Monitoring land cover and land use in boreal and temperate natural biomes
August 25-28, 2010 - Tartu, Estonia

Overview of modeling forest productivity and carbon cycling under climate change

- with emphasis on empirical models

Pekka KAUPPI

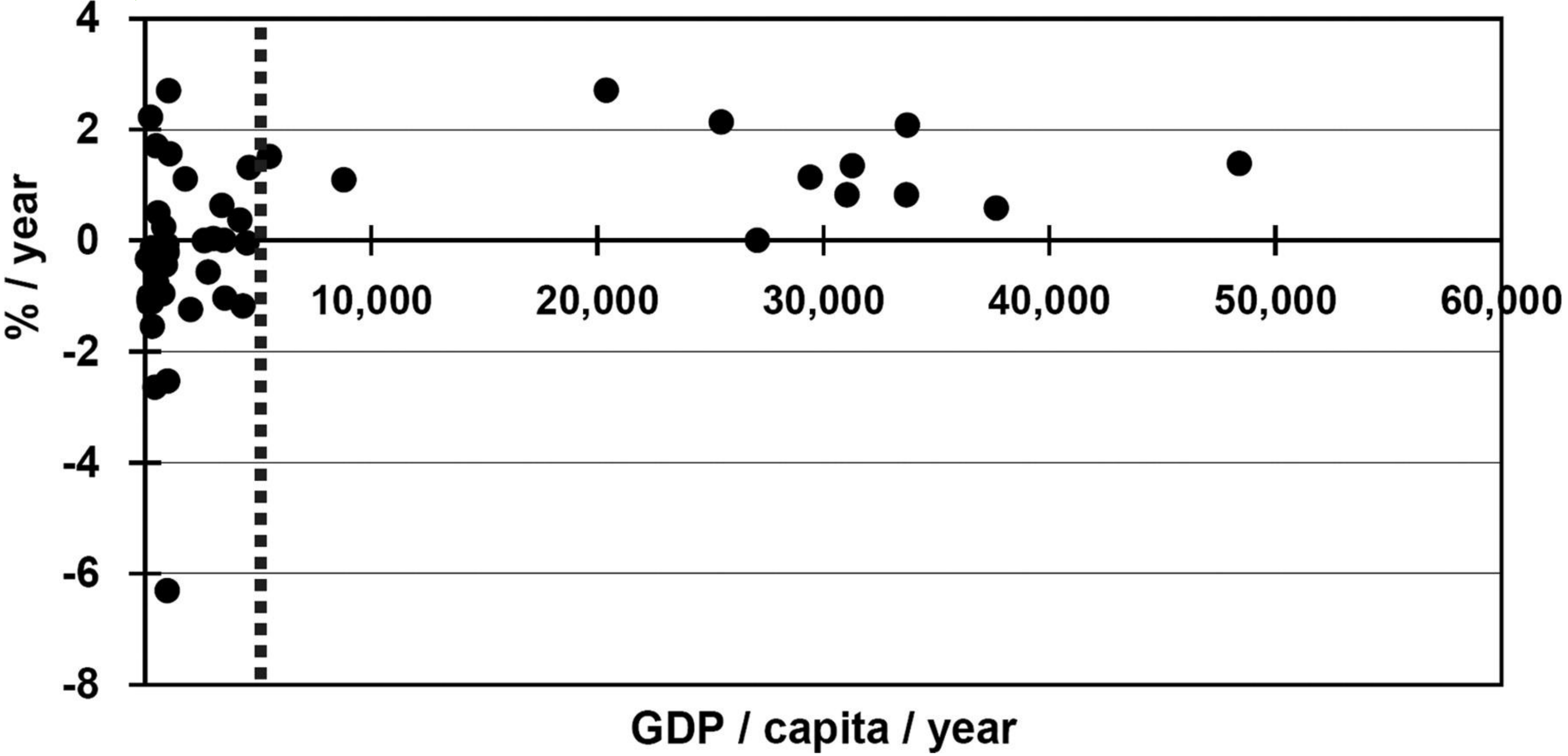
Contents

1. **”*FOREST TRANSITION* ” refers to a historical shift from shrinking to expanding forests.**
2. **Drivers of forest transitions include changes in the management regime and changes in the environment.**
3. **Where have forest transitions been observed and why?**
4. **How do forest transitions affect [CO_2]?**

1. ***”FOREST TRANSITION ” : Mather (1992), Grainger (1995), Rudel (1998), etc.;***

2. ***see ”Forest Transition” in Wikipedia***

The average annual change of growing stock (%) in nations plotted as a function of their GDP per capita.



Kauppi P E et al. PNAS 2006;103:17574-17579

PNAS

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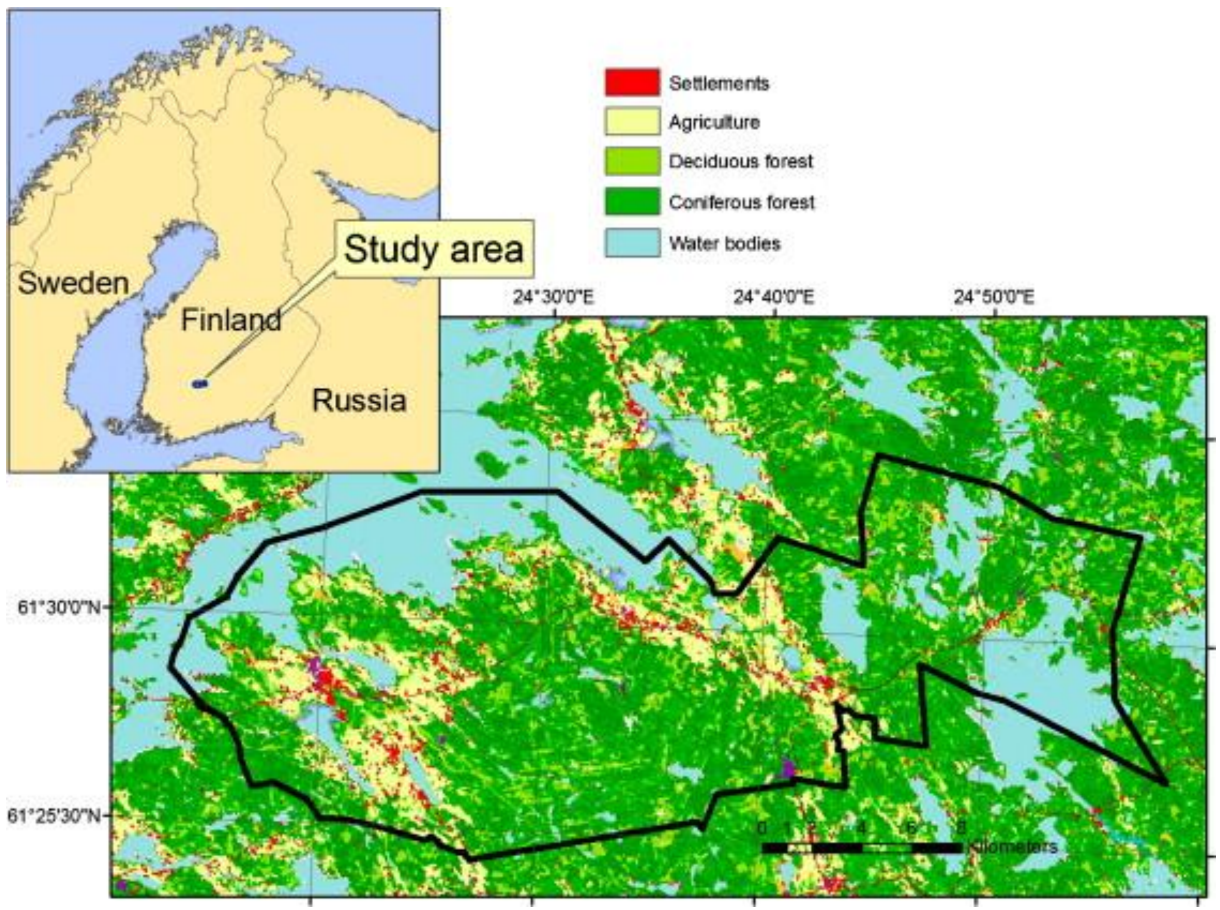
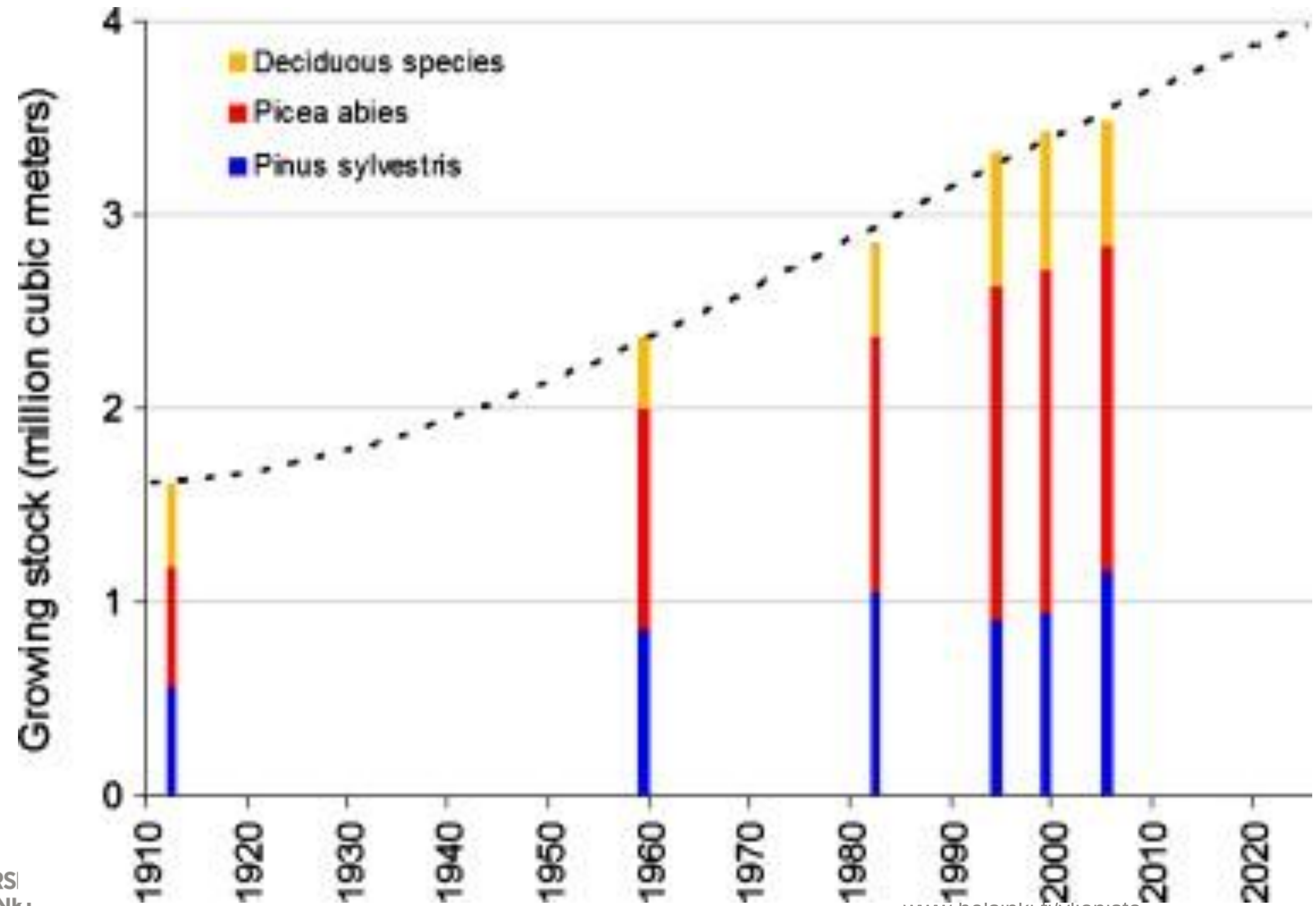
A case in Finland, where changes of forest management dominated the transition impact.



The growing stock more than doubled in 93 years, because the stands recovered from forest degradation:

yellow = Decidious trees
red = Norway spruce
blue = Scots pine

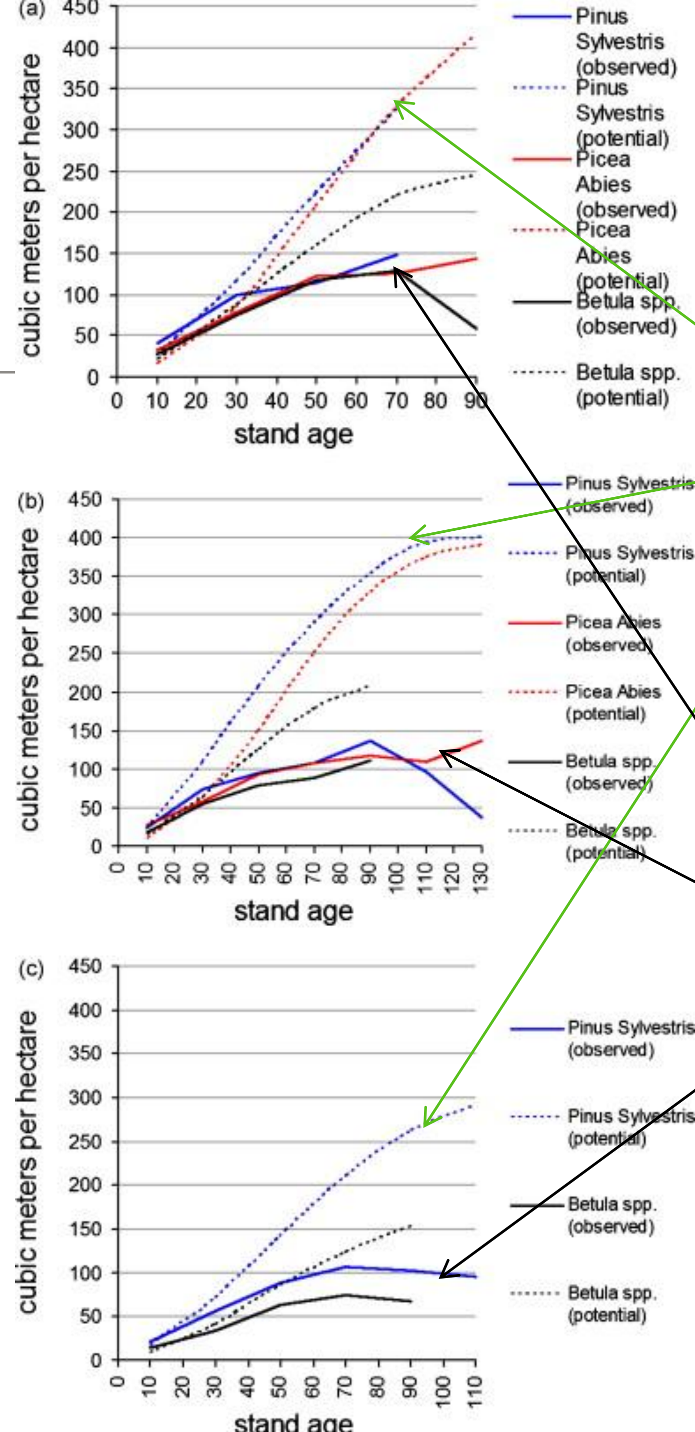
Kauppi, et al. 20 March 2010, **Forest Ecology and Management**, Volume 259, Issue 7, Pages 1239-1244



FERTILE SOILS

MID-FERTILE SOILS

POOR SOILS



THE STAND POTENTIAL = YIELD CURVES

Actual degraded stands as observed in 1912

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HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

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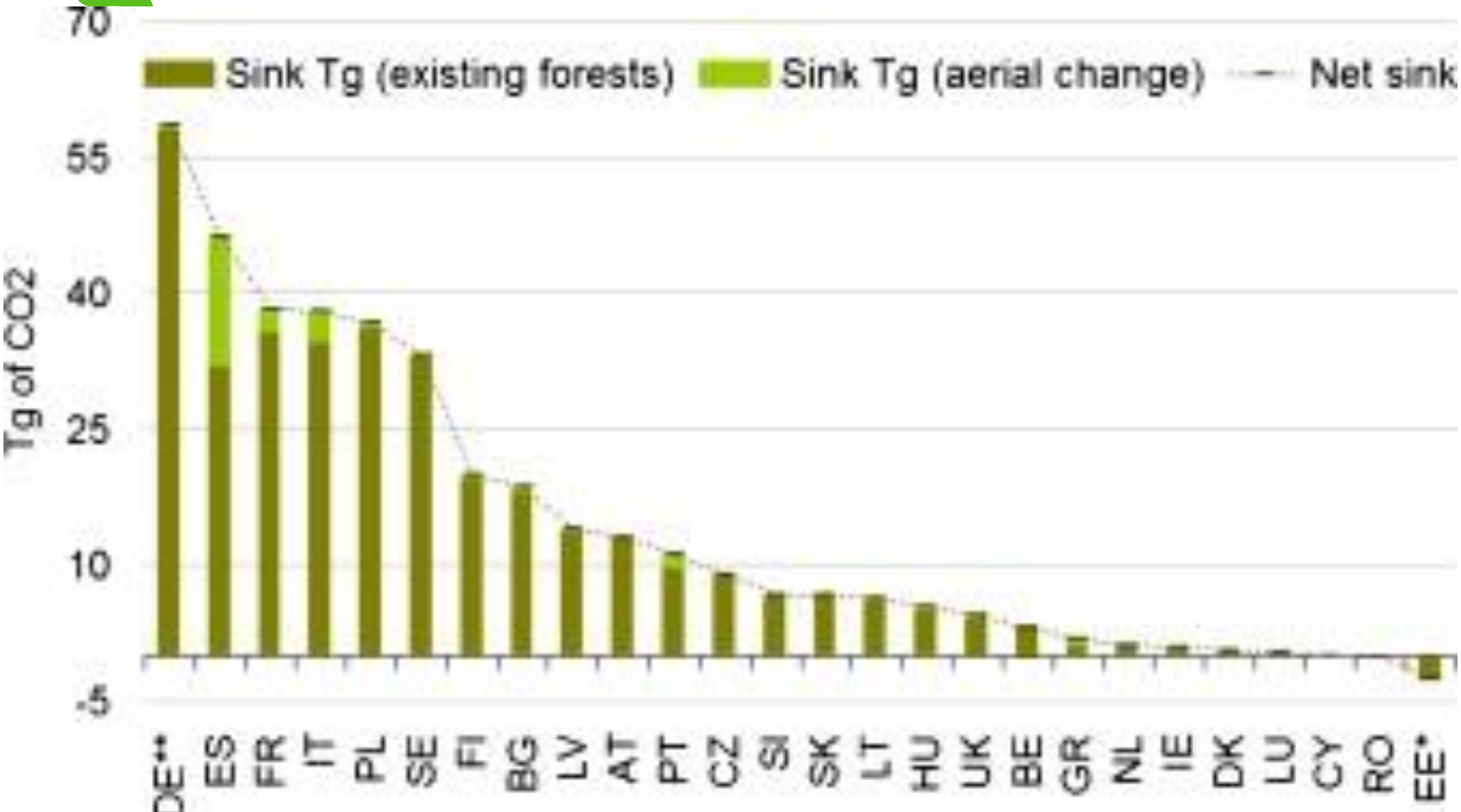
Forest vegetation C expands in all EU countries with one reported exception, Estonia.

A. Rautiainen et al. 20 March 2010, Forest Ecology and Management Volume 259, Issue 7, Pages 1232-1238



After forest transition, it is important to monitor recovery processes from forest degradation.

Note individual stems on average becoming larger, under relatively stable LAI and nearly constant forest area.

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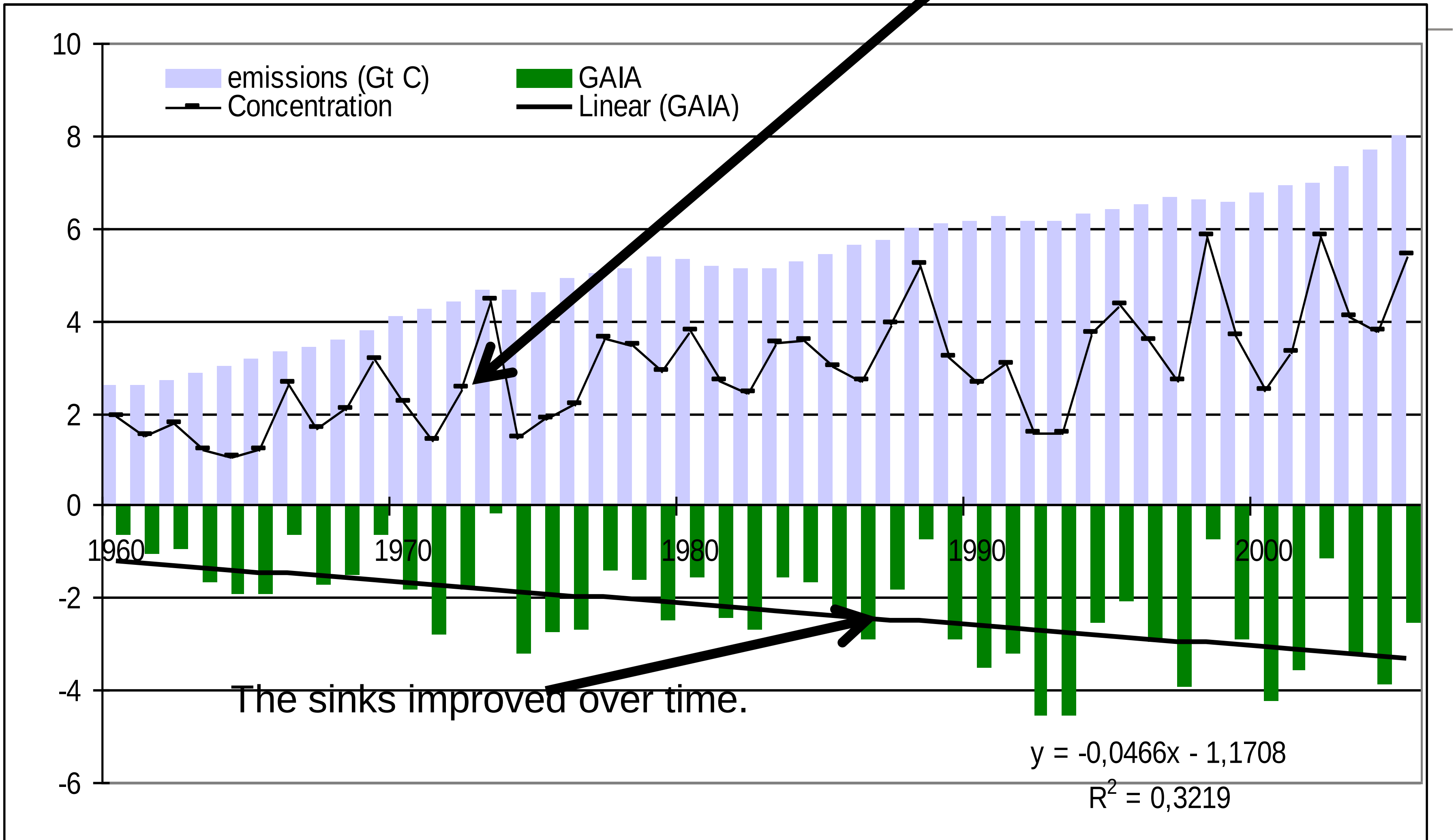
Fossil emissions annually since 1960 (blue), and the annual increment of CO_2 in the air, respectively, () both given as GtCyr⁻¹.



CONCLUSIONS:

A. Global deforestation has decelerated. (Countries switch from shrinking to expanding forests).

B. Forest sequestration has improved. (Area ”beyond forest transition” expands).

C. Changing forest management is the dominant driver. (Why would CO_2 fertilization, climate warming and N deposition consistently benefit only the rich countries? However, can we trust the data from poor (= scientifically least advanced) countries?).

D. Monitoring needs to focus on stem size distribution. (Note live and dead trees).

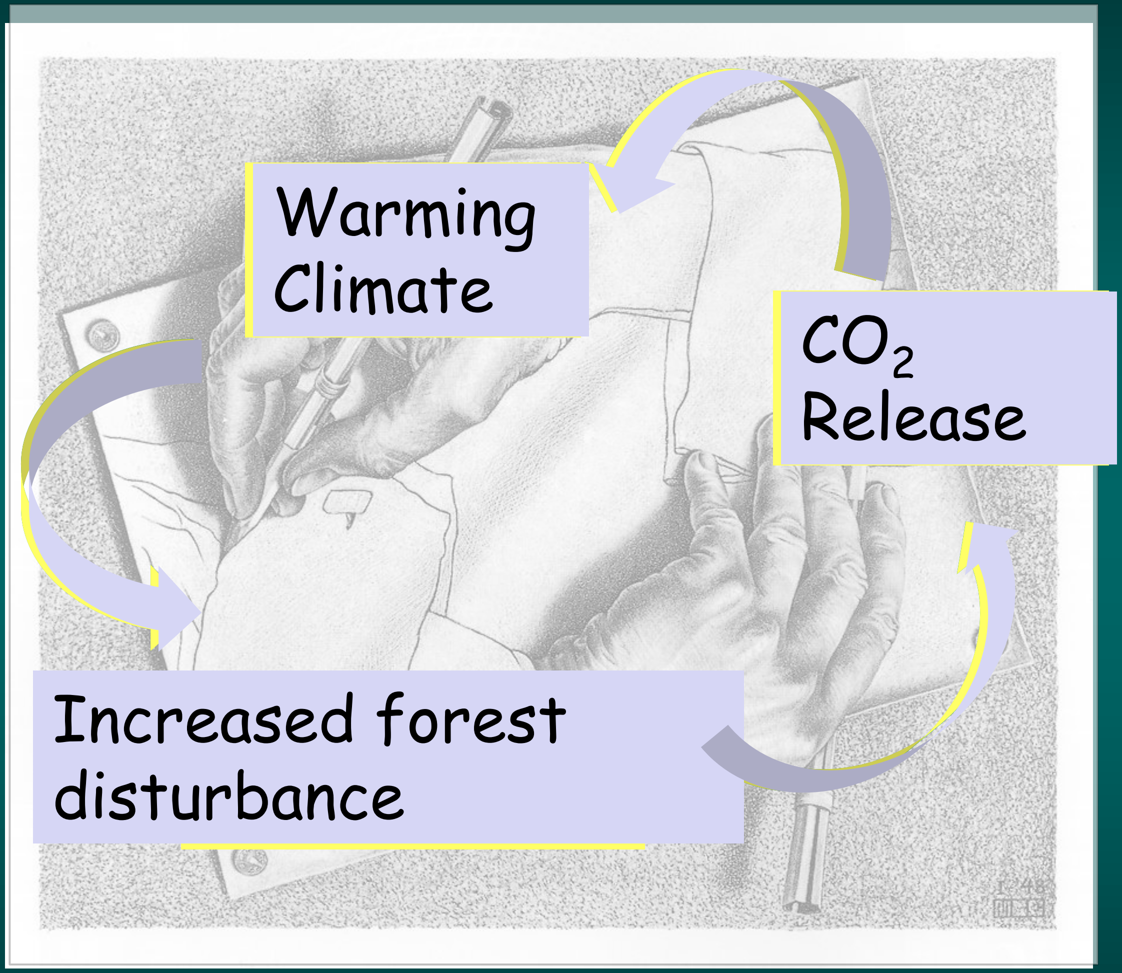
E. Will forest transition trends survive the climatic change?

Overview of modeling forest productivity and carbon cycling

(Emphasis on disturbance)

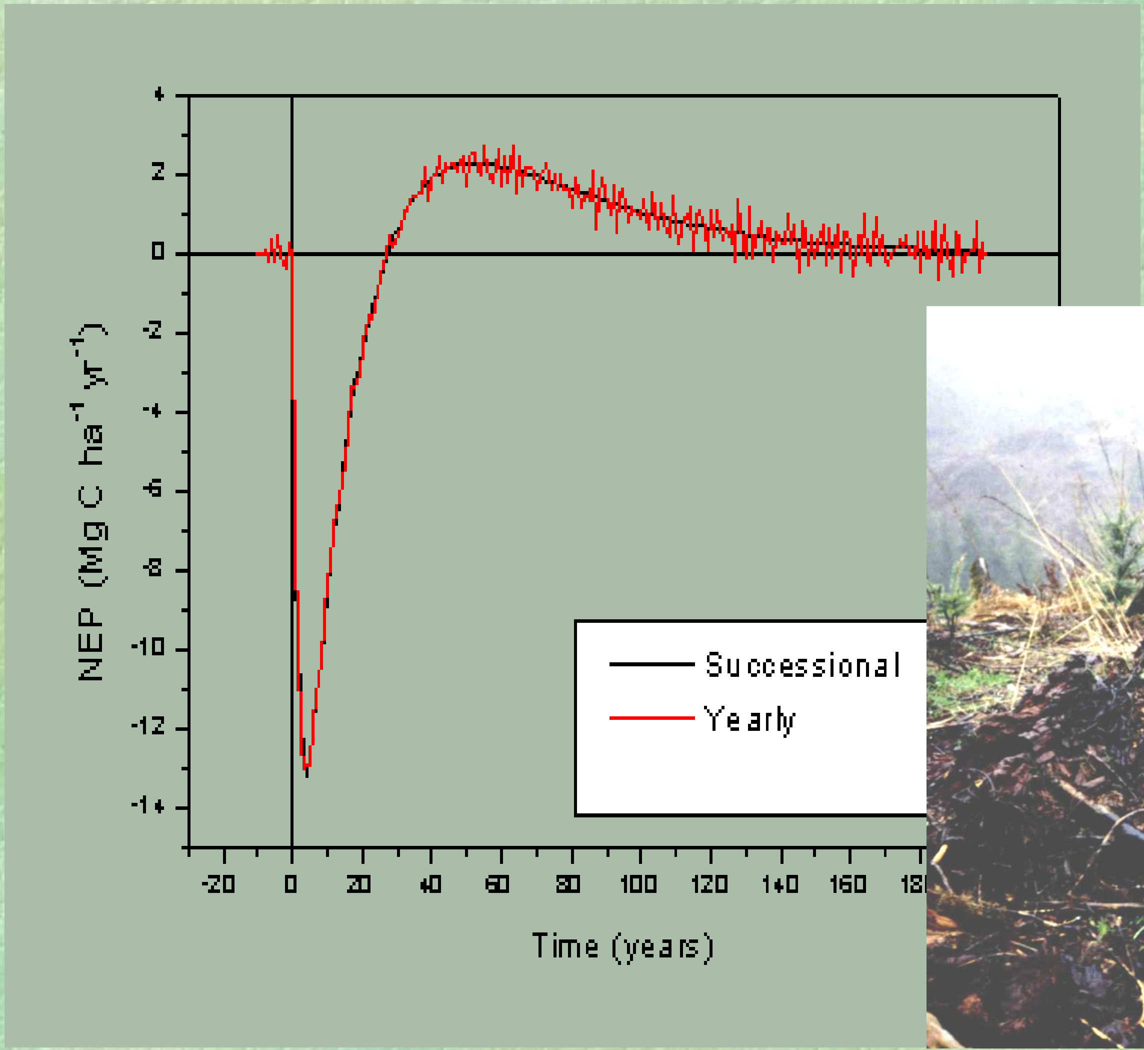
Olga N. Krankina
College of Forestry, OSU

With contributions from Hank Shugart
and Jackie Shuman, UVA



Forest disturbance in a positive feedback loop.

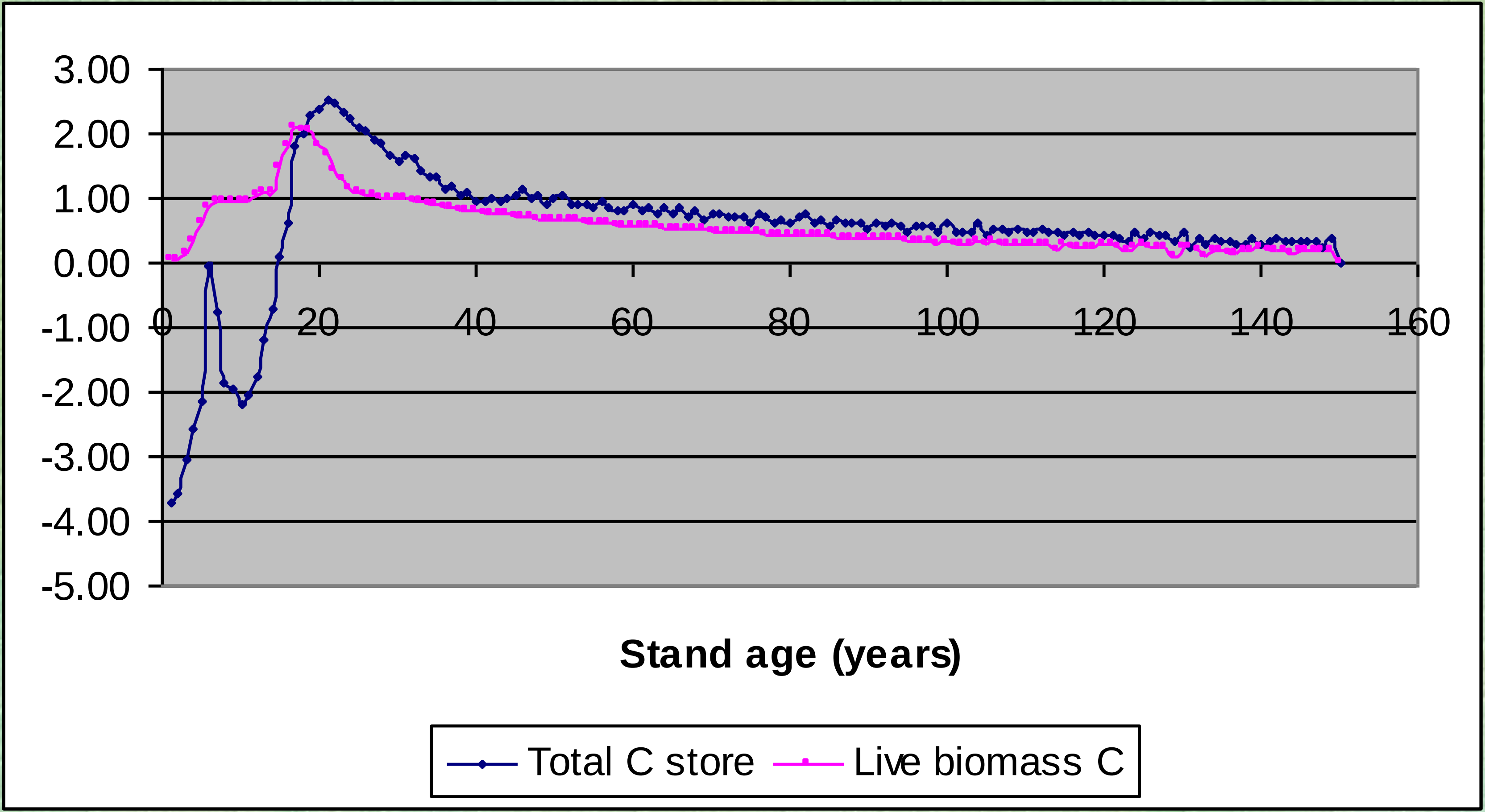
Forest Dieback from Siberian Silkworm Central Siberia



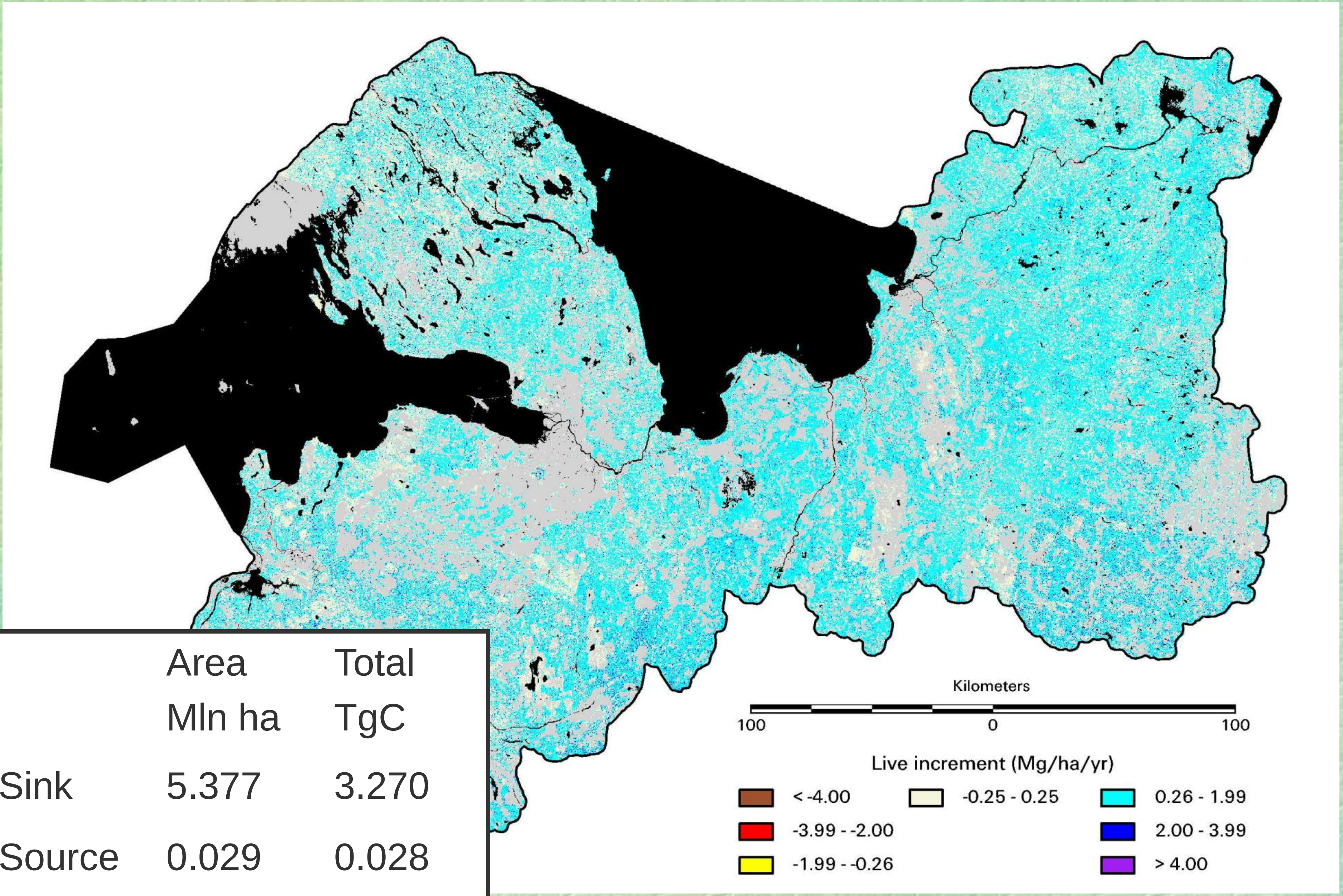
StandCarb Model output, M. Harmon (adapted from Cohen et al. 1996)

Net change in carbon stores with forest stand age

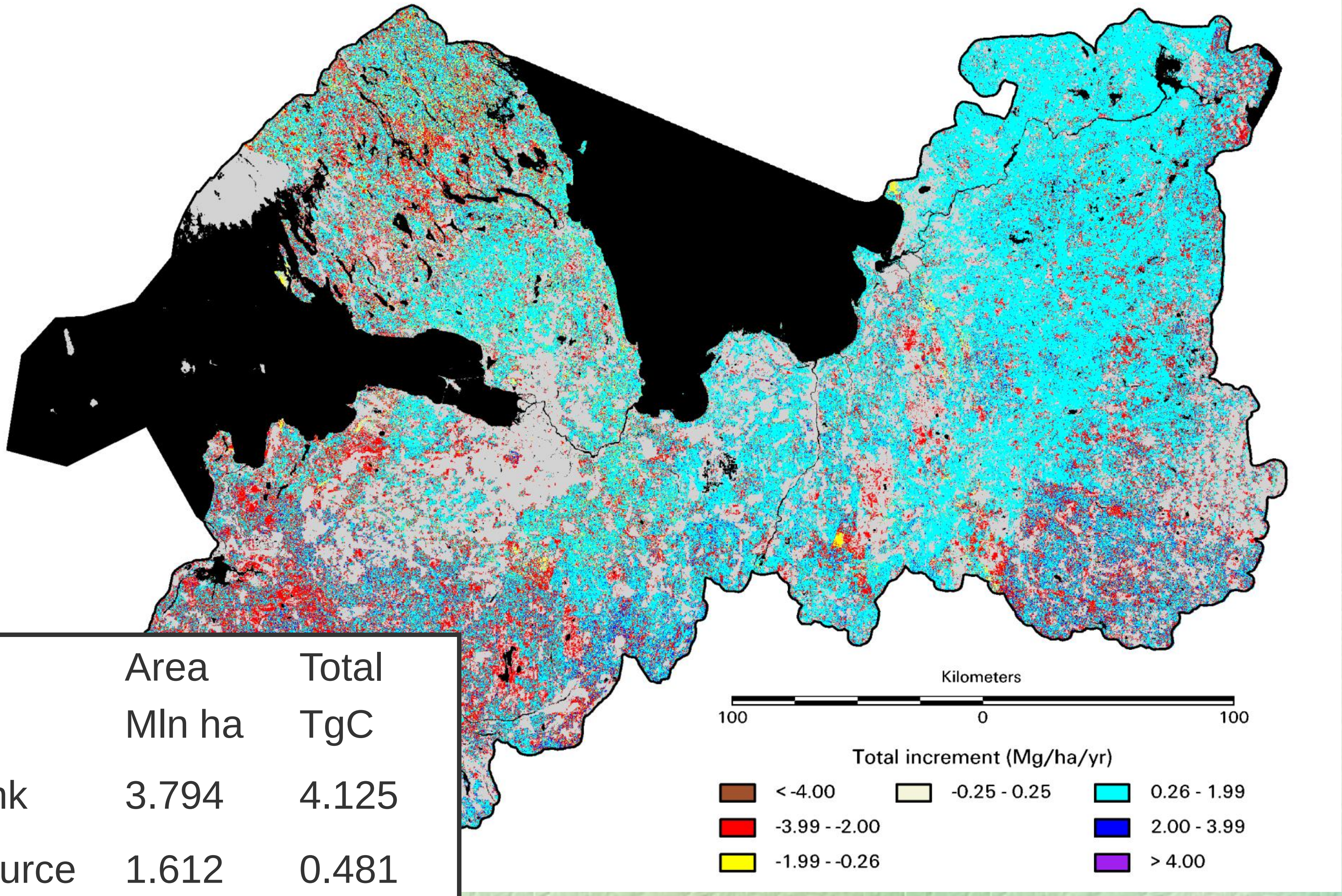
(MgC ha^{-1} yr^{-1})



Krankina, O.N., Harmon, M.E., Cohen, W.B., Oetter, D.R., Zyrina, O., Duane, M. V. 2004. Carbon Stores, Sinks, and Sources in Forests of Northwestern Russia: Can We Reconcile Forest Inventories with Remote Sensing Results? Climatic Change 67(2-3):257-272.



	Area Mln ha	Total TgC
Sink	5.377	3.270
Source	0.029	0.028
Net		3.242



	Area Mln ha	Total TgC
Sink	3.794	4.125
Source	1.612	0.481
Net		3.644

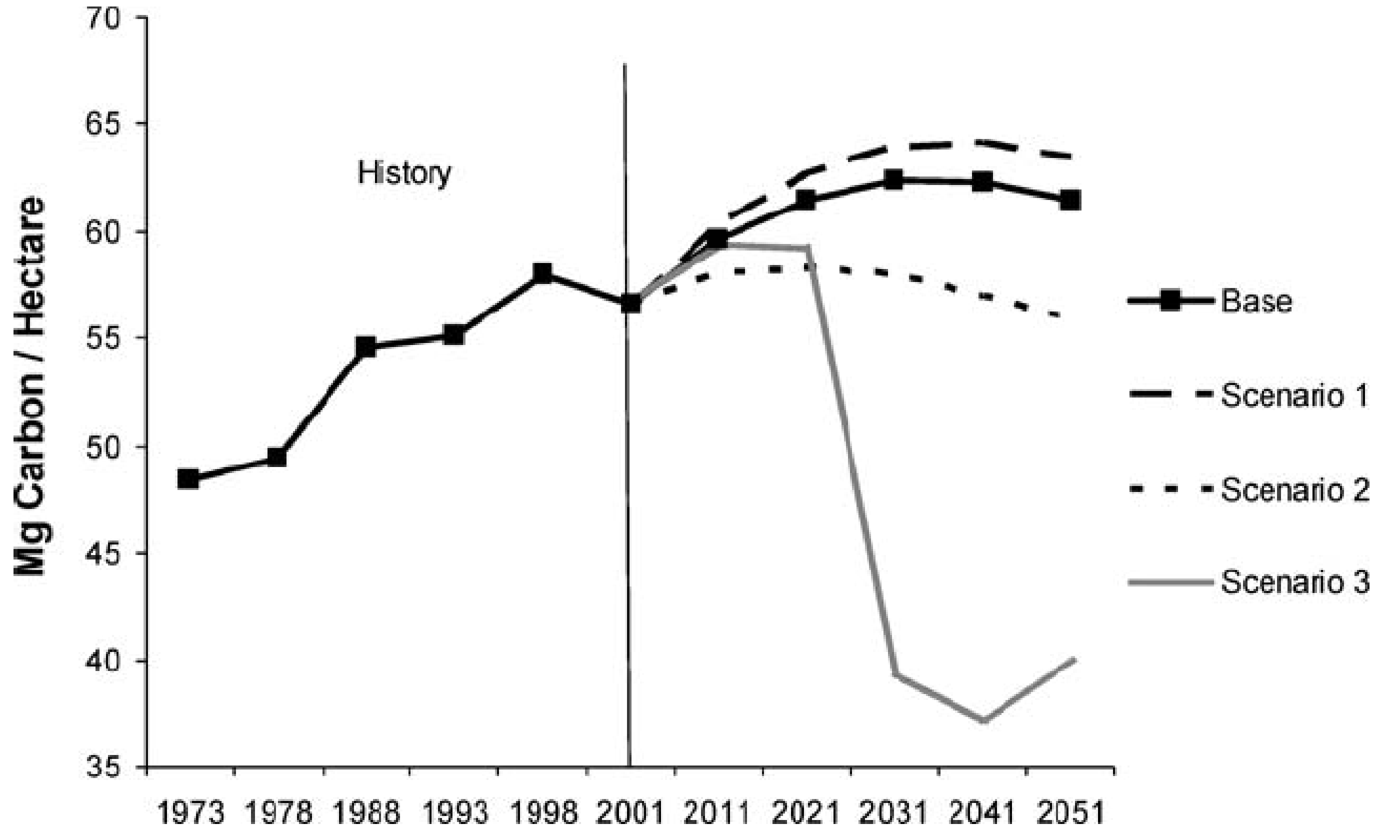
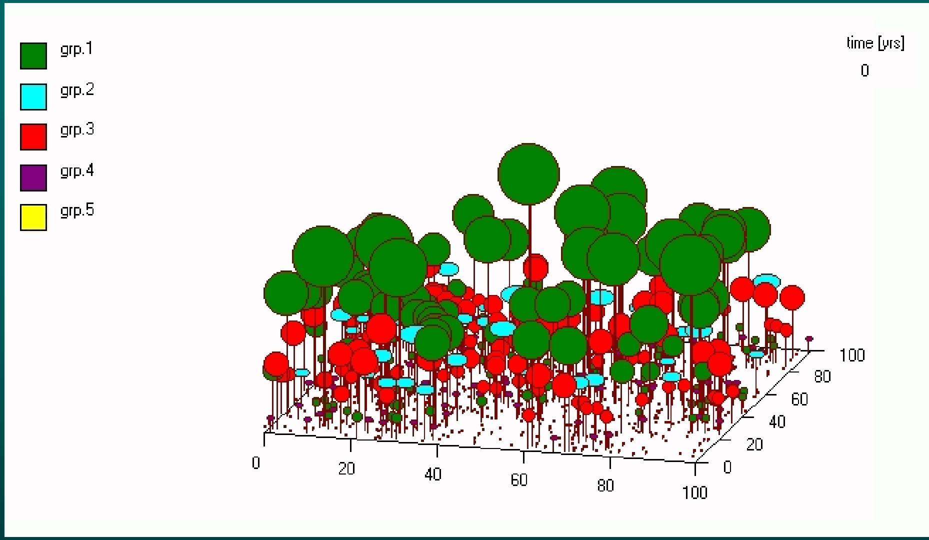


Figure 6. Historic change and future projections of carbon stores in live forest biomass for the St. Petersburg region of Russia. Units are megagrams of carbon per hectare.

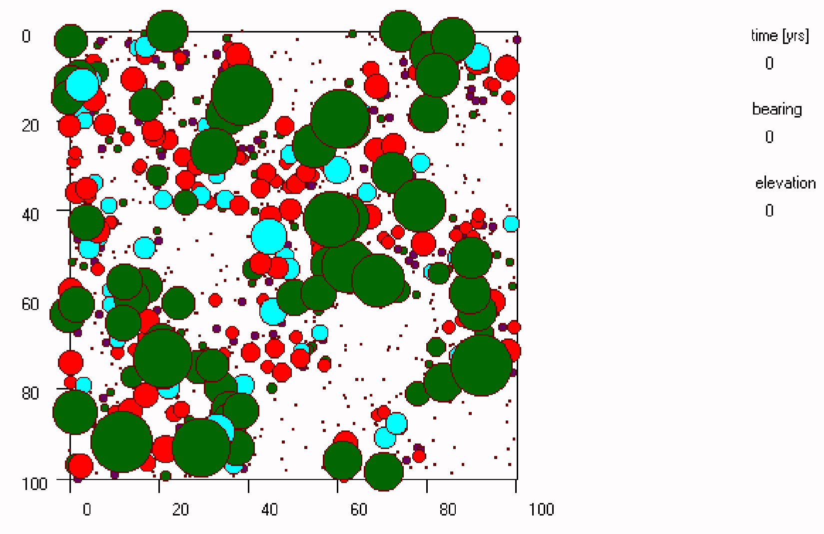
R.J. Alig, O.N. Krankina, A. Yost, J. Kuzminykh. 2006. Forest Carbon Dynamics in the Pacific Northwest (USA) and the St. Petersburg Region of Russia: Comparisons and Policy Implications, Climatic Change 76(3-4):335-360, http://dx.doi.org/10.1007/s10584-006-9077-7

For several decades, Hank Shugart's research group at UVA has been building computer models that predict change of forest by computing the growth, birth and death of each tree.

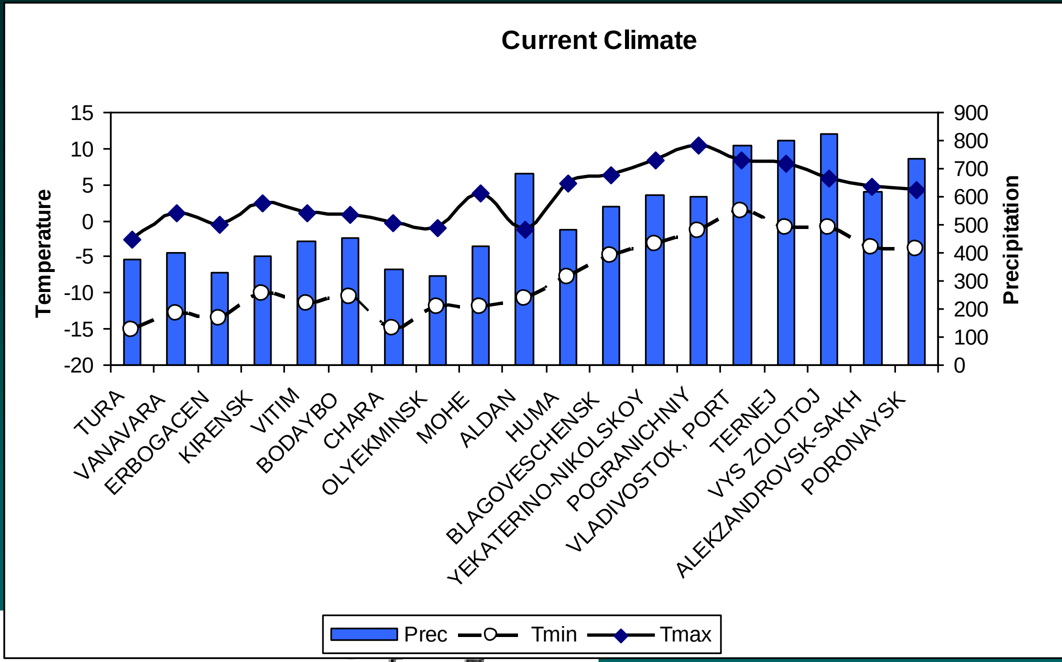
3-D view of Simulated Forest

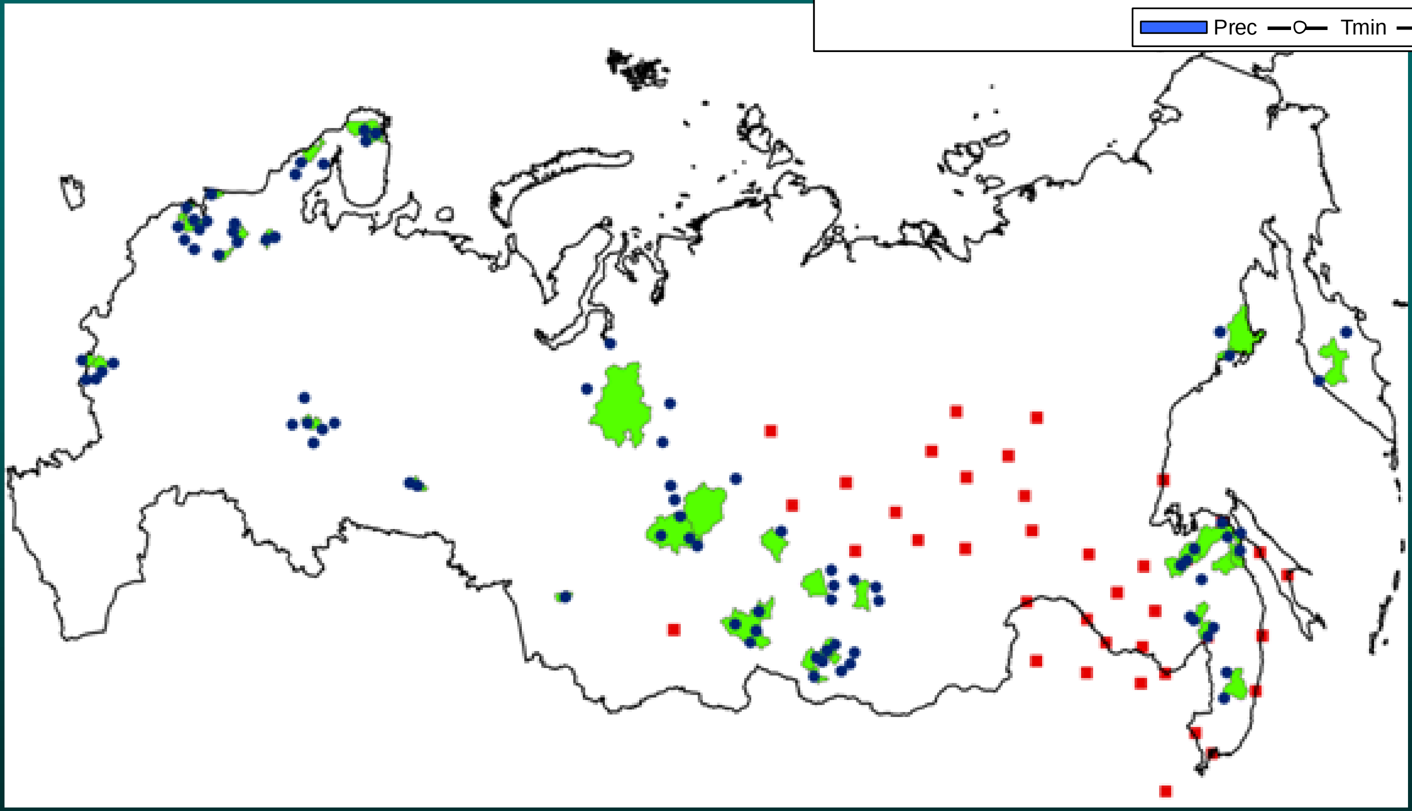


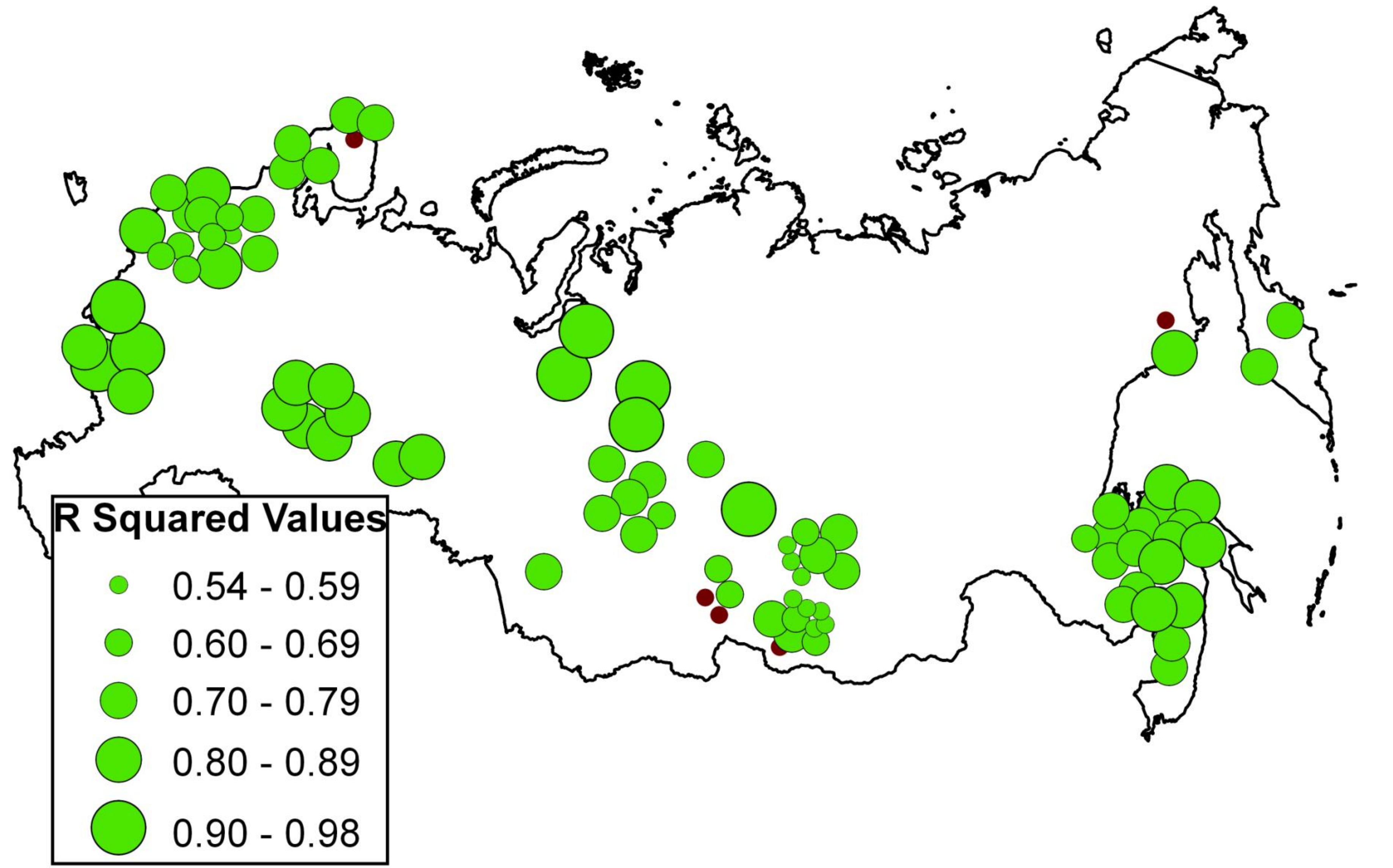
Map of Forest from above

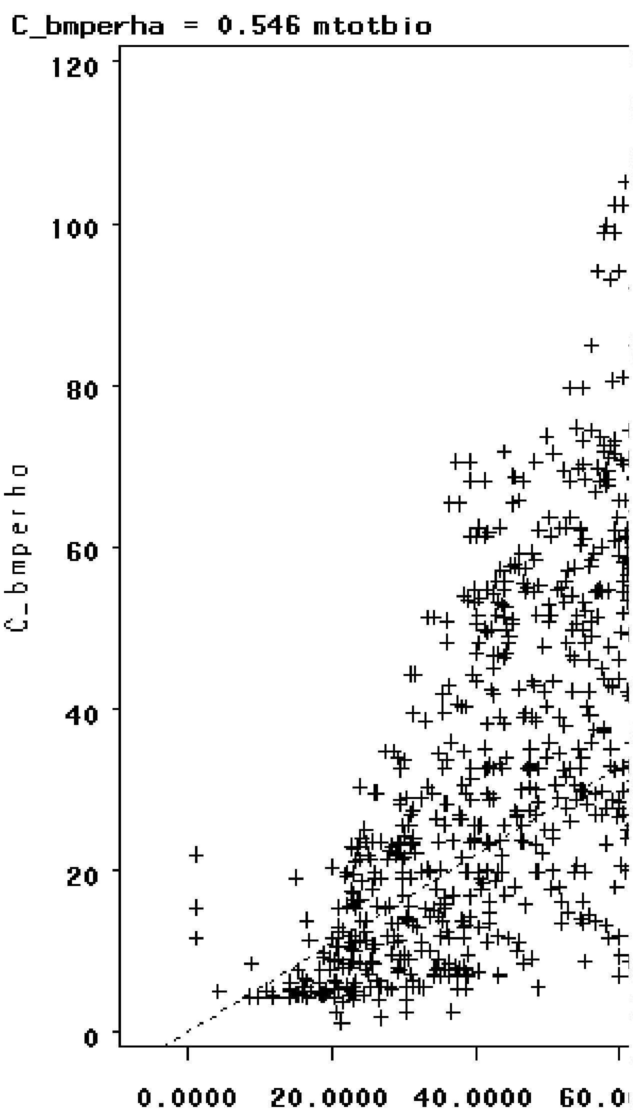


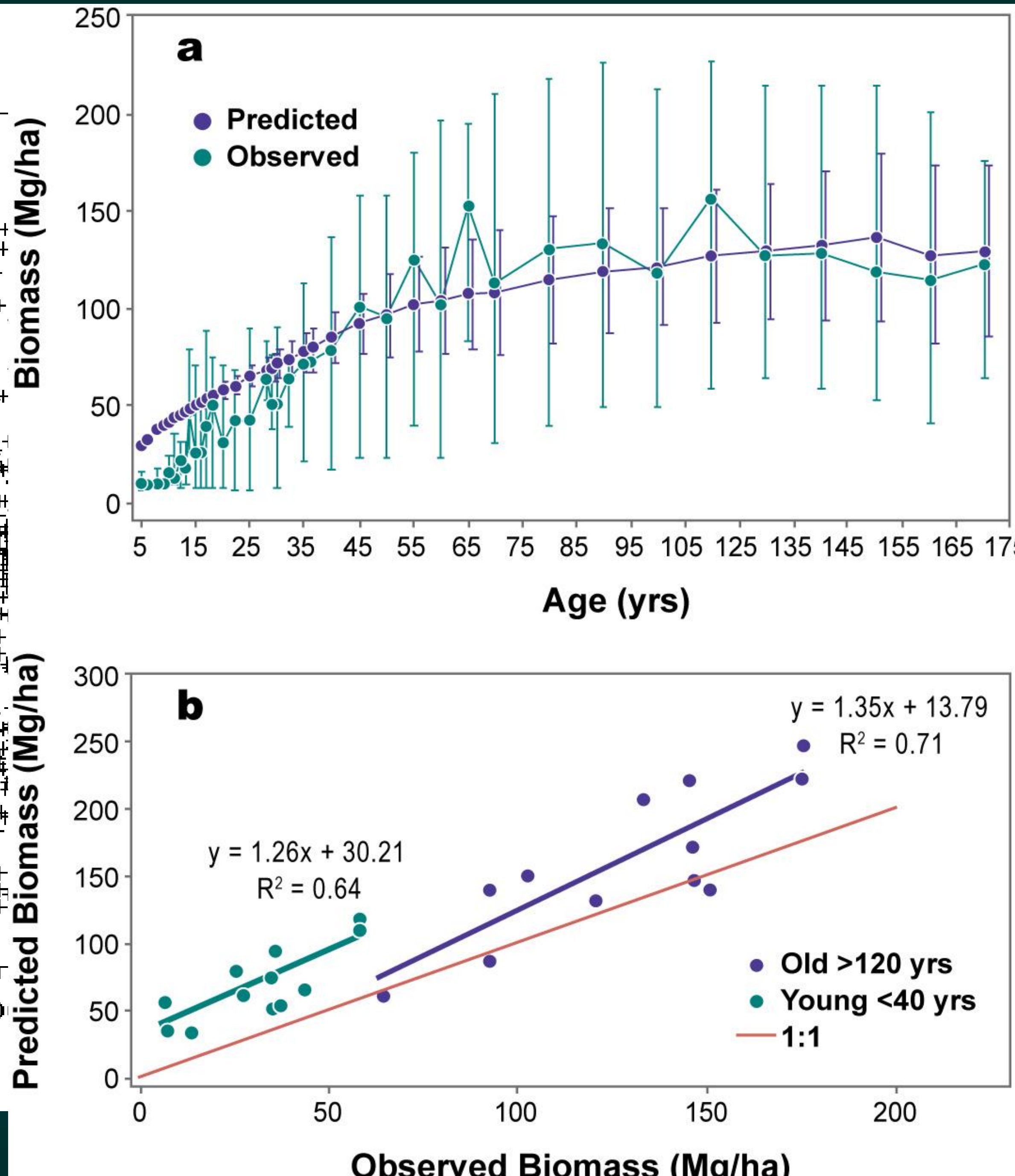
Testing FAREAST model:
42 sites with forest inventory data
82 meteo stations

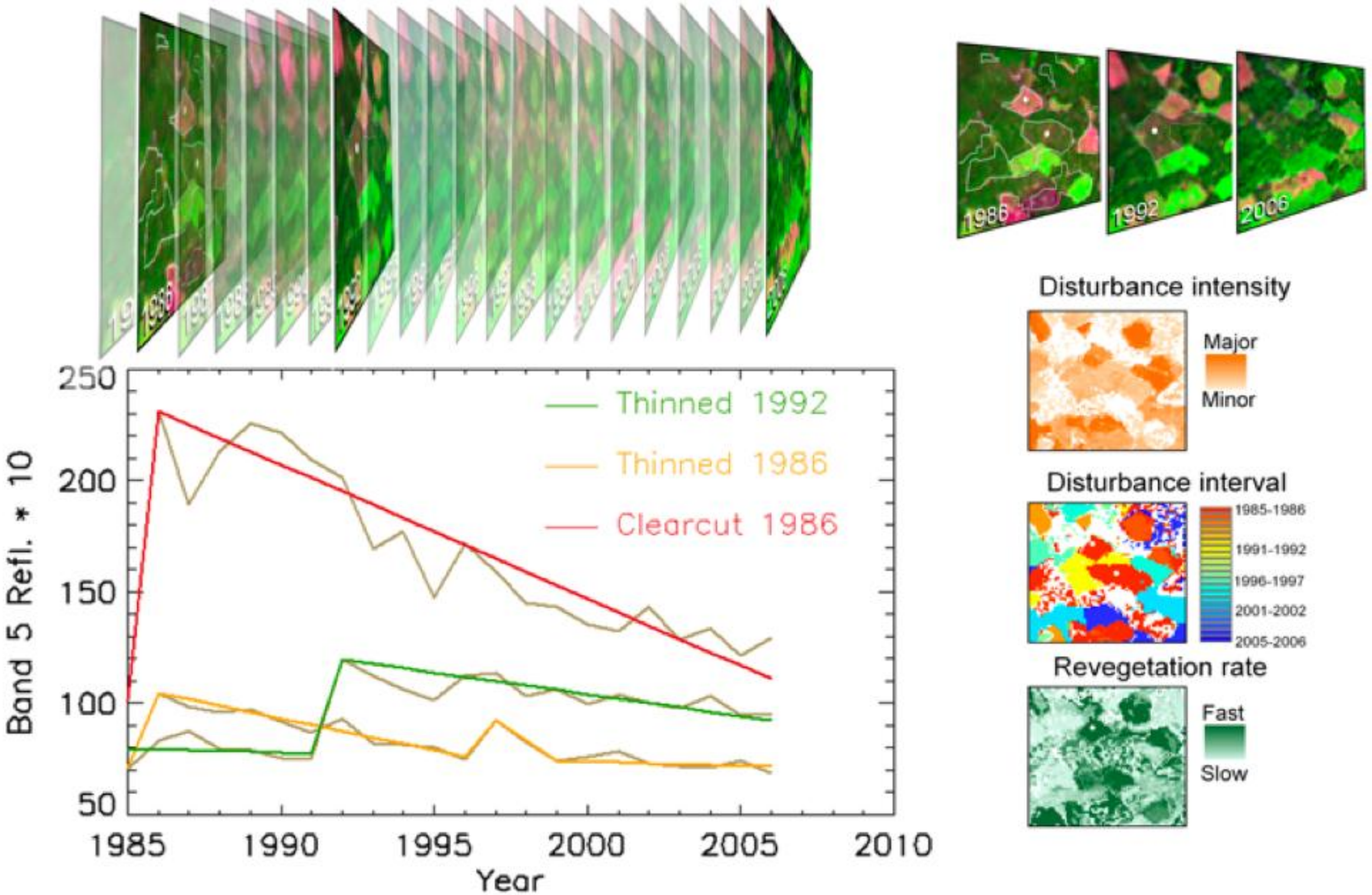





R Squared Values
0.54 - 0.59
0.60 - 0.69
0.70 - 0.79
0.80 - 0.89
0.90 - 0.98


C_bmperha = 0.546 mtotbio
C_bmperha
120
100
80
60
40
20
0
0.0000
20.0000
40.0000


a
Predicted
Observed
Biomass (Mg/ha)
Age (yrs)
0
50
100
150
200
250
5
15
25
35
45
55
65
75
85
95
105
125
135
145
155
165
175
b
y = 1.35x + 13.79
R2 = 0.71
y = 1.26x + 30.21
R2 = 0.64
Old >120 yrs
Young <40 yrs
1:1
Predicted Biomass (Mg/ha)
Observed Biomass (Mg/ha)
0
50
100
150
200
250
300

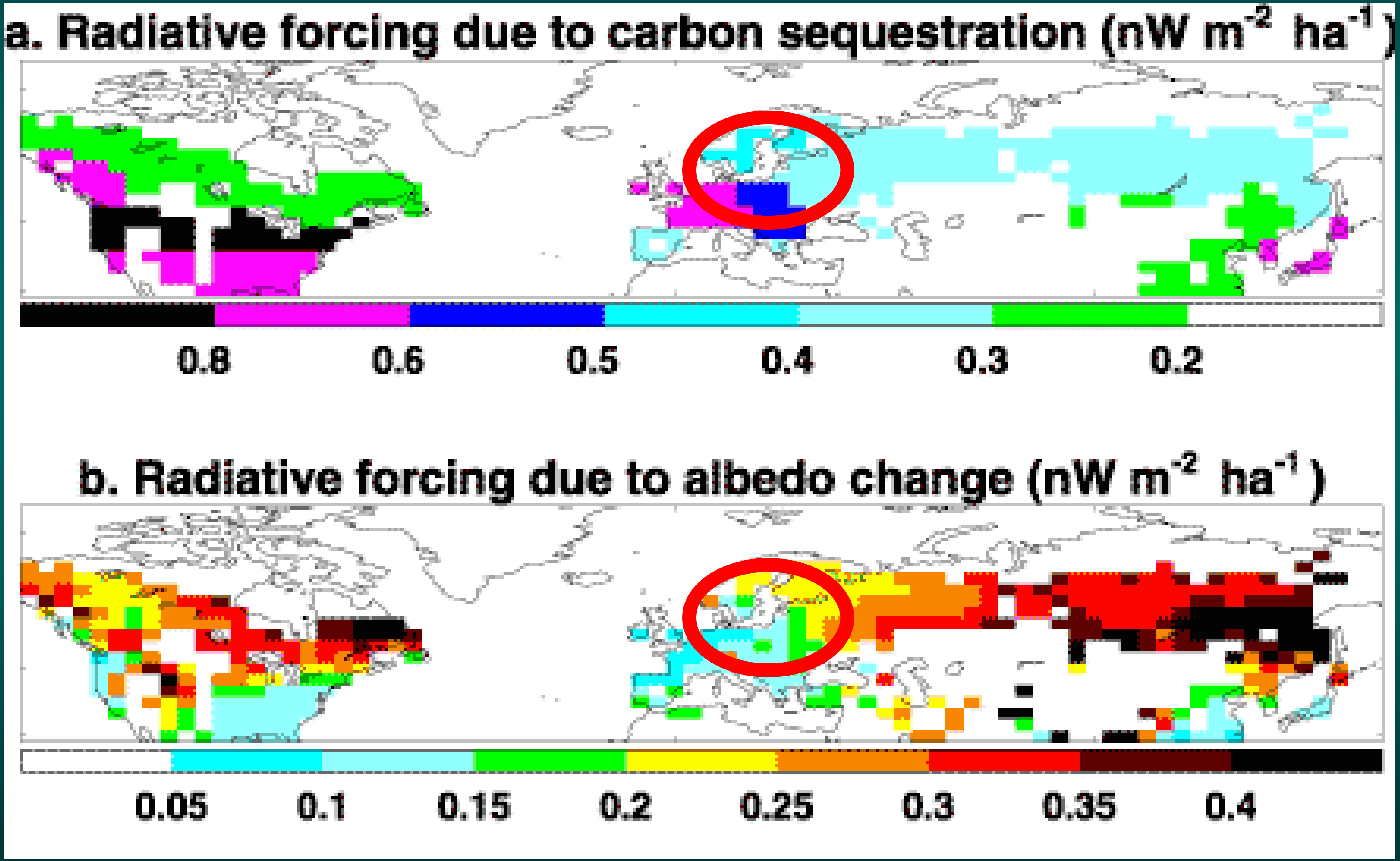


LandTrendr algorithms segment time-series of yearly Landsat TM data to characterize both long-term trends and abrupt events (disturbances). Source: Robert Kennedy et al. 2007

Sweden, storm of 2005
~ 1 million cubic meters of wood
~ 0.25 Mt C

Dead trees
do not go to heaven

Growing trees stores carbon and reduces global warming but it also changes the Earth's surface. How do these factors trade-off?



From: Richard A. Betts. 2000. *Offset of the potential carbon sink from boreal forestation by decreases in surface albedo*. Nature 408:187-190.

The End