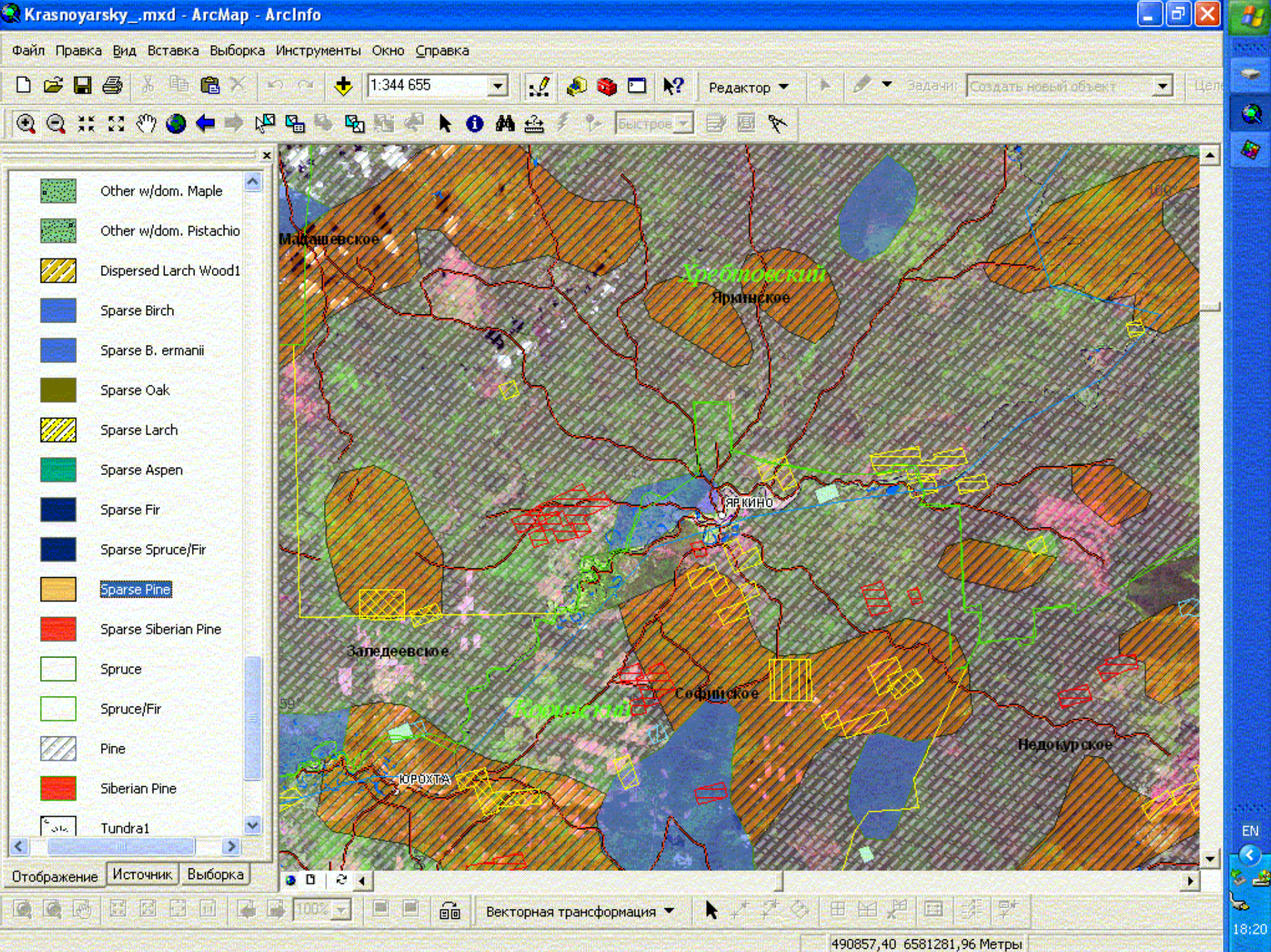
Decreases following 2001 and 2000 fires could be sufficient to cancel out carbon emissions from low-severity fires in 2-3 years.


Nevensky Site, 2005
Soil Respiration (Pre -Fire)
Plot #
25
23
21
19
17
15
13
11
9
7
5
3
1
0
500
1000
1500
2000
2500
Soil Resp.
mg CO 2 / m2/hr

Ground Validation of Burn Severity



Over 70 sites have been visited over the past 3 years. Work is in progress to relate ground data to satellite data from Landsat and Modis.


Krasnoyarsky_.mxd - ArcMap - ArcInfo
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Задачи:
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Other w/dom. Maple
Other w/dom. Pistachio
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Sparse Birch
Sparse B. ermanii
Sparse Oak
Sparse Larch
Sparse Aspen
Sparse Fir
Sparse Spruce/Fir
Sparse Pine
Sparse Siberian Pine
Spruce
Spruce/Fir
Pine
Siberian Pine
Tundra1
Отображение
Источник
Выборка
Хребтовский
Яркинское
ЯРКИНО
Заледеевское
Софийское
Недокурское
ЮРОХТА
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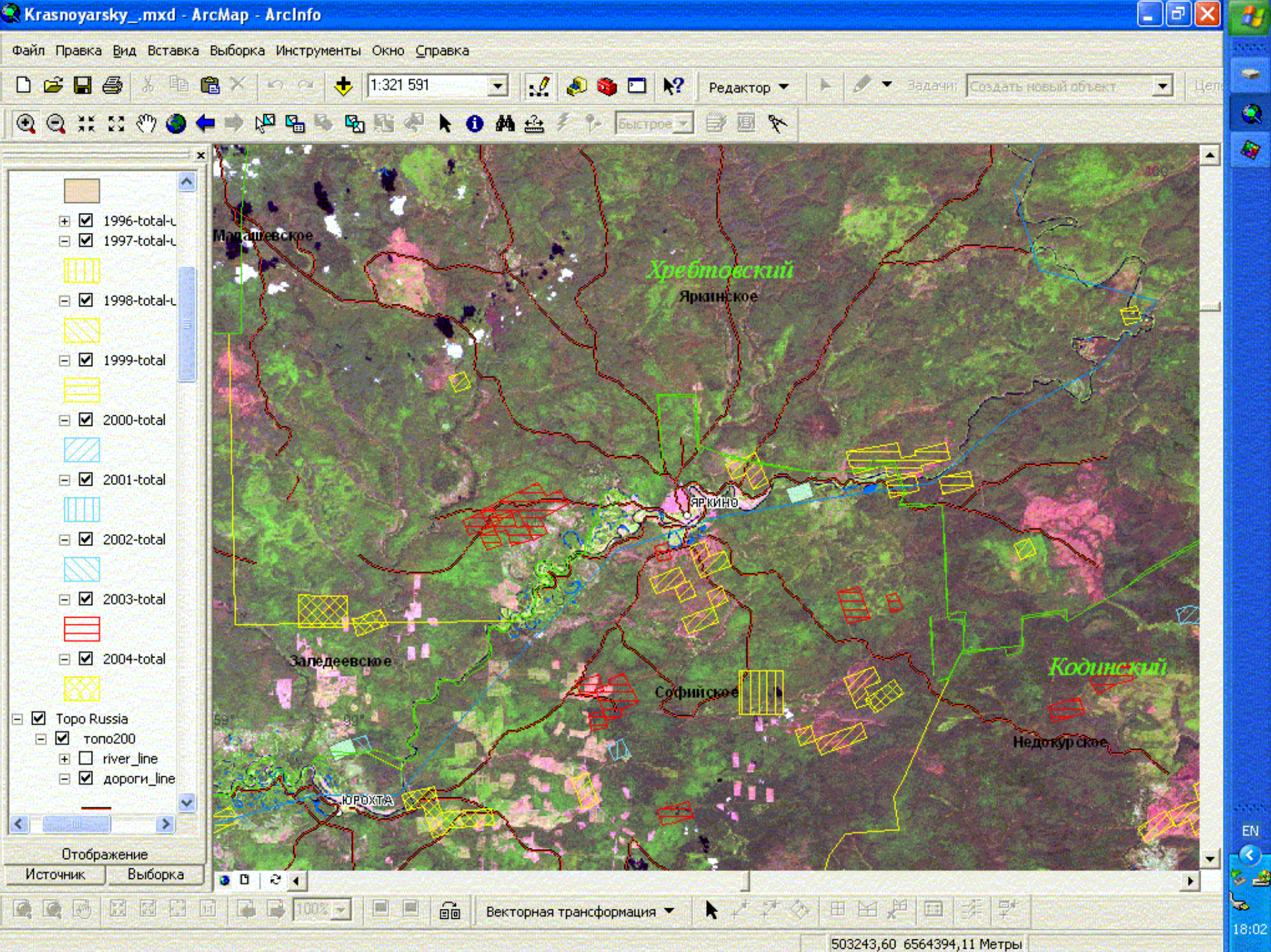
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Редактор
Задачи:
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1997-total-u
1998-total-u
1999-total
2000-total
2001-total
2002-total
2003-total
2004-total
Topo Russia
топо200
river_line
дороги_line
Отображение
Источник
Выборка
Малышевское
Хребтовский
Яркинское
ЯРКИНО
Заледеевское
Софийское
Кодинский
Недокурское
ЮРОХТА
Векторная трансформация
503243,60 6564394,11 Метры
EN
18:02

Take-home Messages

- Fires in Scots pine forests exhibit a wide range in behavior.
- The amount of fuel burned varies widely, depending on fuel conditions and fire behavior.
- From 5 to 15 t/ha of carbon were emitted in surface fires; 3 to 7 t/ha more might be emitted in crown fires.
- Fire hazard indices appear useful for predicting fuel consumption, depth of burn, and fire rate of spread.
- Smoke sampling allows us to partition emissions into different gases, as well as aerosols.
- Soil respiration is depressed substantially for up to several years after fires.
- We are beginning similar work in larch forests.
- Extensive ground sampling of wildfire areas will be linked to remote sensing data, to extend experimental data to the landscape scale.

Research Collaborators:

Federal Forest Service of Russia

- Forestry Committee and Leshozes of Krasnoyarsk Region
- Forest Protection Airbases, Krasnoyarsk Region

Russian Academy of Science, Siberian Branch

- V.N. Sukachev Institute of Forest, Krasnoyarsk
- Institute of Chemical Kinetics and Combustion, Novosibirsk

Universities

- Siberian Technological University
- University of Virginia

USDA Forest Service

- Washington DC
- Rocky Mountain Research Station
- International Programs

Canadian Forest Service

- Great Lakes Forestry Centre


Thank You