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

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Spatially Explicit IBMs

Interactive Mosaic Models

Homogeneous Models

\[ \frac{dx}{dt} = I - O \]
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.

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

Chang Bai Shan
Northern China
Forest Patterns on Chang Bai Shan

[Diagram showing observed basal area with different tree species represented by colored bars.]

[Images of forest landscapes at different elevations.]
Tests of the FAREAST Model on Chang Bai Shan Gradients

Actual Versus Observed Basal Area by Species at Four Elevations

\[ y = 0.8546x \]

\[ R^2 = 0.8539 \]
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.*

- **Biomass (tCha⁻¹)**
- **Age (years)**

- **Inventory measured** *Larix spp.* biomass
- **Model simulated** *Larix spp.* biomass
- \( y = 0.8804x \)
- \( R^2 = 0.994 \)

**Southern Siberia model site** *Larix spp.*

- **Biomass (tCha⁻¹)**
- **Age (years)**

- **Inventory measured** *Larix spp.* biomass
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- \( y = 0.8804x \)
- \( R^2 = 0.994 \)
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

- Abies spp
- Betula pendula
- Pinus koraiensis
- Pinus sylvestris
- Larix
- Picea spp
Species Range Maps

Increase from 44 to 52 total species

28 species specific parameters for 12 new species

- 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.

High diversity
NRFE

Low diversity
Central Siberia

Low diversity
NW Siberia
Reconstructing Disturbances

Disturbance Rate
1% per year in 1980s
1.6% year in 1990s

~73% forest undisturbed over the past 30 years
Mapping Ongoing Disturbances
MODIS burned-area based on a regional algorithm:

- Does Not Map Harvest
- Focused on Forests
- Improves Performance over Global Products

Area burned by year:
- 2011
- 2010
- 2009
- 2008
- 2007
- 2006
- 2005
- 2004
- 2003
- 2002

Kilometers
Mapping Ongoing Disturbances

Catastrophic Fires of 2010 in European Russia

Catastrophic Fires of 2003 around Baikal Region
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
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

Carbon biomass (tC ha⁻¹)
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!

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