Synthesis of Forest Growth, Response to Wildfires and Carbon Storage for Russian Forests using a Distributed, Individual-Based Forest Model

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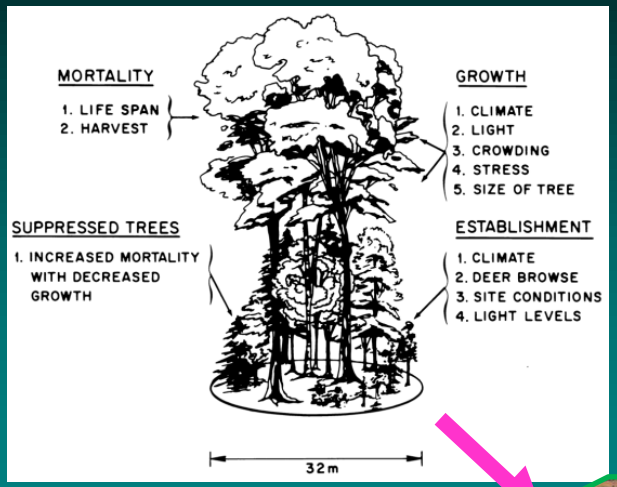
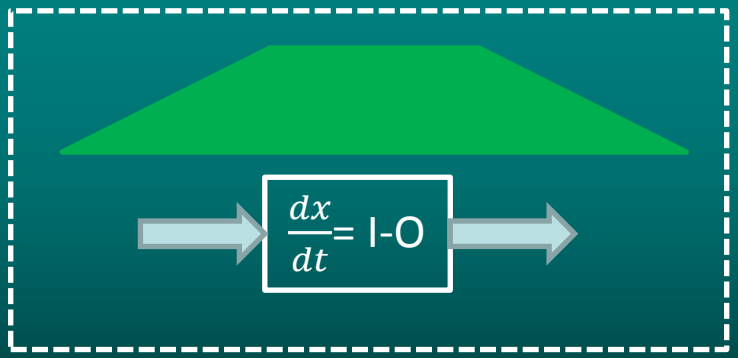
A Forest Modeling Primer

Gap Models



Spatially Explicit IBMs

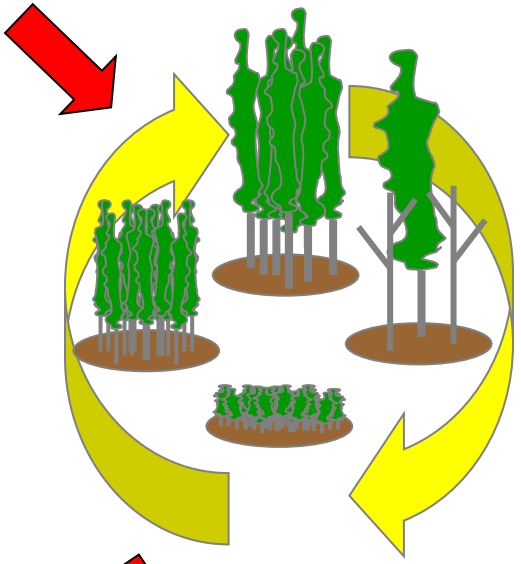
Interactive Mosaic Models



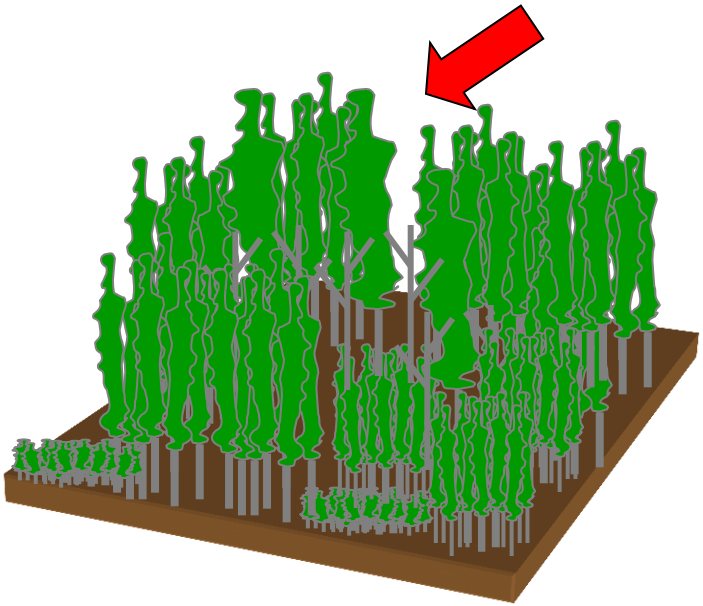
Homogeneous Models

Increasing Spatial Resolution
Increasing Size of "Pixel"

Grow individual trees according to species, diameter and the environment.



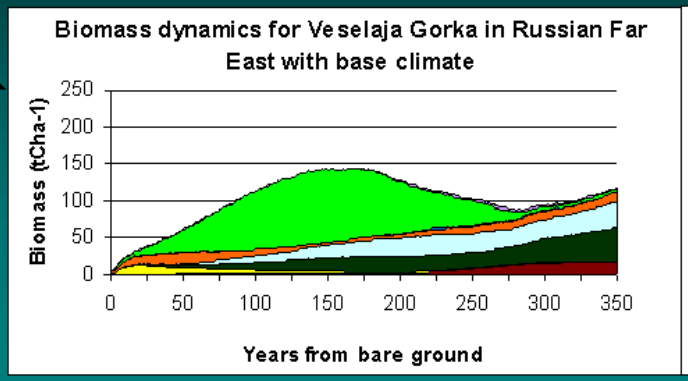
Plot dynamics by: Species, Age, Biomass, Basal Area and Average DBH.

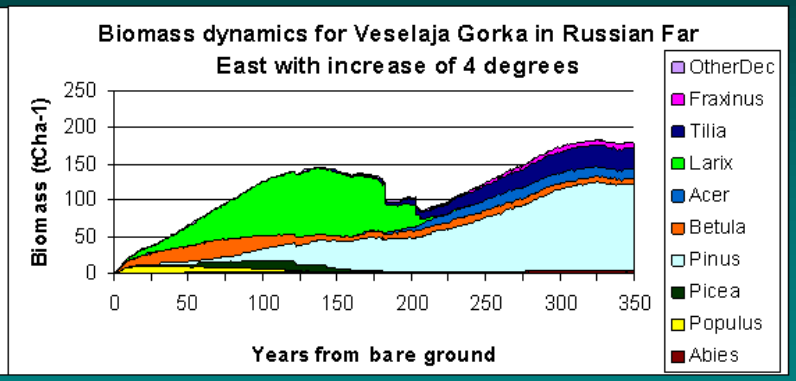


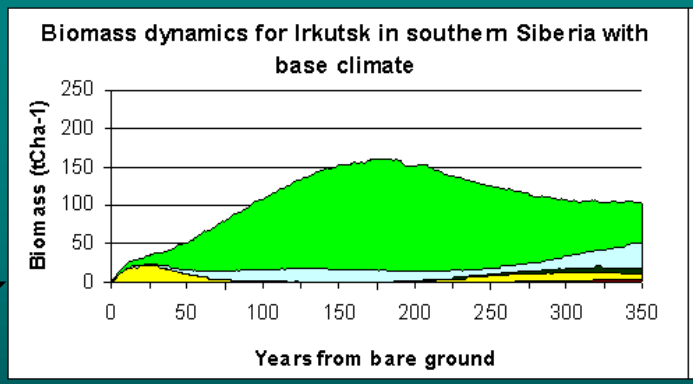
Model output: Average of individually simulated plots with a dynamic climate and vegetation change.

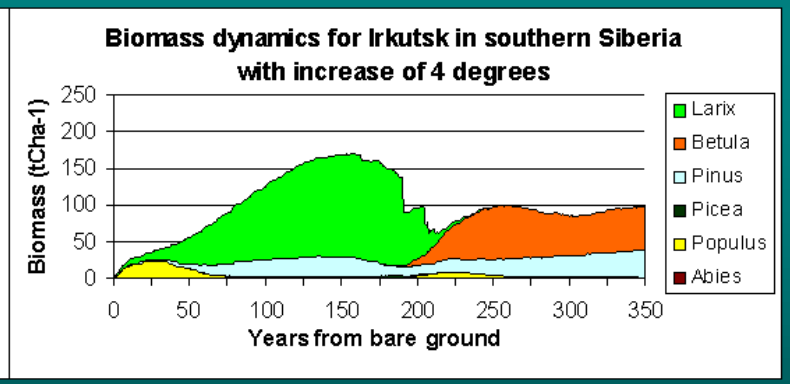
Cumulative biomass (tC ha^{-1}) of species from model simulations for two locations in Russia.

BASE CASE





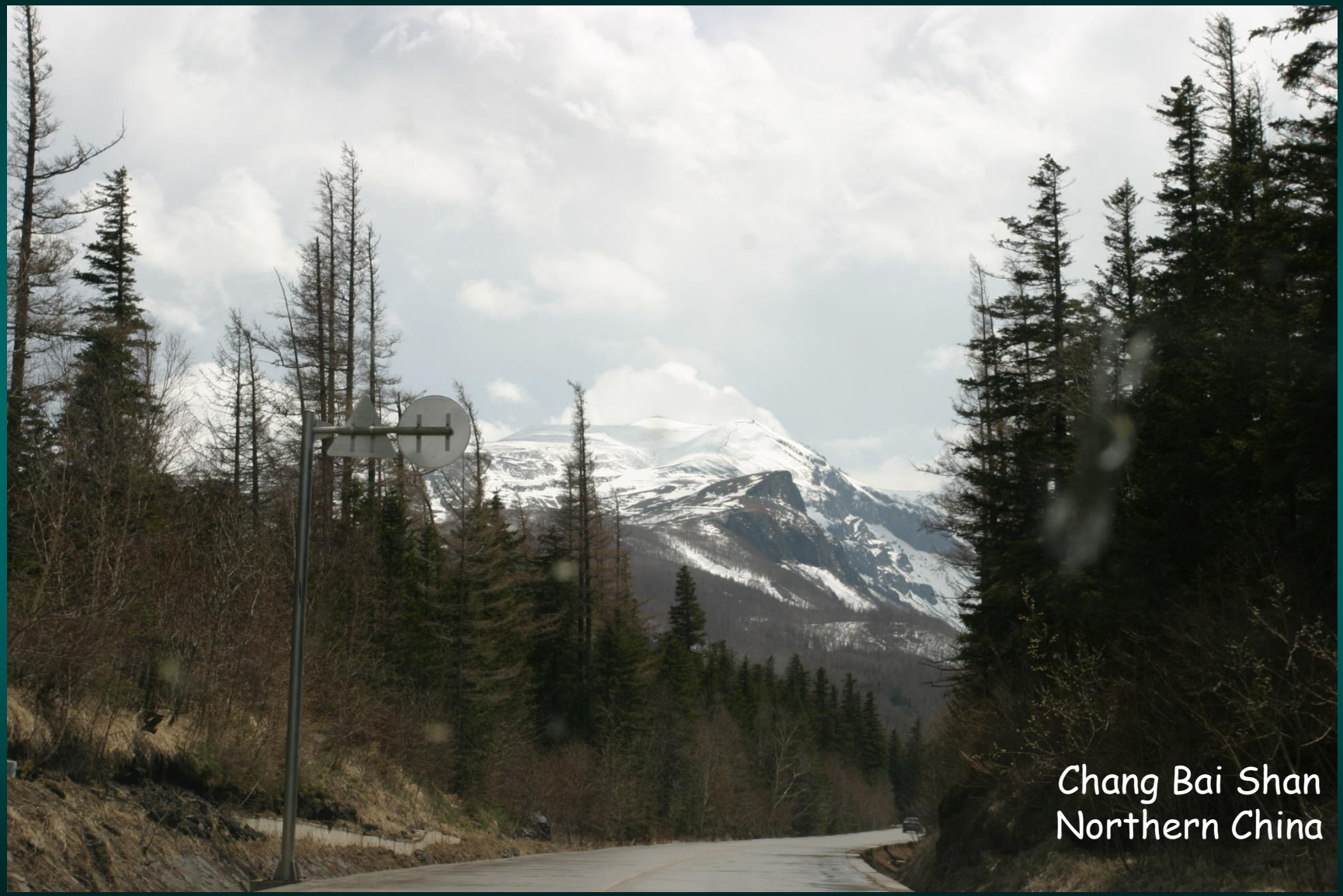




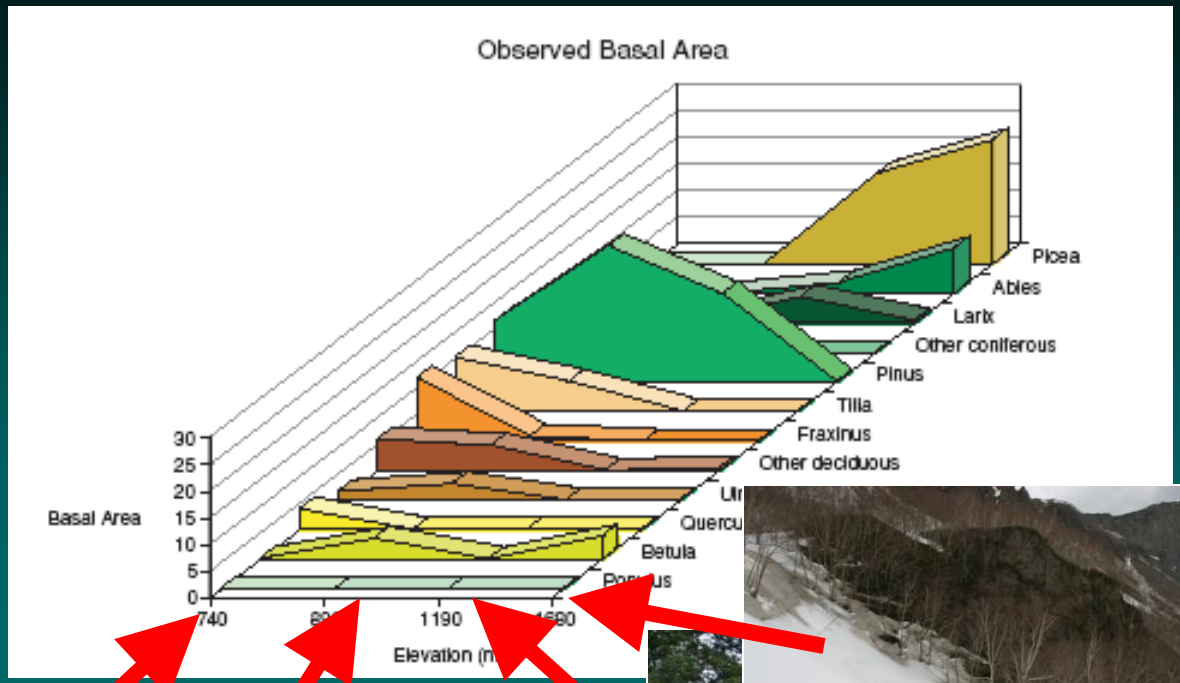
WARMING

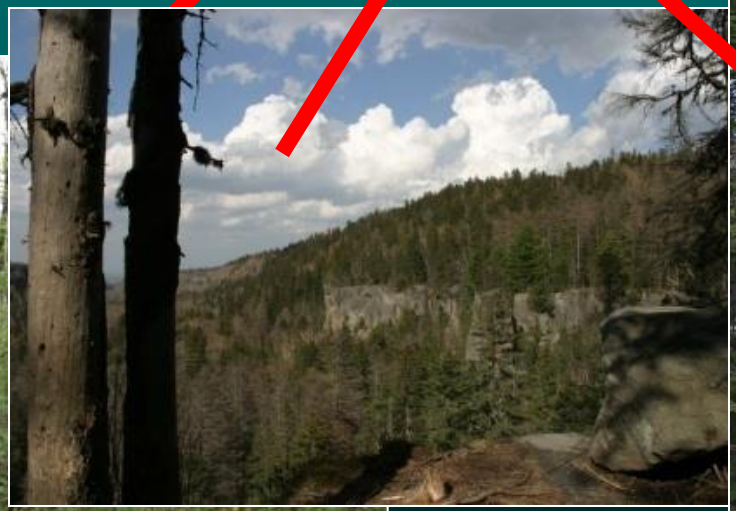
Each graph displays composition by the dominant genera. The base cases in each of the pairs of graphs represent the successional dynamics from a bare ground condition in year 0 for 350 years of ecological succession.

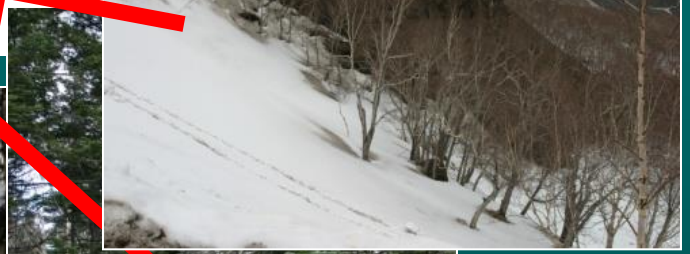
Model Testing in China and Russia



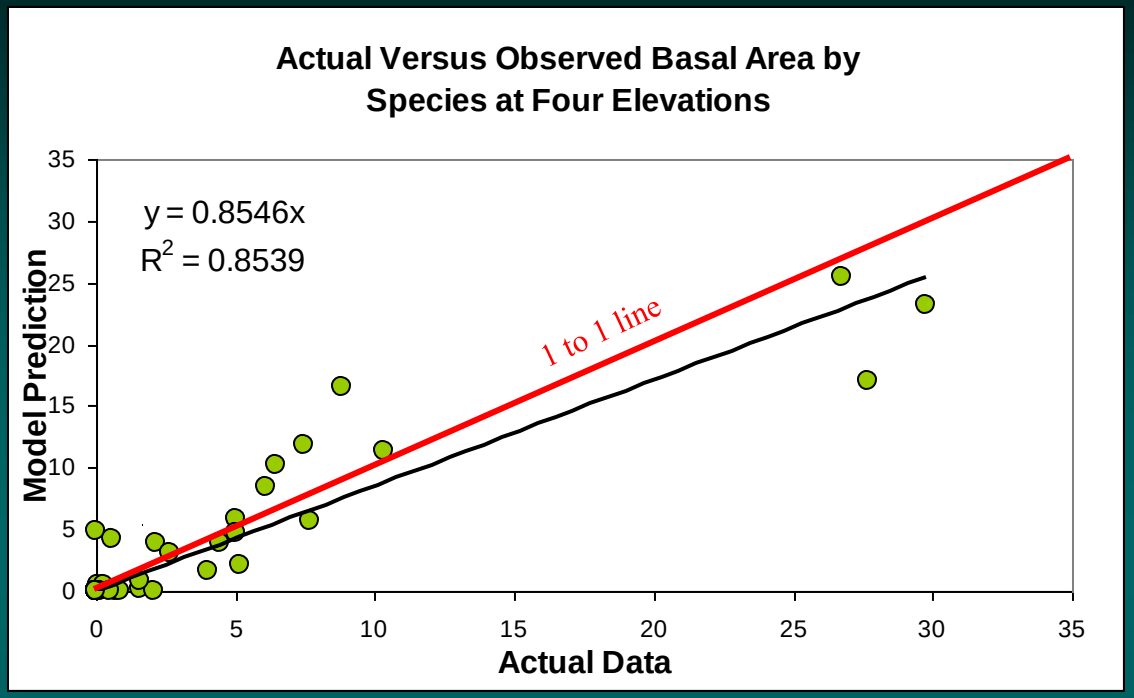
Forest Patterns on Chang Bai Shan

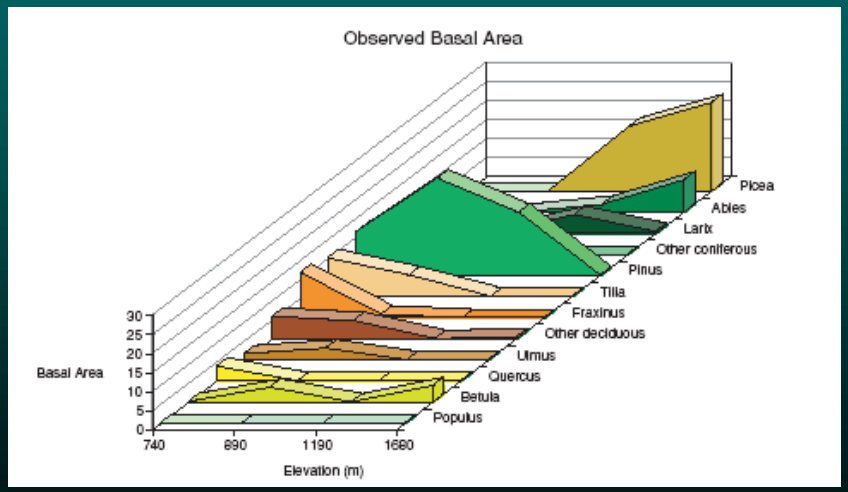


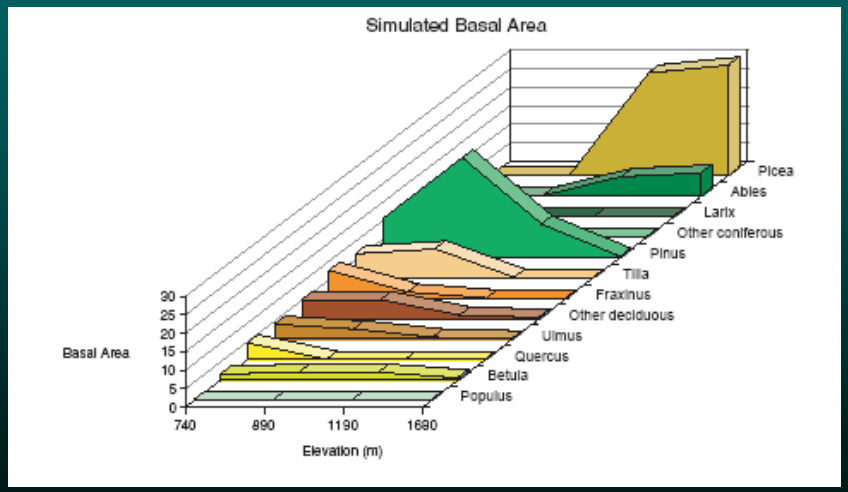




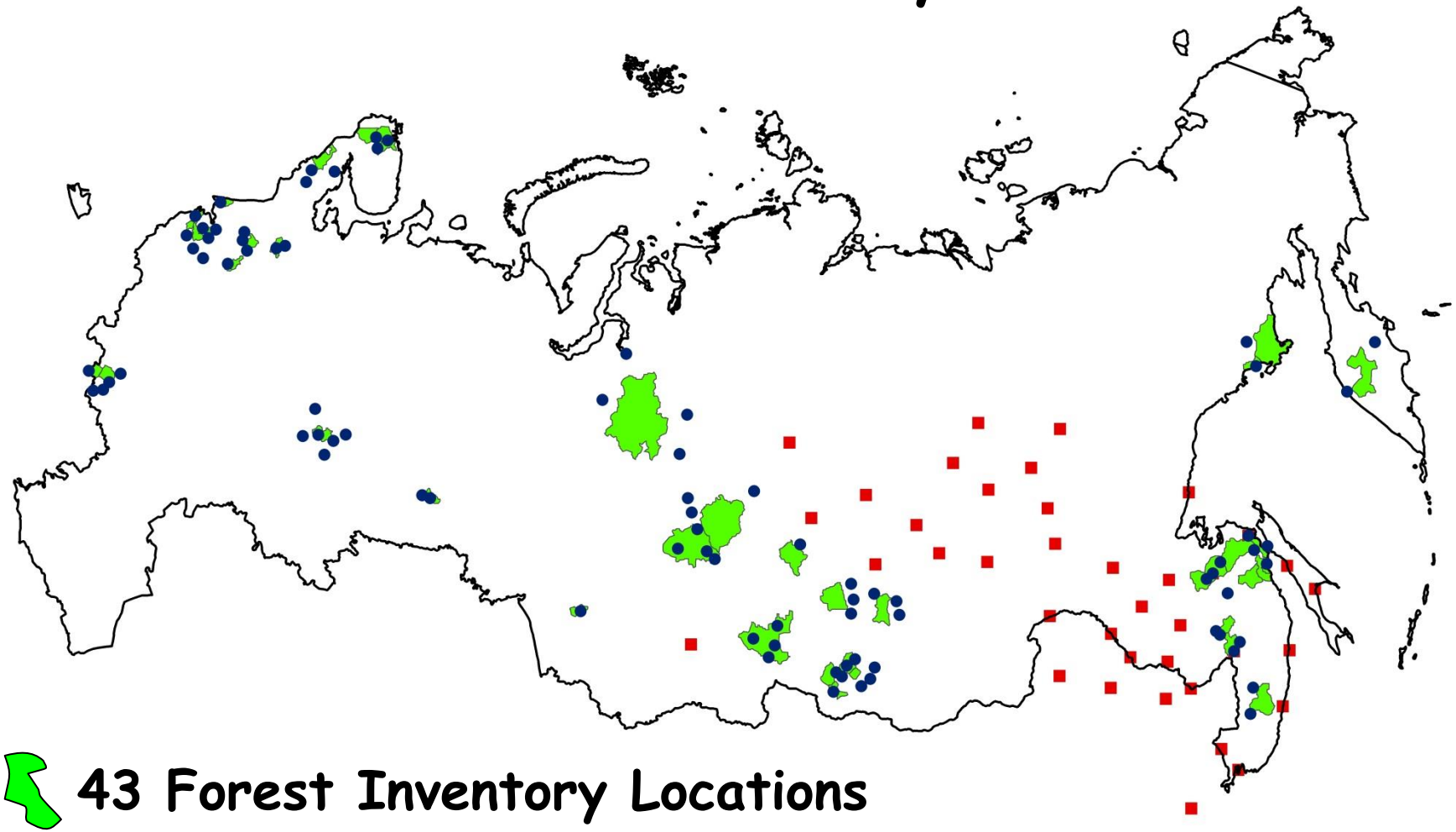
Tests of the FAREAST Model on Chang Bai Shan Gradients







Model to Inventory Locations



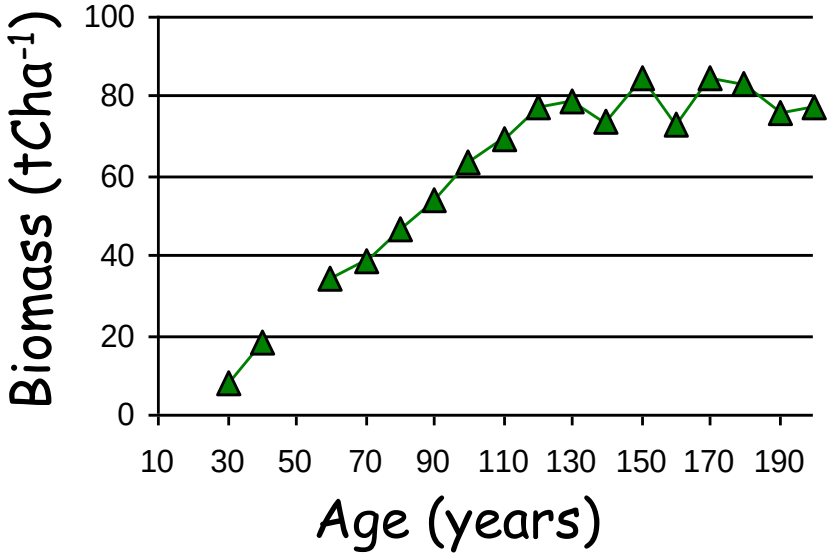
43 Forest Inventory Locations

93 Comparisons (Maximum Distance 125km)

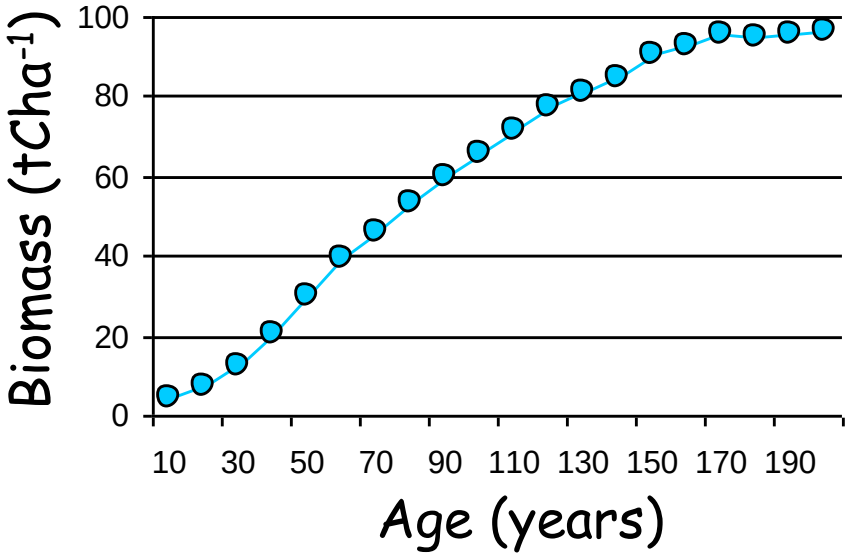
Original sites (Yan and Shugart 2005)

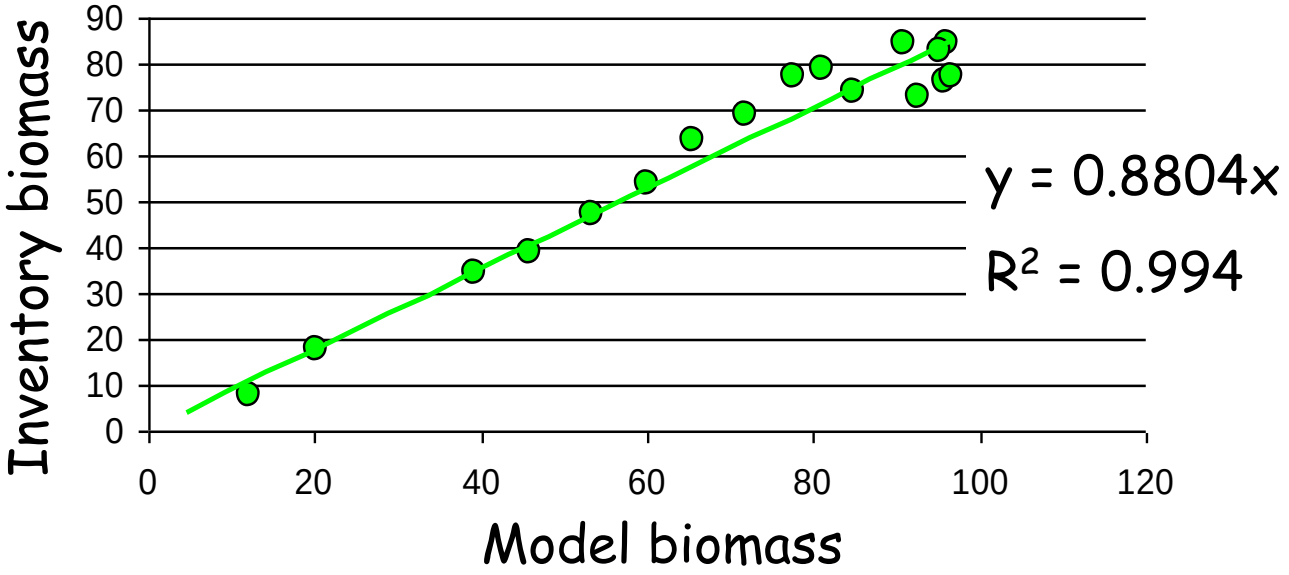
Model Validation with Inventory Data

Southern Siberia inventory *Larix spp.*

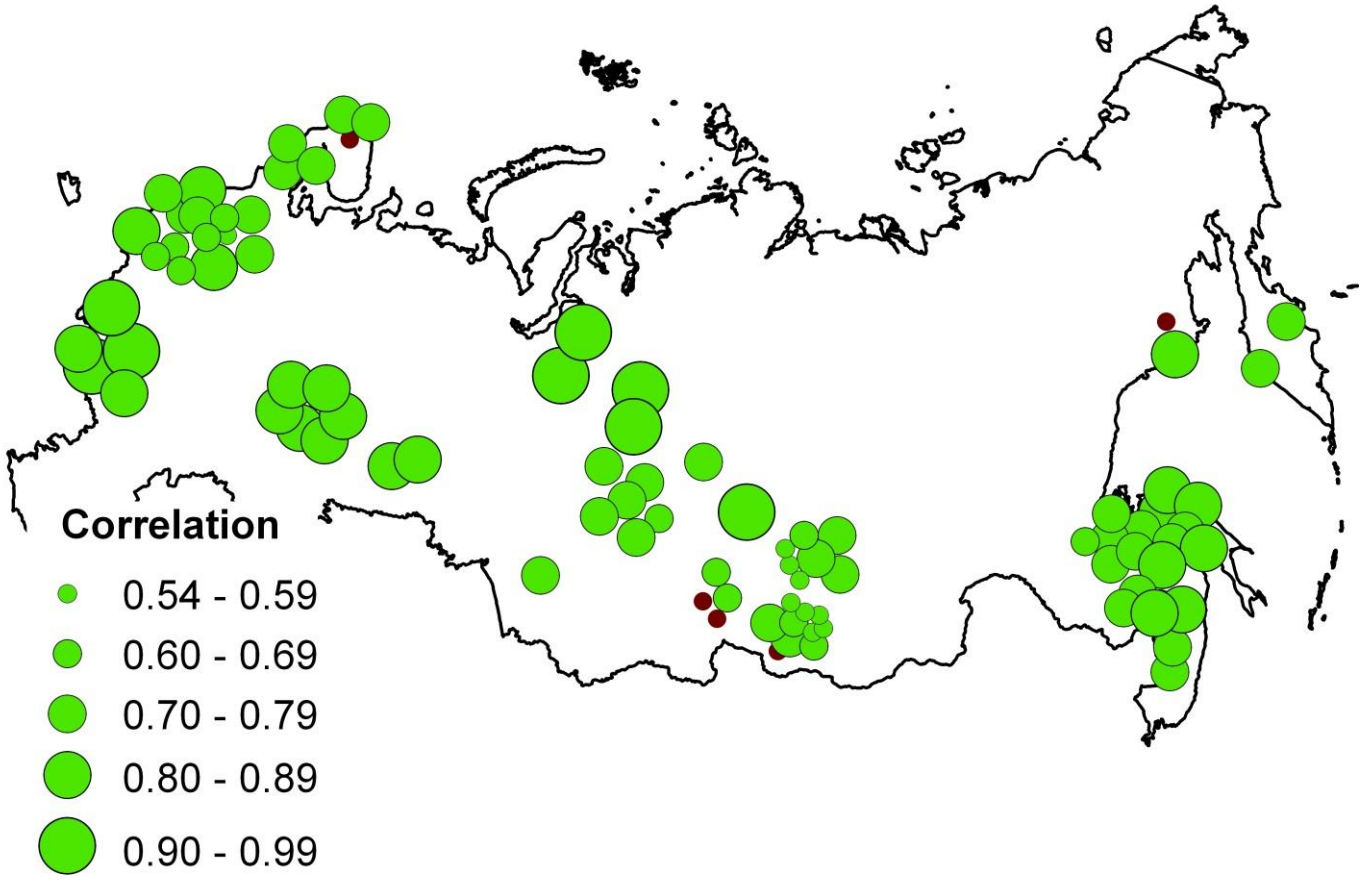


Southern Siberia model site *Larix spp.*





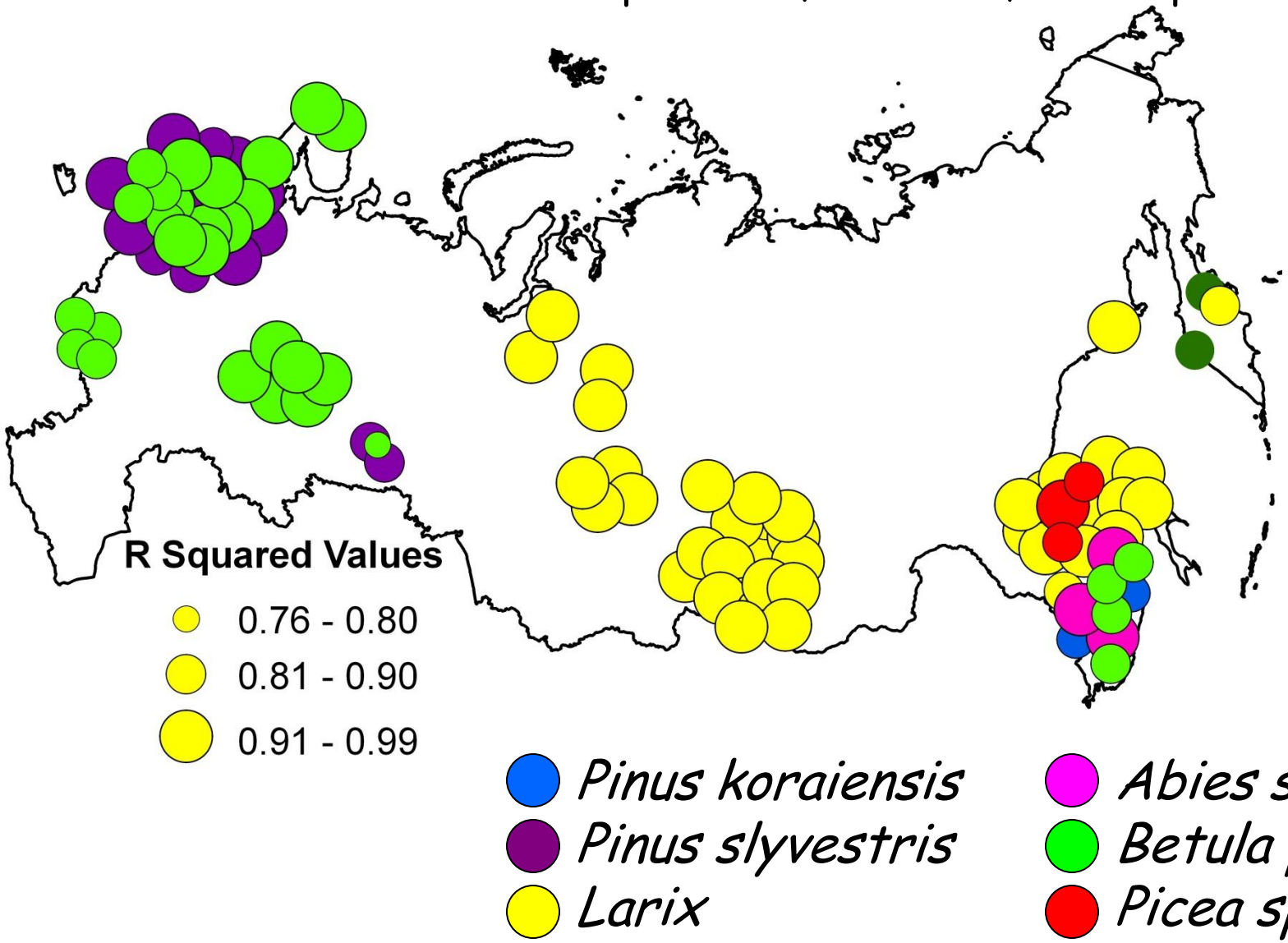
Linear regression of total model simulated to forest measured biomass (tC ha^{-1})



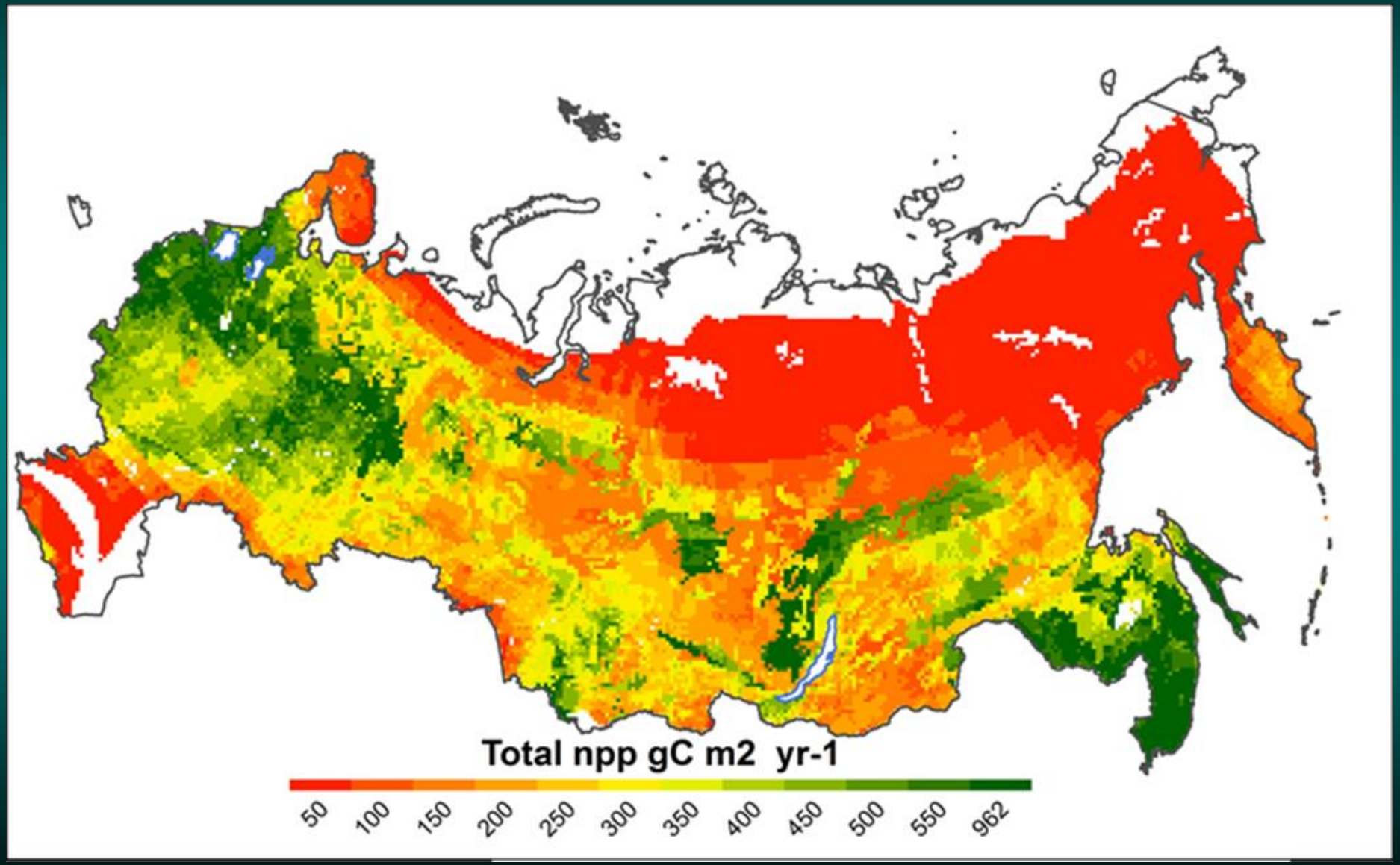
Successful correlations met all of the following criteria:
$p<0.001$, $R^2 > 0.54$, and slope < 1.5 for a linear trend line with an intercept of zero

Correlation of model to inventory data

Successful correlations: $p < 0.001$, $R^2 > 0.65$, and slope < 1.5



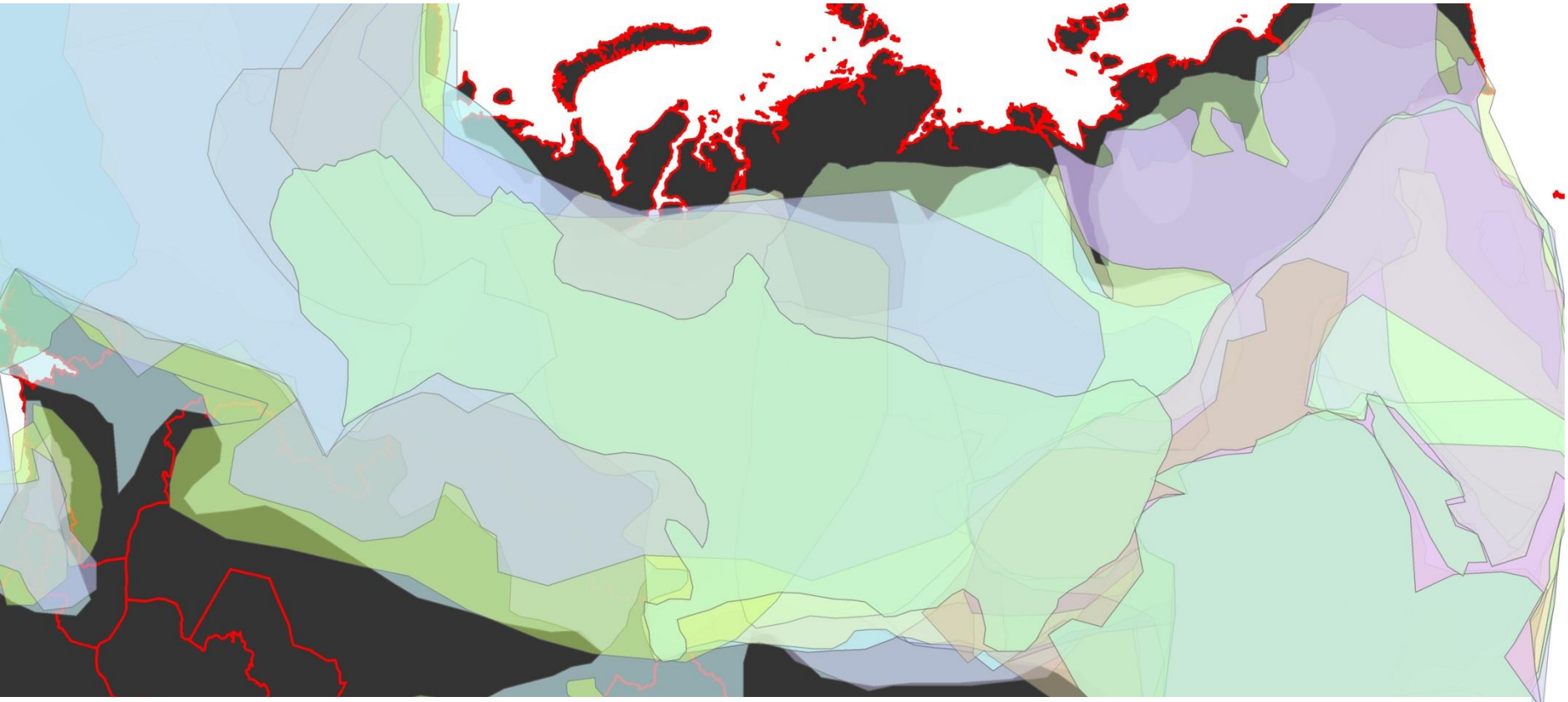
Large Area Applications



Species Range Maps

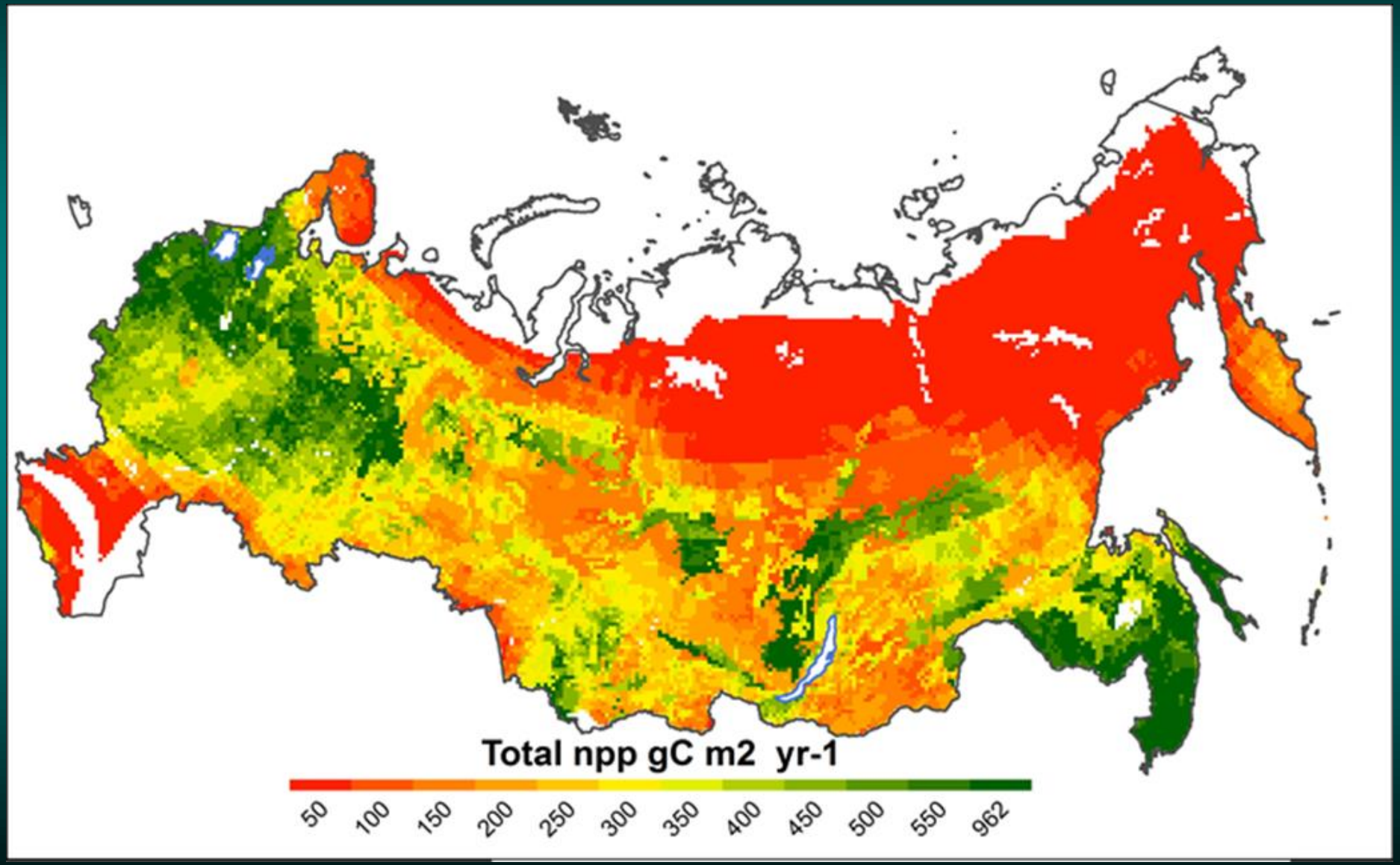
Increase from 44 to 52 total species

28 species specific parameters for 12 new species

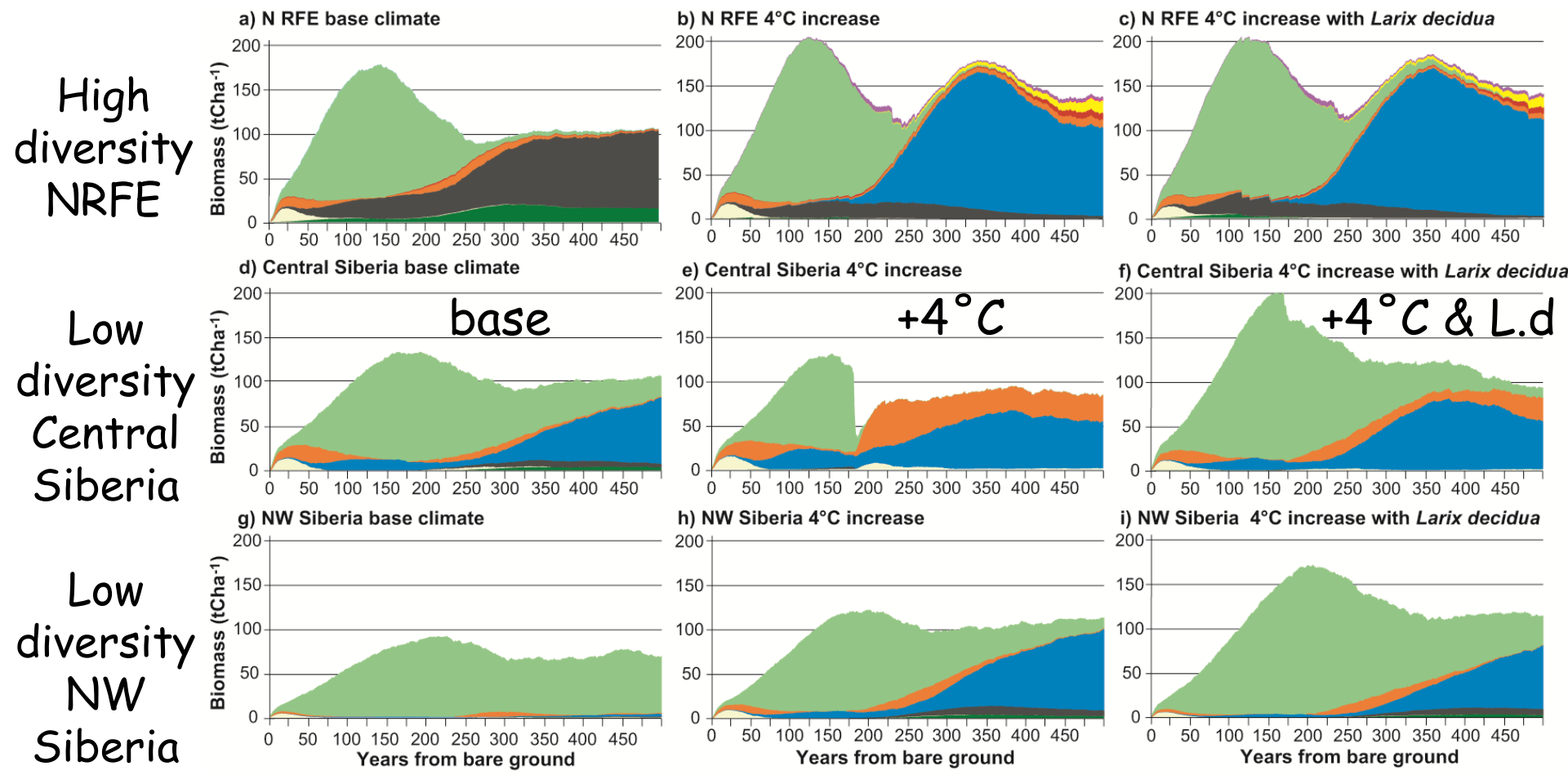


- Data: Nikolov and Helmisaari (1992), Hytteborn et al (2005) and Kienast (1987)
- 52 species ranges incorporated as presence or absence using GIS

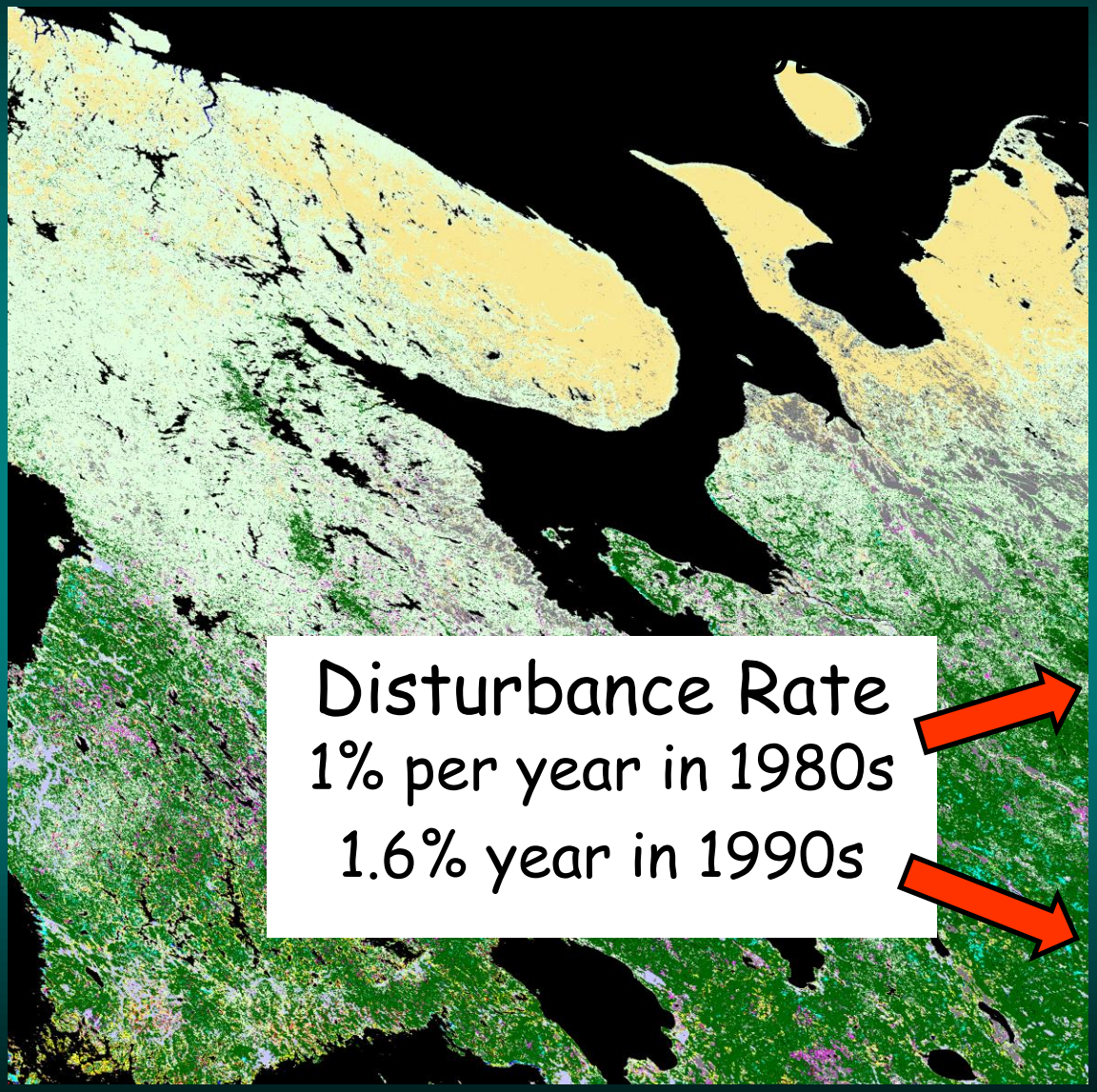
Large Area Applications



For each of these points, given data on climate and soil, the FAREAST model simulates the growth, death and mortality of each individual tree on a small plot to assemble and produce change in a forest.



Reconstructing Disturbances



Non-Forest

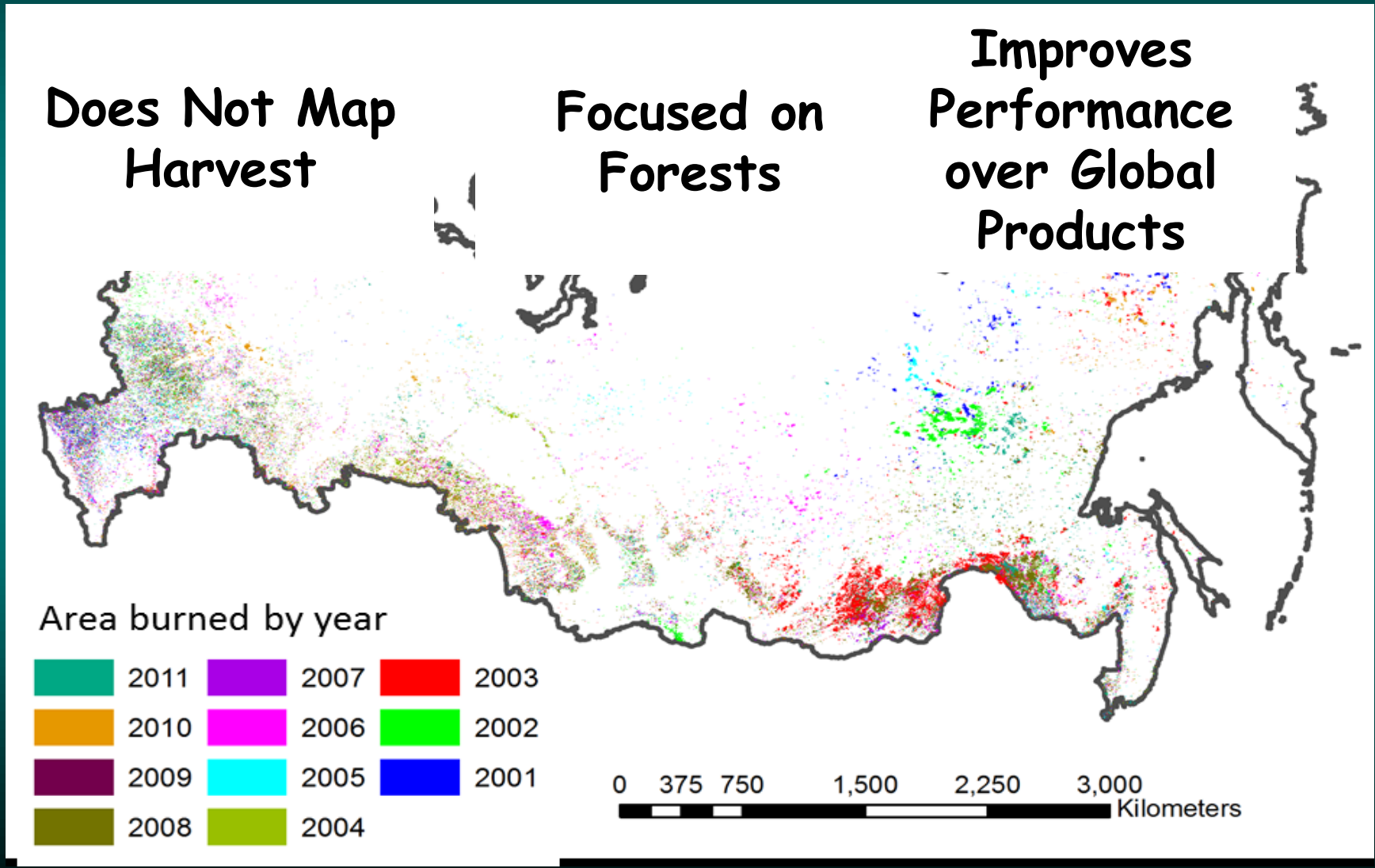
~73% forest undisturbed over the past 30 years

Forest Disturbance

- undisturbed forest
- disturbance 1985
- disturbance 1987
- disturbance 1988
- disturbance 1989
- disturbance 1990
- disturbance 1991
- disturbance 1992
- disturbance 1993
- disturbance 1995

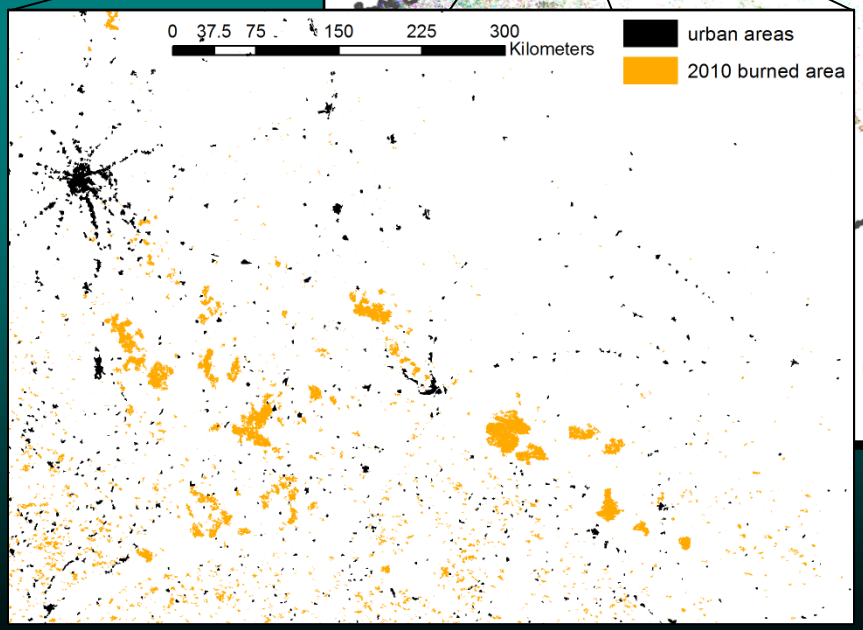
Mapping Ongoing Disturbances

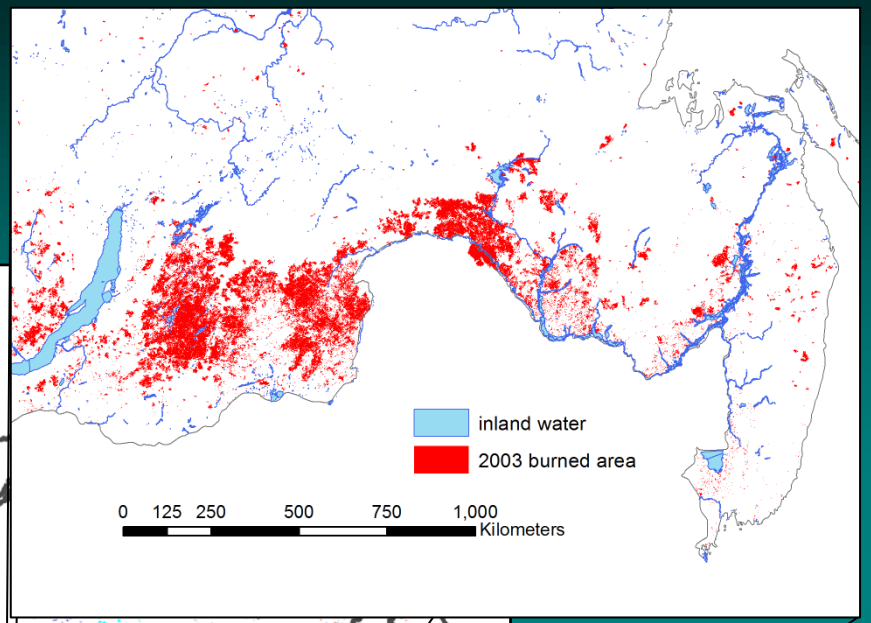
MODIS burned-area based on a regional algorithm:

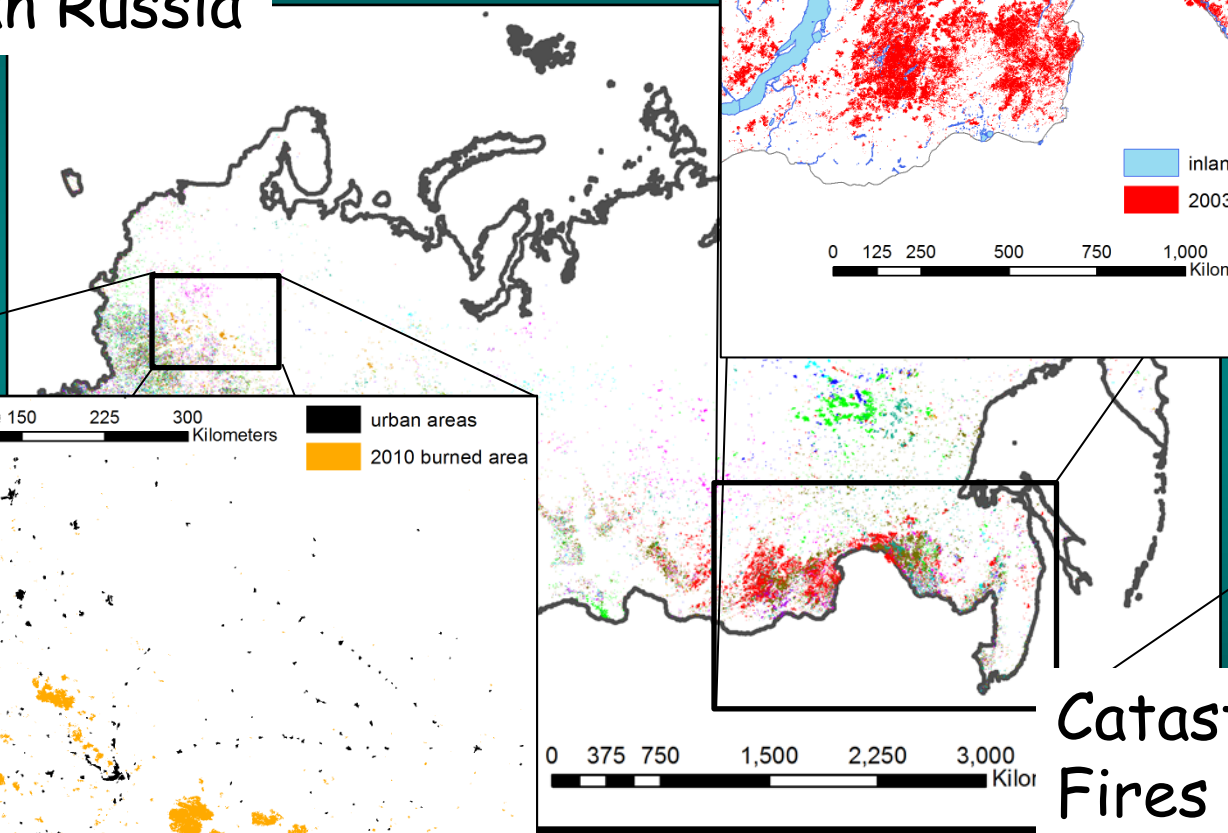


Mapping Ongoing Disturbances

Catastrophic Fires of 2010 in European Russia

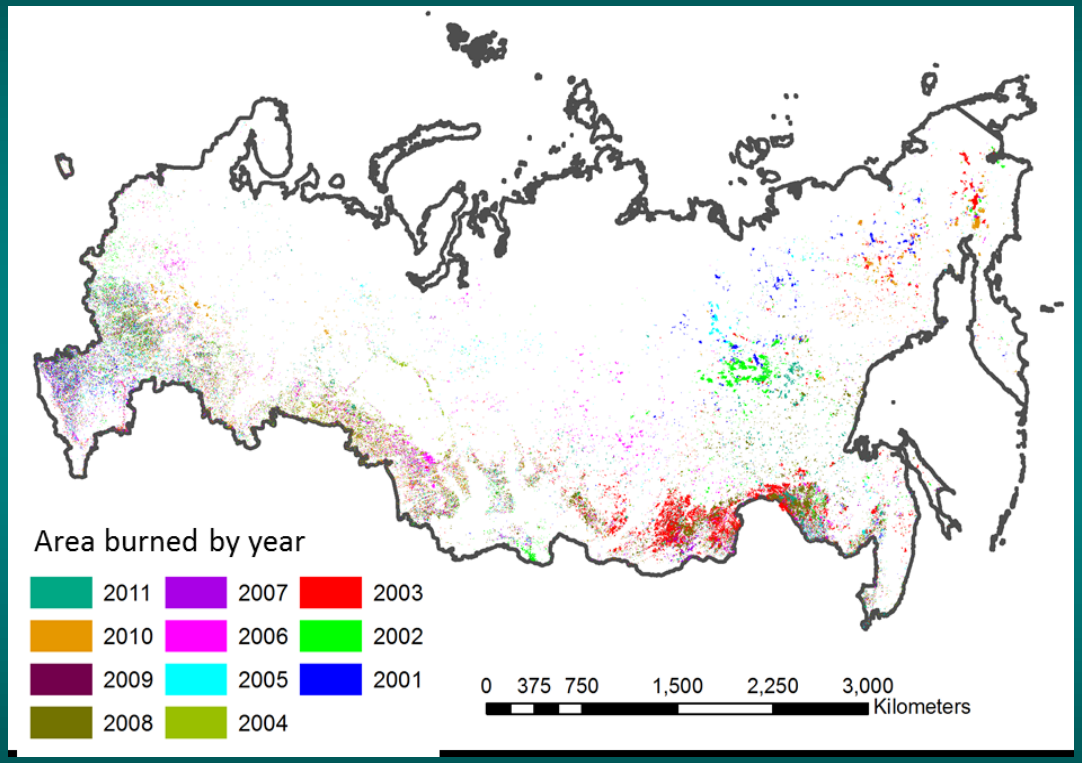






Catastrophic Fires of 2003 around Baikal Region

Mapping Ongoing Disturbances

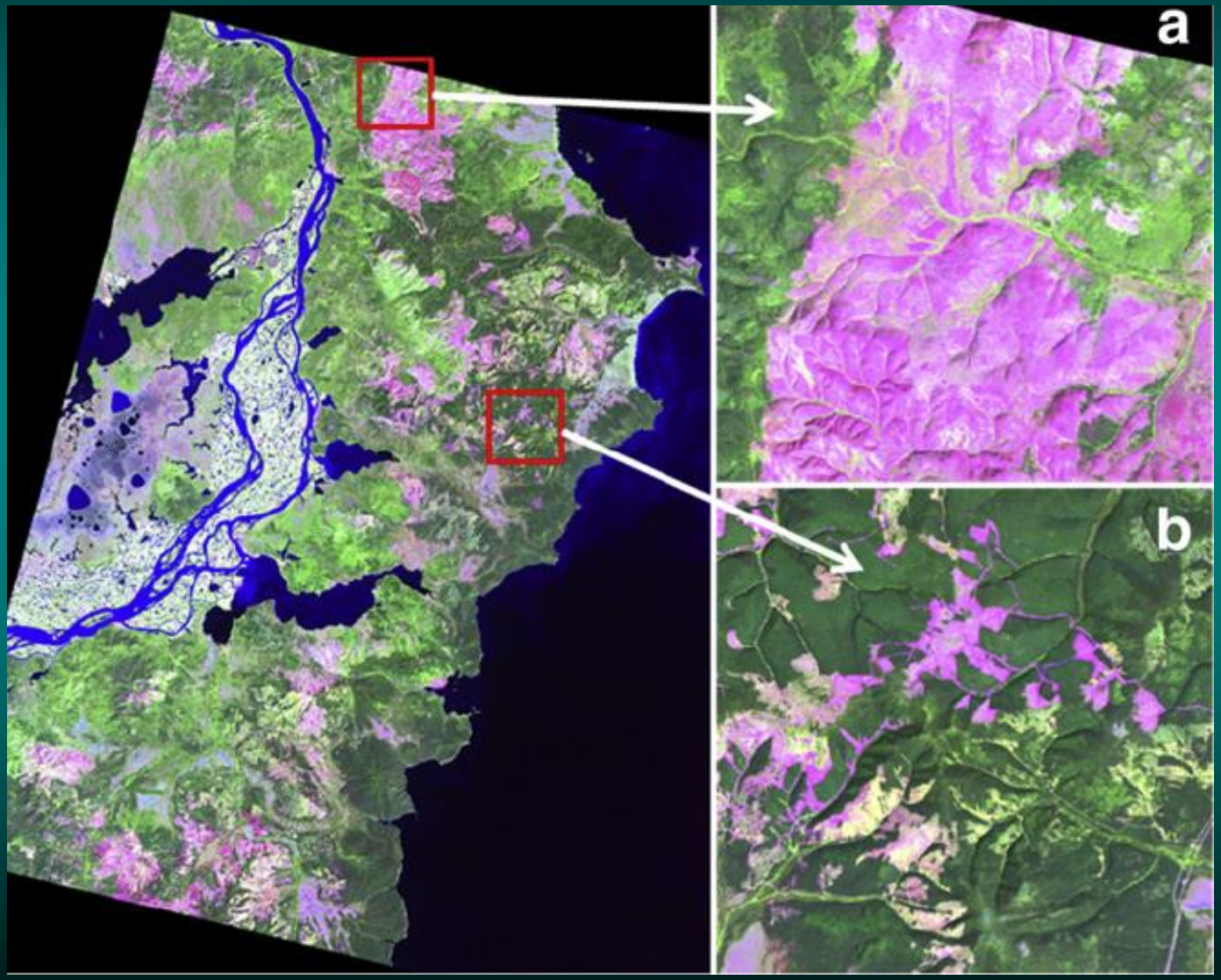


2001 - 2011:

- 7% of forests (> 31 million ha) burned
- Disturbance rate for 2000s is ~ 0.6% per year
- By forest type*:
  - Larch 61%
  - Mixed 26%
  - Spruce/fir/pine 10%
  - Broadleaf 3%

* As defined by the MODIS land cover product

Simulating Wildfire Drivers of Mosaic Landscapes with Climate Change



Impacts of Climate Change on Biomass and Composition

Forest Stand Initialization (years)	Model simulation year					
	0	25	50	75	100	..200
0	begin climate change					
25	historic	begin climate change				
50	historic climate		begin climate change			
75	historic climate			begin climate change		
100	historic climate				begin climate change	

Table 1: Forest model initialization and timing of incorporation of climate change scenario data

An example follows with FAREAST run at 31,010 sites across Russia for historic climate and with temperature changes from NCAR CCSM sresA1B (720ppm CO2).

Results for mixed-age forest landscape

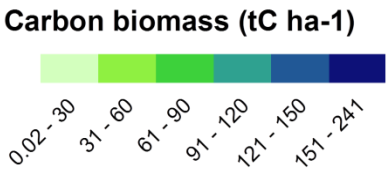
Historic climate at year 100

NCAR CCSM sres A1B at year 100

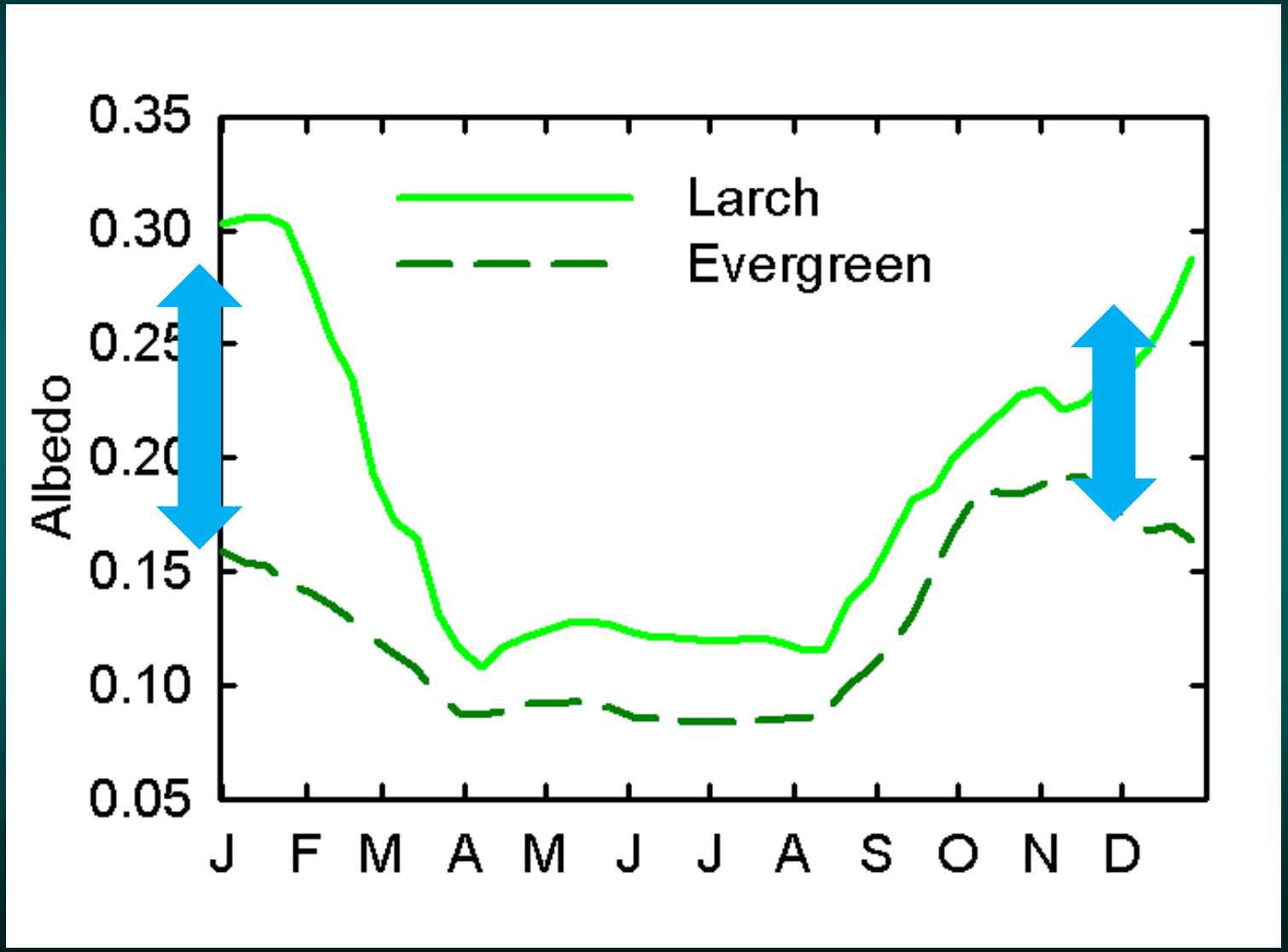
Larix species biomass

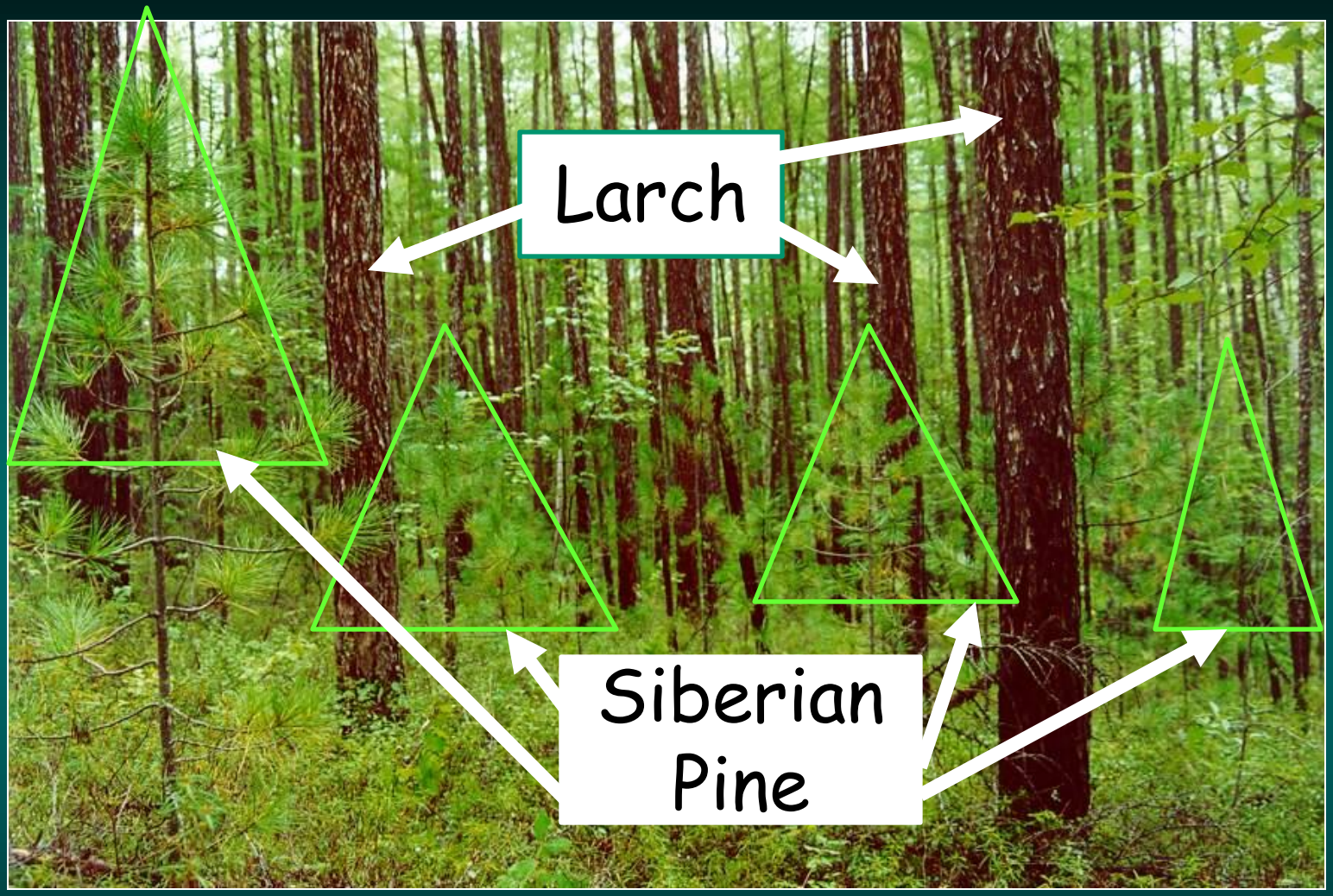
Broad-leaved deciduous species biomass

Total mixed species biomass



Larch trees reflect more light back into space year-round but the effect is very large in the winter.





Siberian Pine regeneration under a Larch canopy

THANK YOU!

Funding:

NEESPI: Northern Eurasian Earth Science Partnership Initiative