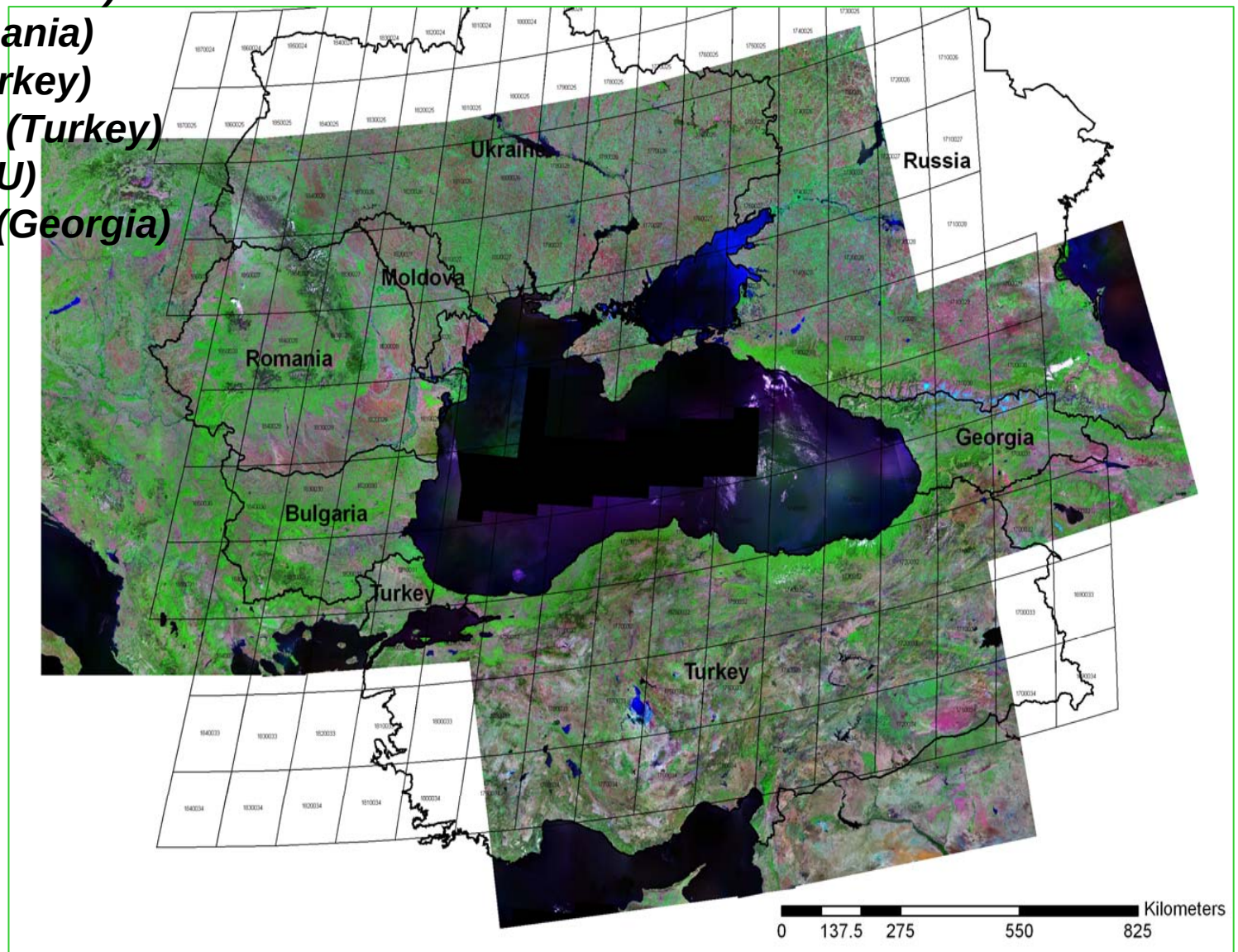
C. Woodcock BU
S. Houghton WHRC
M. Ozdogan (U Wisc)
A. Baccini WHRC)
V. Blujdea (Romania)
V. Gancz (Romania)
E. Baskent (Turkey)
A. Tufekcioglu (Turkey)
P. Olofsson (BU)
P. Torchinova (Georgia)
S. Jeon (BU)

The effects of land use change on terrestrial carbon dynamics in the Black Sea Region (and New England)



Science Goals

- Quantify the effects of land use change on terrestrial carbon budgets in the Black Sea Region
- Significantly minimize the uncertainties associated with the carbon cycle dynamics, particularly associated with land-use change
- Approach is to use remote sensing to measure rates of land use change
- Use rates of land use change in Houghton's book keeping model to estimate carbon dynamics

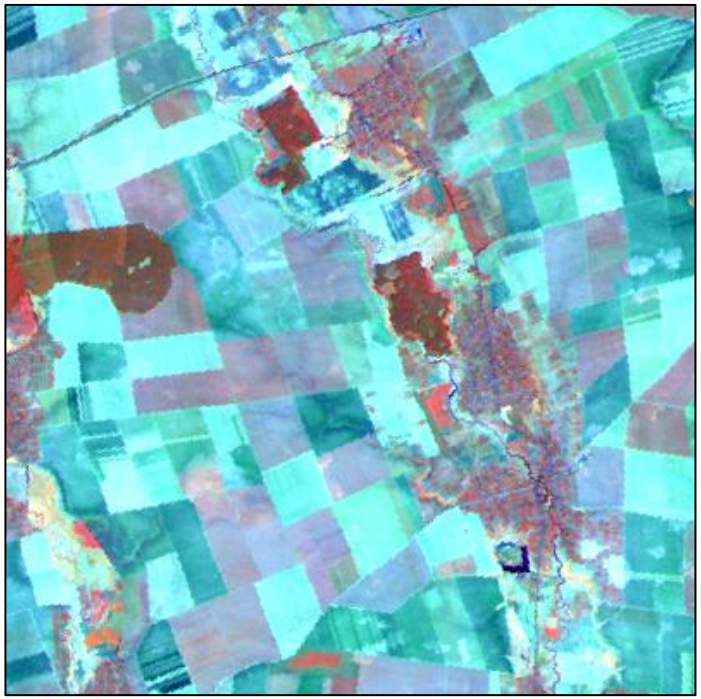
- Additionally, apply the same approach to New England

Today: Results from Romania, Turkey and Georgia

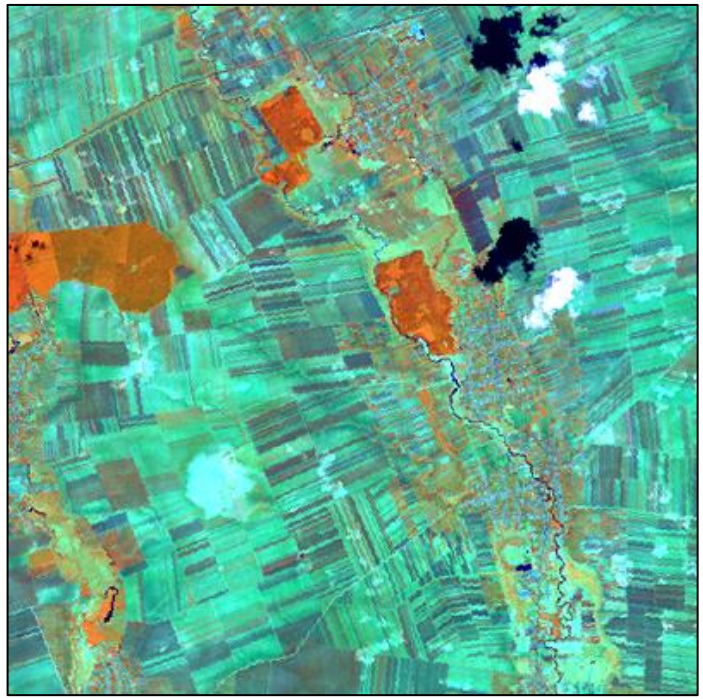
- Interesting differences between these countries:
  - Turkey has lowest rates of forest change - urban migration is reducing pressure on rural land use and leading to some abandonment of small parcels of pasture
  - Georgia - limited organized forest harvest - but to some partial harvest (often illegal) from forests in close proximity to roads and settlements
  - Romania has modest forest harvest rates (1990-2000) and little conversion of forest to other uses

Romania

- We knew very little about land cover dynamics in this region
- Significant political/economic changes following the collapse of the USSR



Time 1 1990/08/21



Time 2 2000/06/05

Questions: Carbon and Romanian Forests

- What is happening to Romanian forests?
  - Now 2 kinds of forest ownership:
  - State Forests
  - Private Forest
    - Land returned to families owning forests prior to the communist era, sometimes as “shares” in collective private forests
    - Forest land or “shares” given to towns, schools, ets
- Is Romania a carbon sink or source?
- What are existing carbon stocks?

Carbon Accounting

$$A = F - S \pm L$$

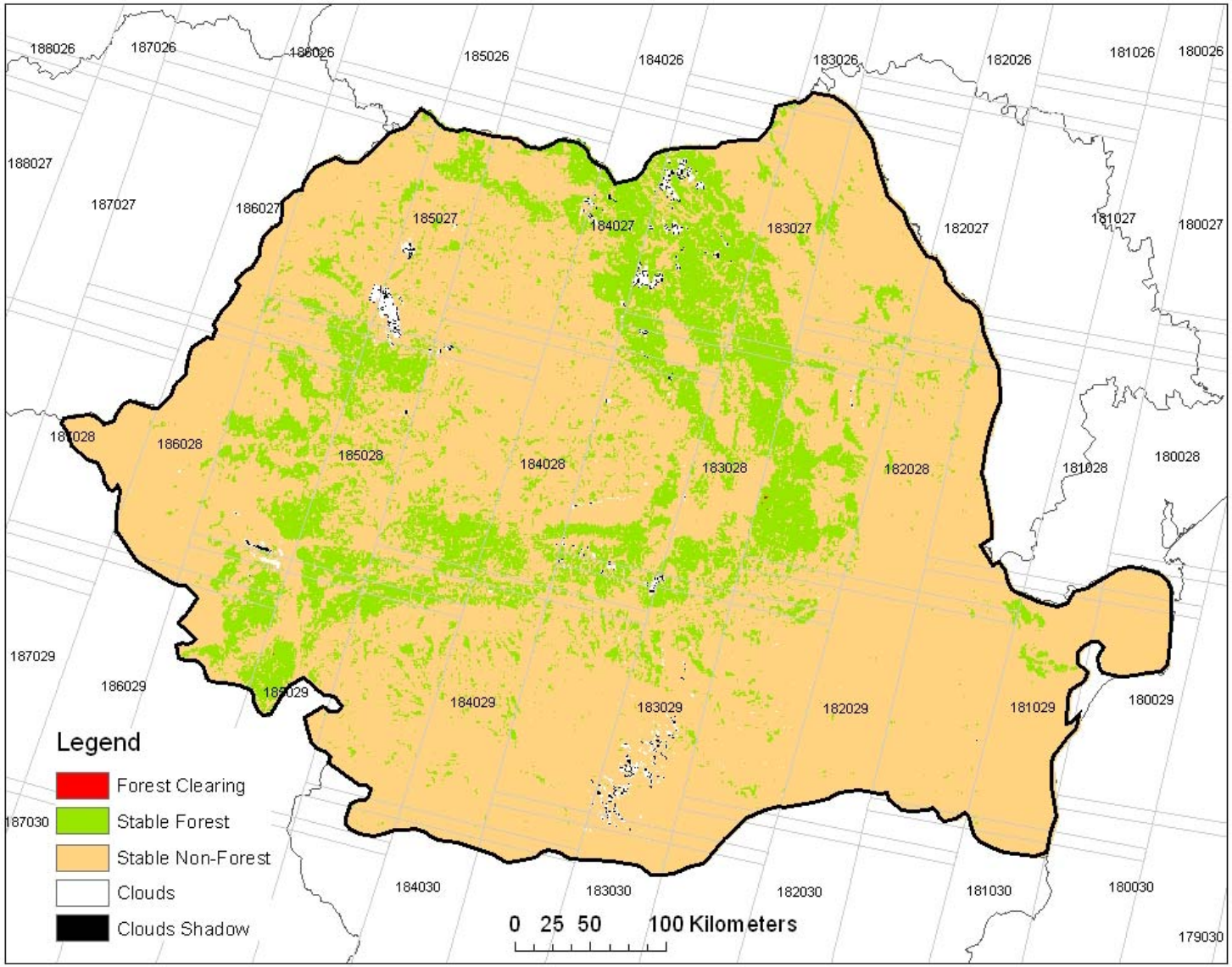
A = Annual increase in atmospheric CO_2

F = Release of CO_2 fossil fuel combustion

S = Movement of carbon into oceans

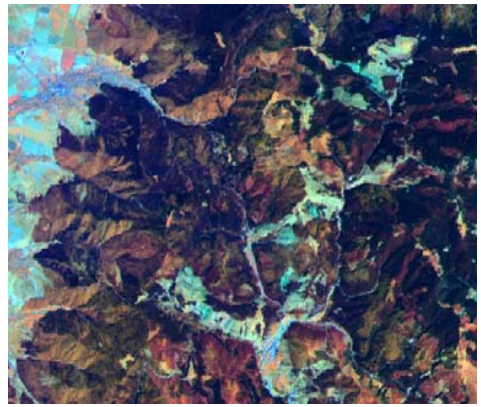
L = Net exchange of C between atmosphere and the land surface (L is large and positive in areas of deforestation, but what about forests in the more developed parts of the world, often with longer land use histories?)

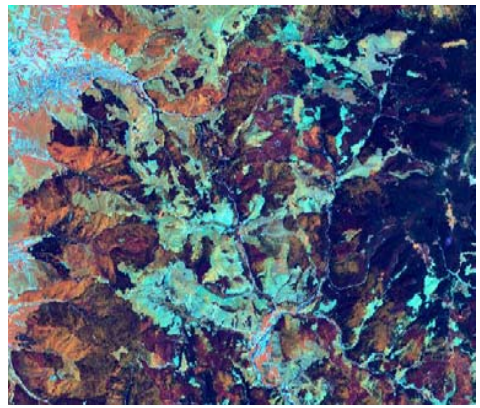
Romania Land Cover Change Map 1990 – 2000

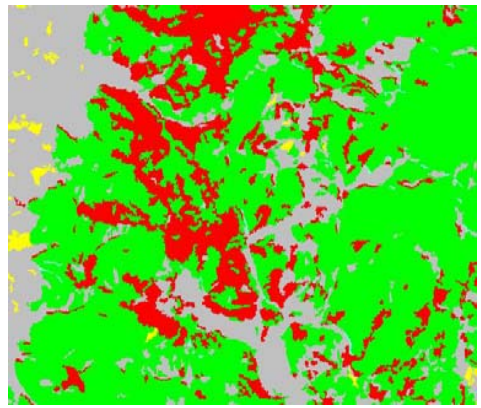


Results

- Forest covers 5.9 millions ha
- In the period 1990 - 2000, 2.4 percent of what was forest in 1990 changed to non forest. (No evidence of land use change from forest to other uses.)
- Average change size 7.9 ha
- Accuracy (829 sites) assessment results used to adjust area estimates
- Most harvesting concentrated in a few areas, mostly on private forests)



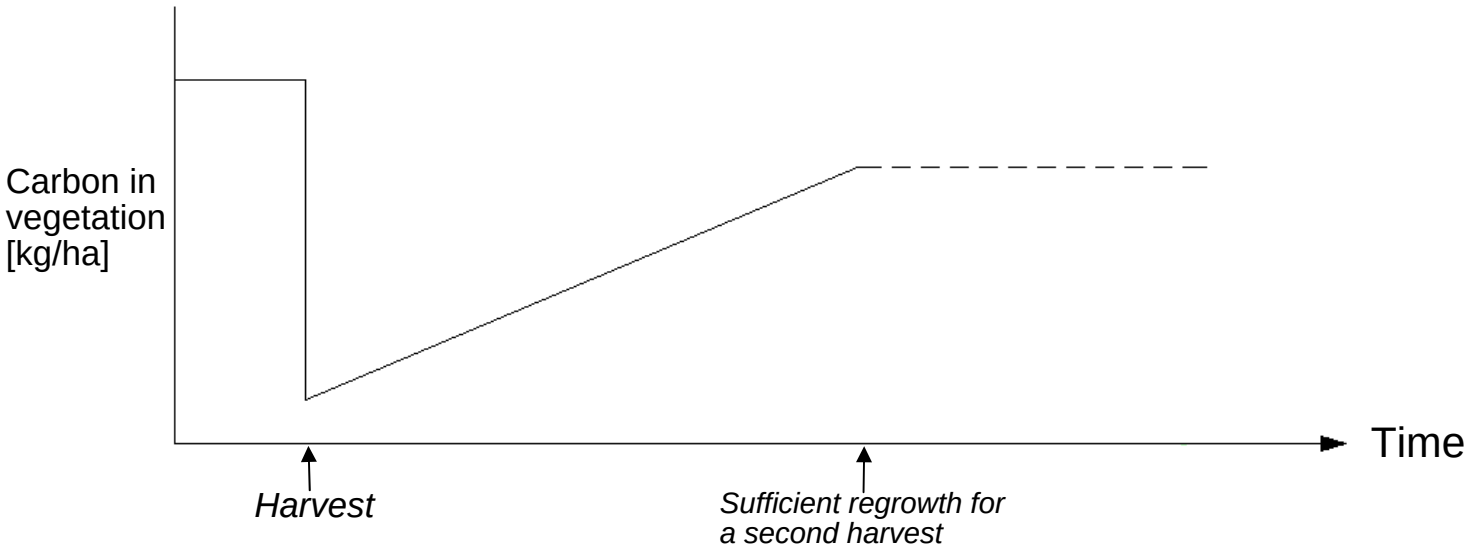


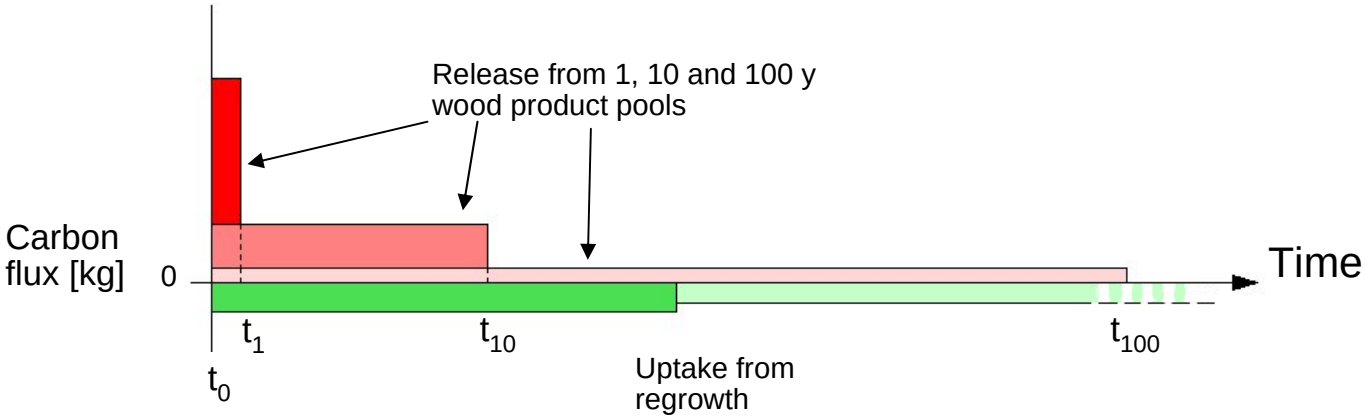


Carbon Bookkeeping model

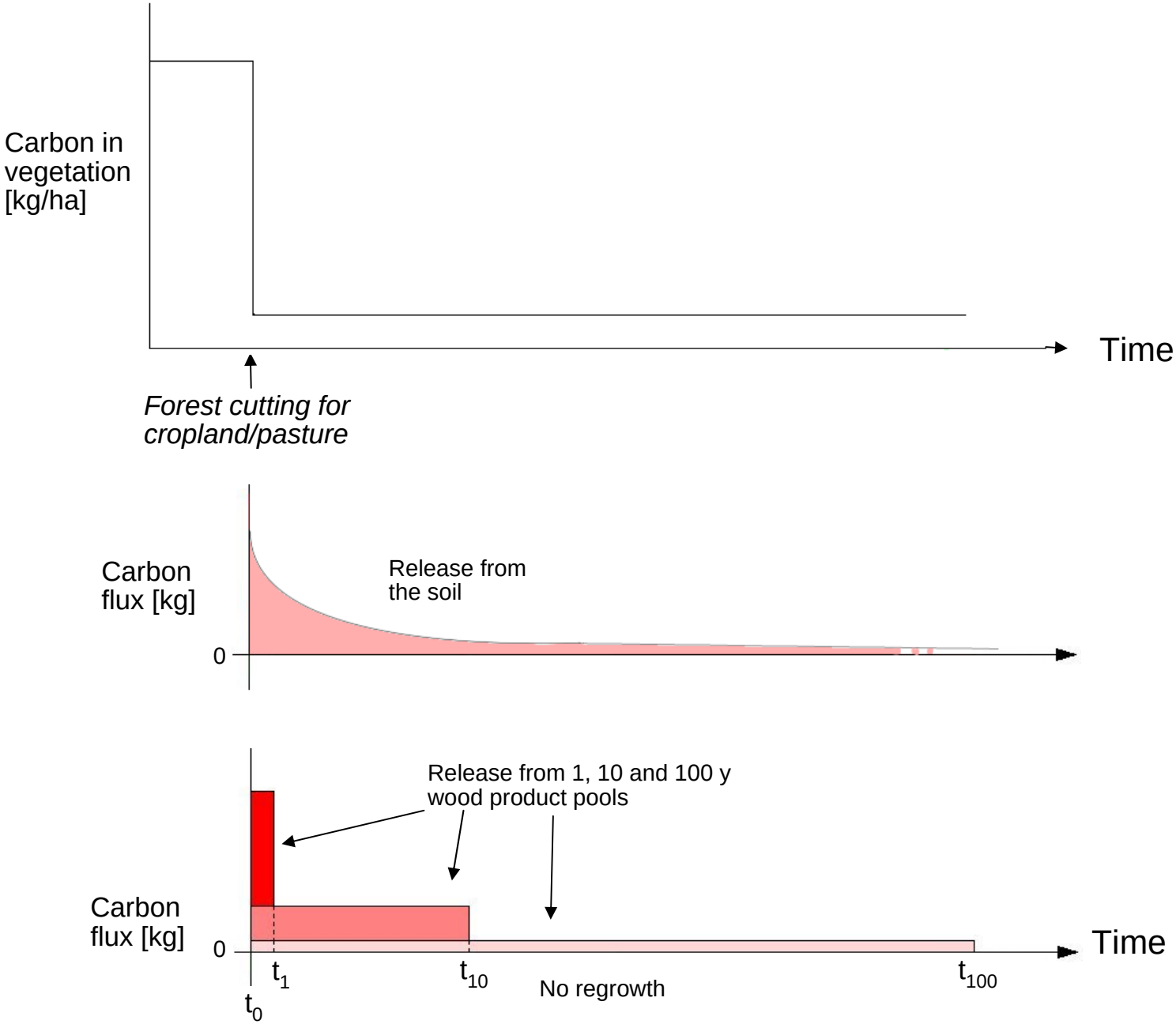
- Originally by Skee (Richard) Houghton et al., Woods Hole Research Center
- Calculates the net flux of carbon as a function of land-use change
- Describes the responses of an ecosystem over time following disturbance events
- Events may include i) forest harvest, ii) conversion to cropland, iii) abandoment, etc.
- Makes extensive use of forest inventory data for growth rates, age distributions of forests and average biomass
- Includes the effects of decomposition of forest products
- Integrates the history of harvest and land use change
- Innovation in this project is integration of remote sensing measurements of forest area and forest change rates

The effect of a forest harvest event

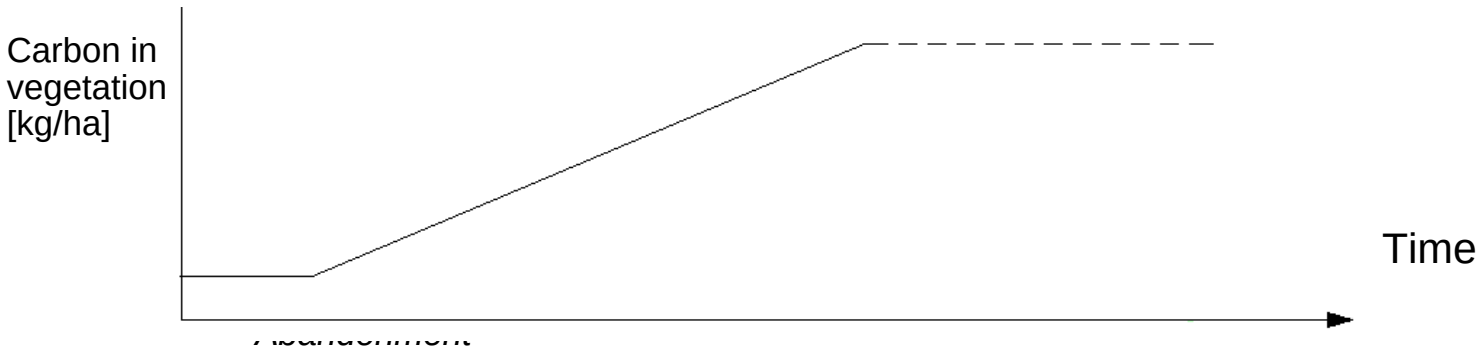


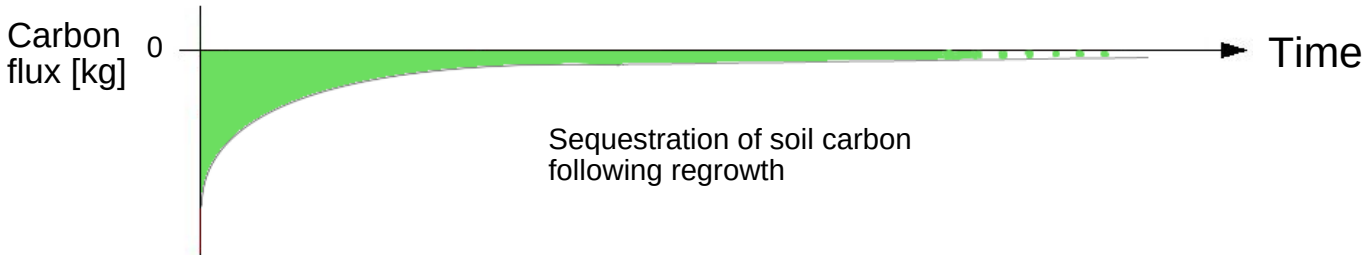


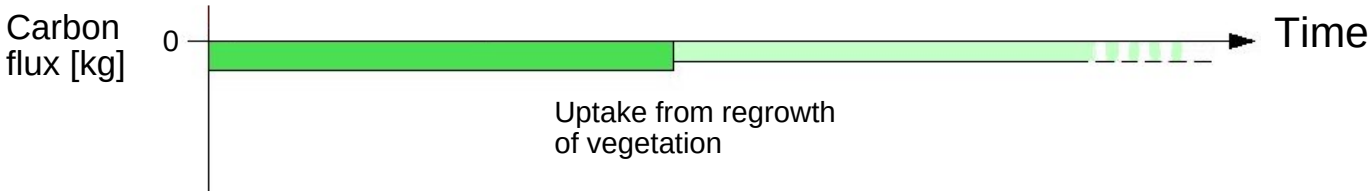
The conversion of a forest to cropland/pasture



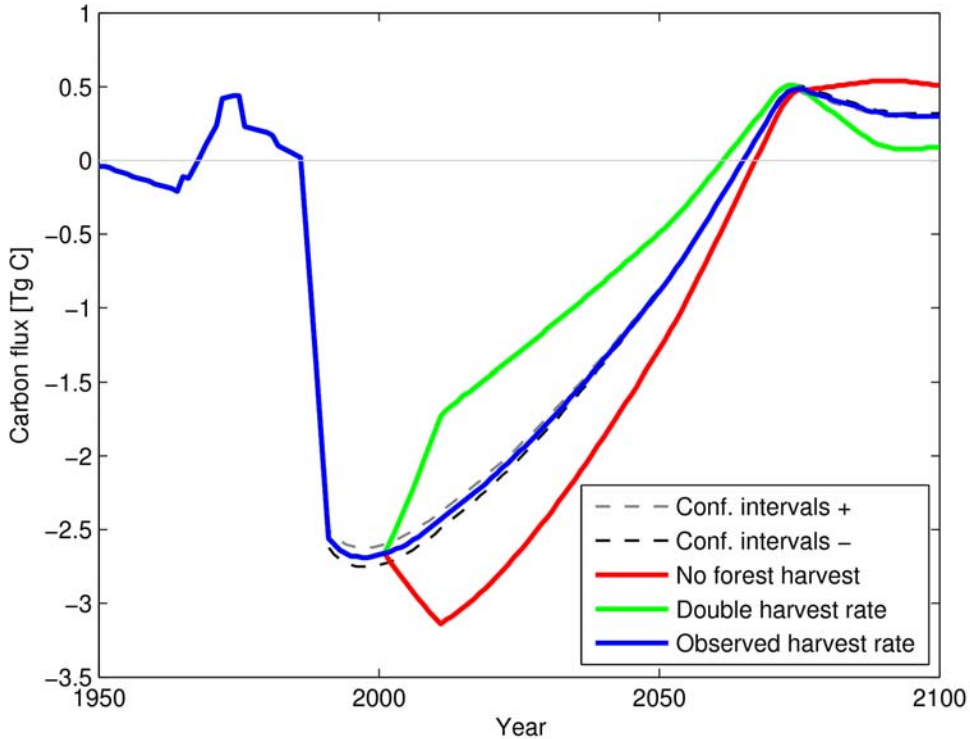
abandonment of cropland/pasture







Terrrestrial Carbon Budget for Romania



The magnitude of the current sink is equal to about 10% of the emissions from burning of fossil fuels

Romanian Ecosystems are currently a carbon sink and will remain a sink until about 2070.

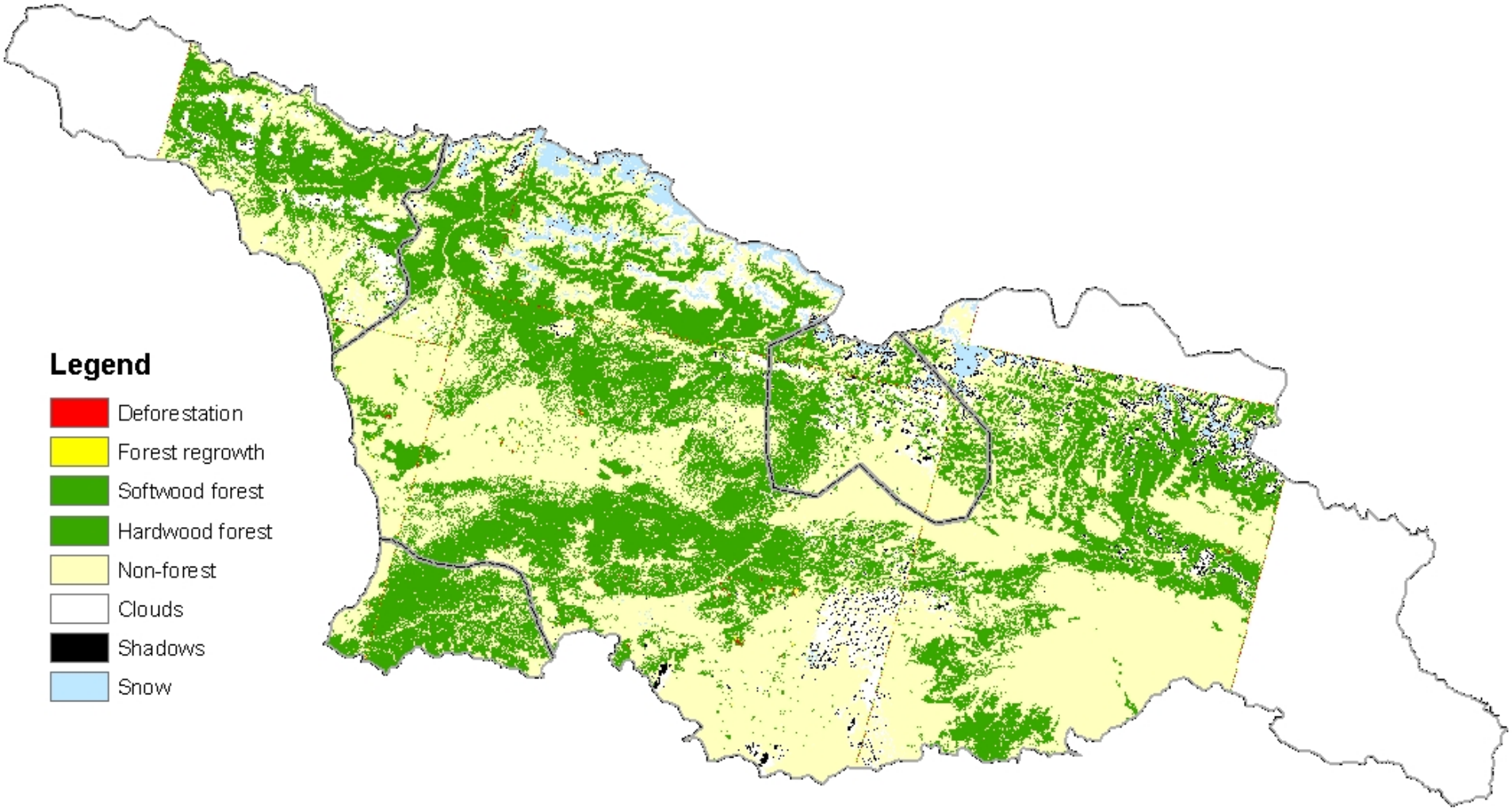
Summary: Romania

- Remote sensing of forest change and a book keeping model allow estimation of national level carbon budgets
- Romania is currently a net carbon sink (approximately 10% of fossil fuel emissions)
- Under the current harvesting rates the annual sink will decline to zero in about 60 years
- Interestingly, doubling the rate of forest harvest would not dramatically change the magnitude or length of the projected carbon sink.

Forest change in Georgia, circa 1990-2000

- Not much forest change - around 2% of the forested area in 1990 has been cut or partially cut (preliminary result)
- Illegal logging apparent in proximity to villages
- 60% of harvest as unrecorded fuelwood (according to FAO)
- Forest change concentrated near roads and villages (much Georgian forest is protected by inaccessibility)
- Less harvesting than in Romania, more than in Turkey
- Higher degree of partial cutting than in Romania and Turkey

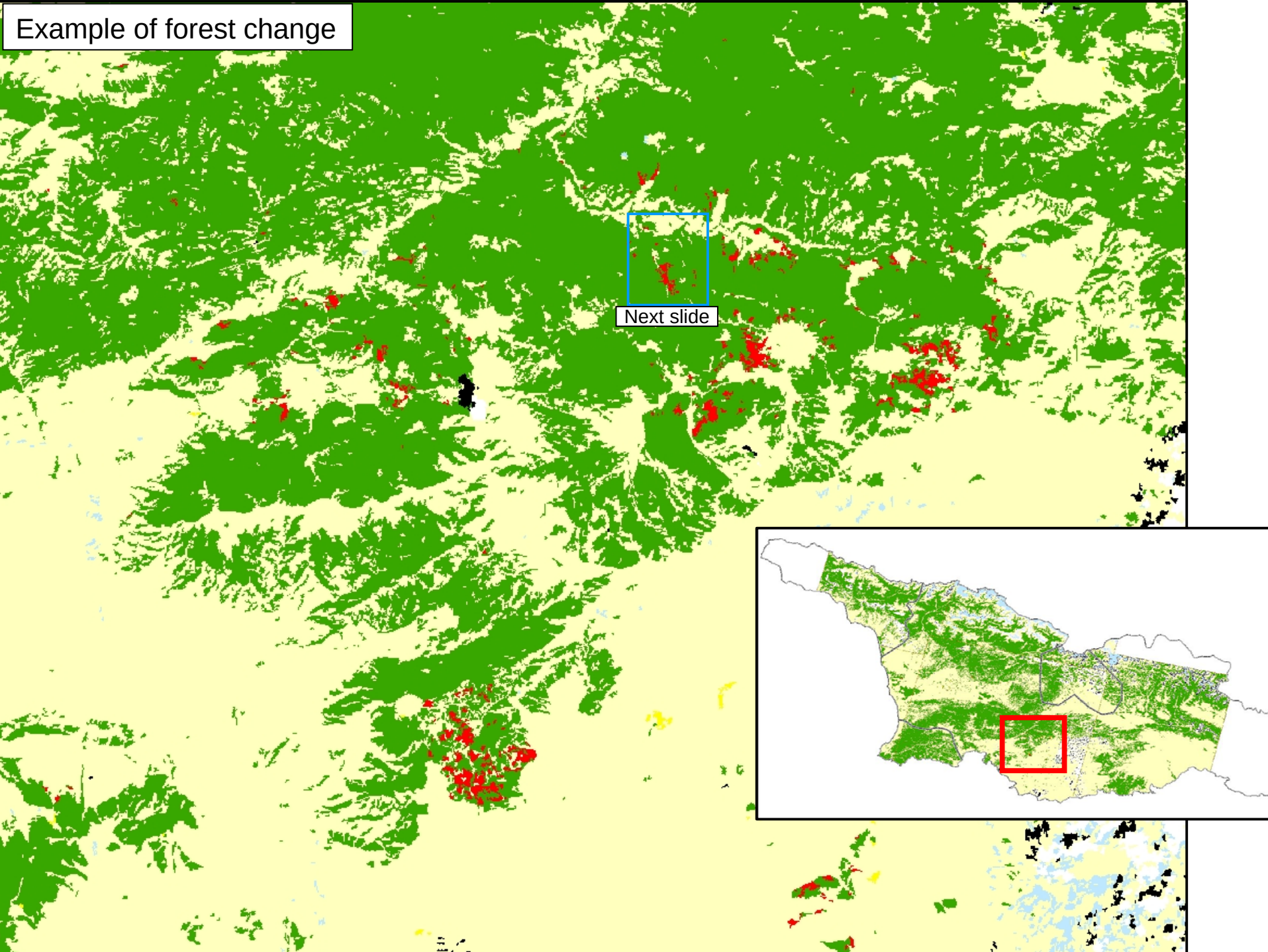
Changemap for Georgia, 1990 to 2000



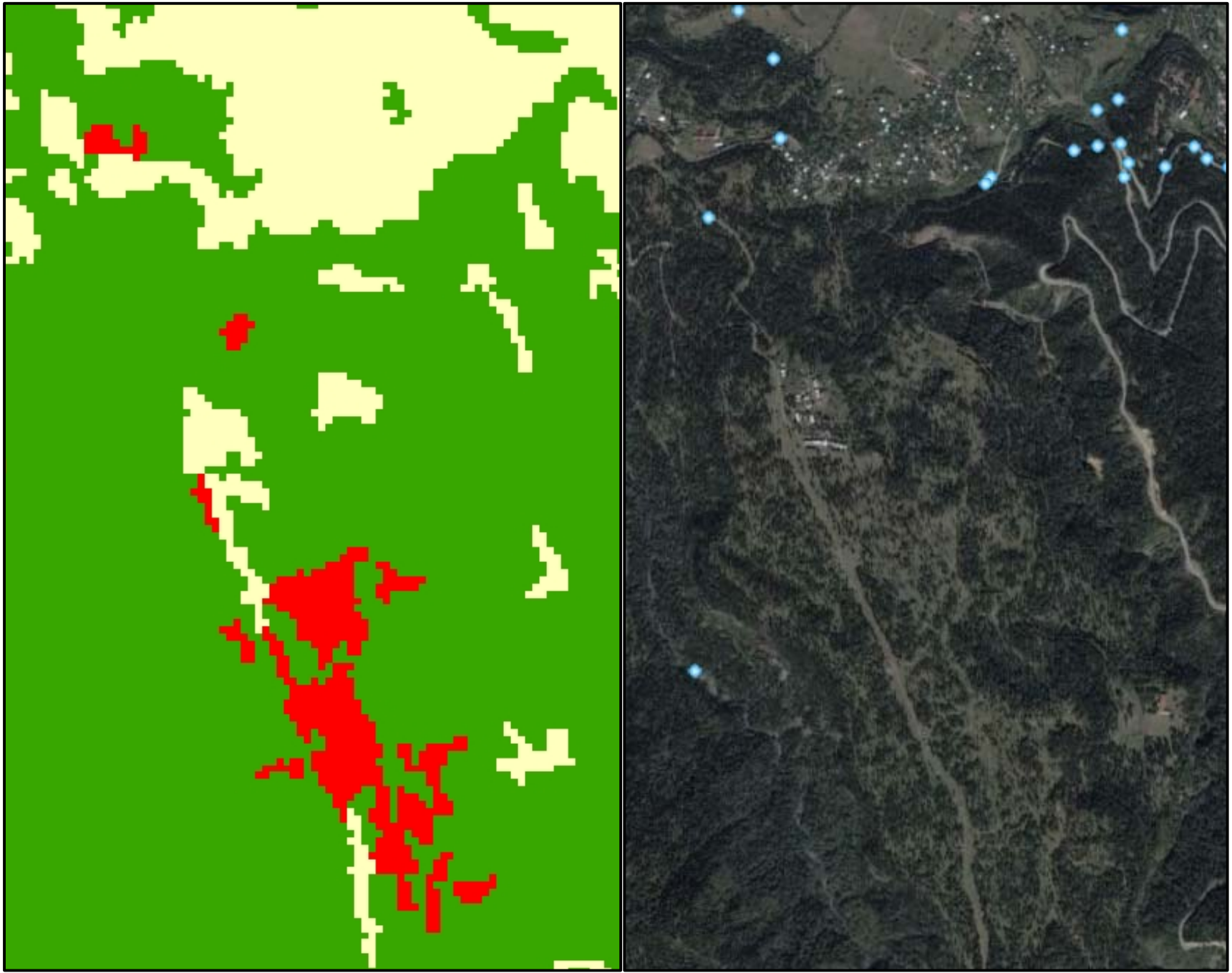
0 100 200 Kilometers

BOSTON UNIVERSITY

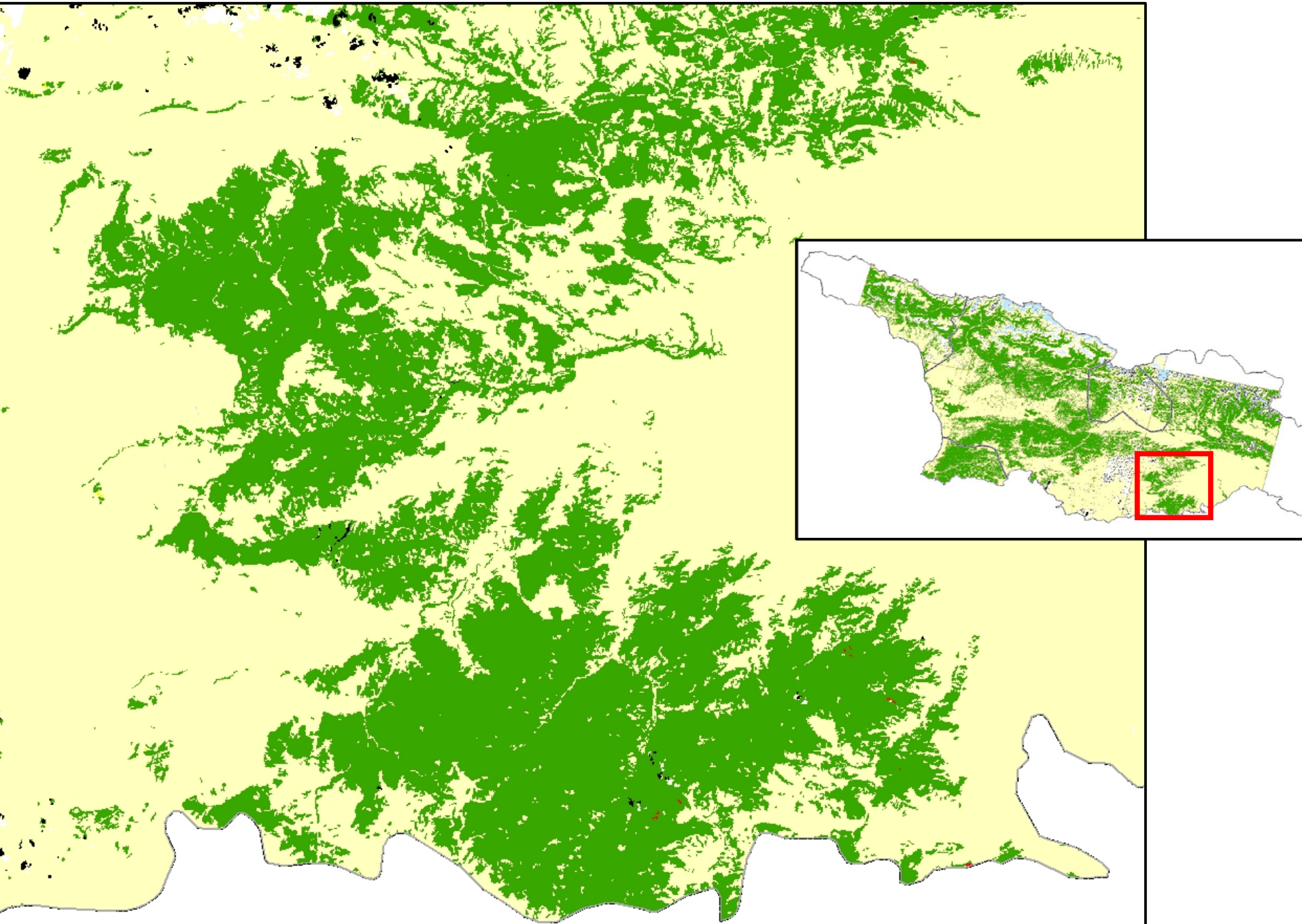
Example of forest change



Example of partial cutting (illegal) in Central Georgia



Example of stable forest in Southern Georgia



Conclusions

- Rates of land use change are low in the forests of Turkey, Romania and Georgia for the period 1990-2000
- Remote sensing observations are central to our ability to monitor land cover change
- Romania is a carbon sink currently, and I expect Turkey and Georgia will be, too.

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Forest transitions: towards a global understanding of land use change

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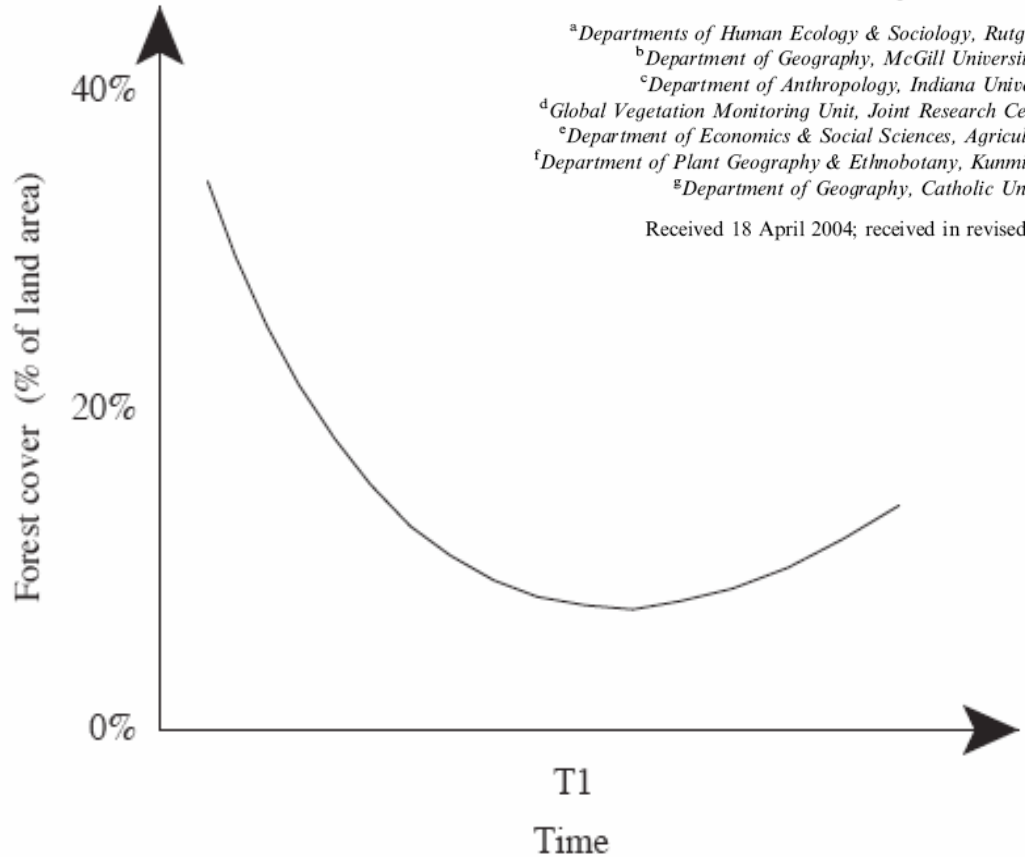


Fig. 1. The forest transition.

Forest Transitions: Is the question when, and not if?

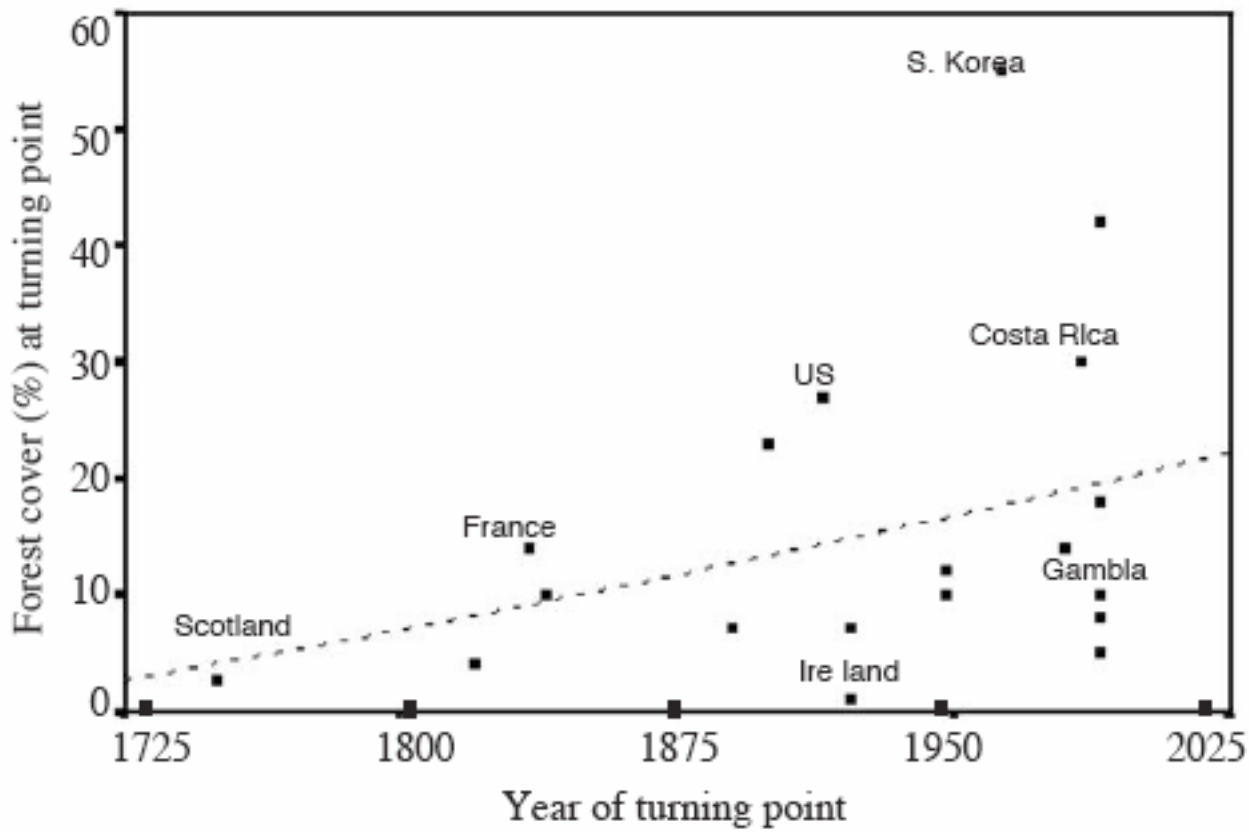
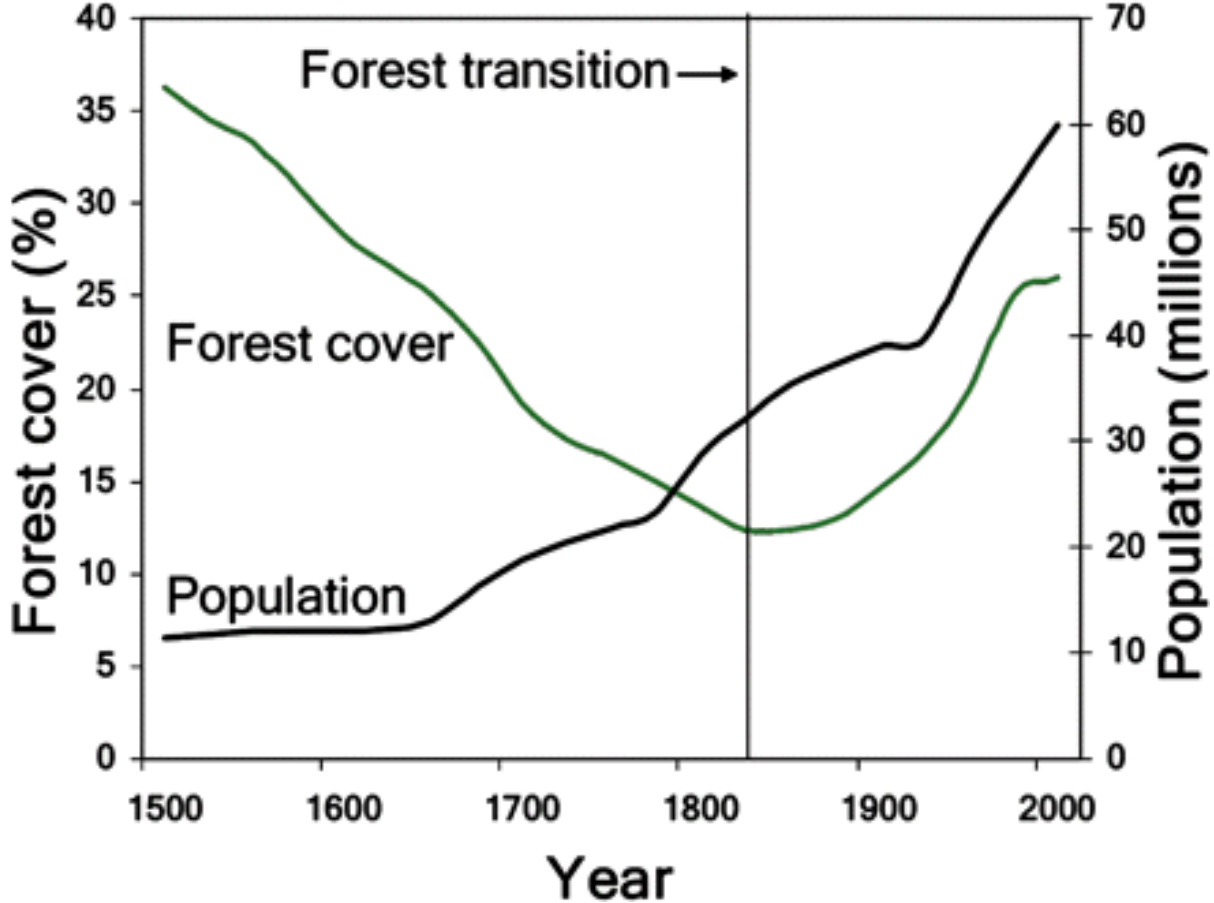


Fig. 2. Forest cover at the turning point.

Data for France as an example of historical trends in forest cover in the developed world. Note that following a long decline due to conversion of lands for grazing and agriculture, as development progresses through the 19th and 20th centuries, forest area (and environmental health) increases



source

Returning forests analyzed with the forest identity

Pekka E. Kauppi*, Jesse H. Ausubel†, Jingyun Fang‡, Alexander S. Mather§, Roger A. Sedjo¶, and Paul E. Waggoner‖**

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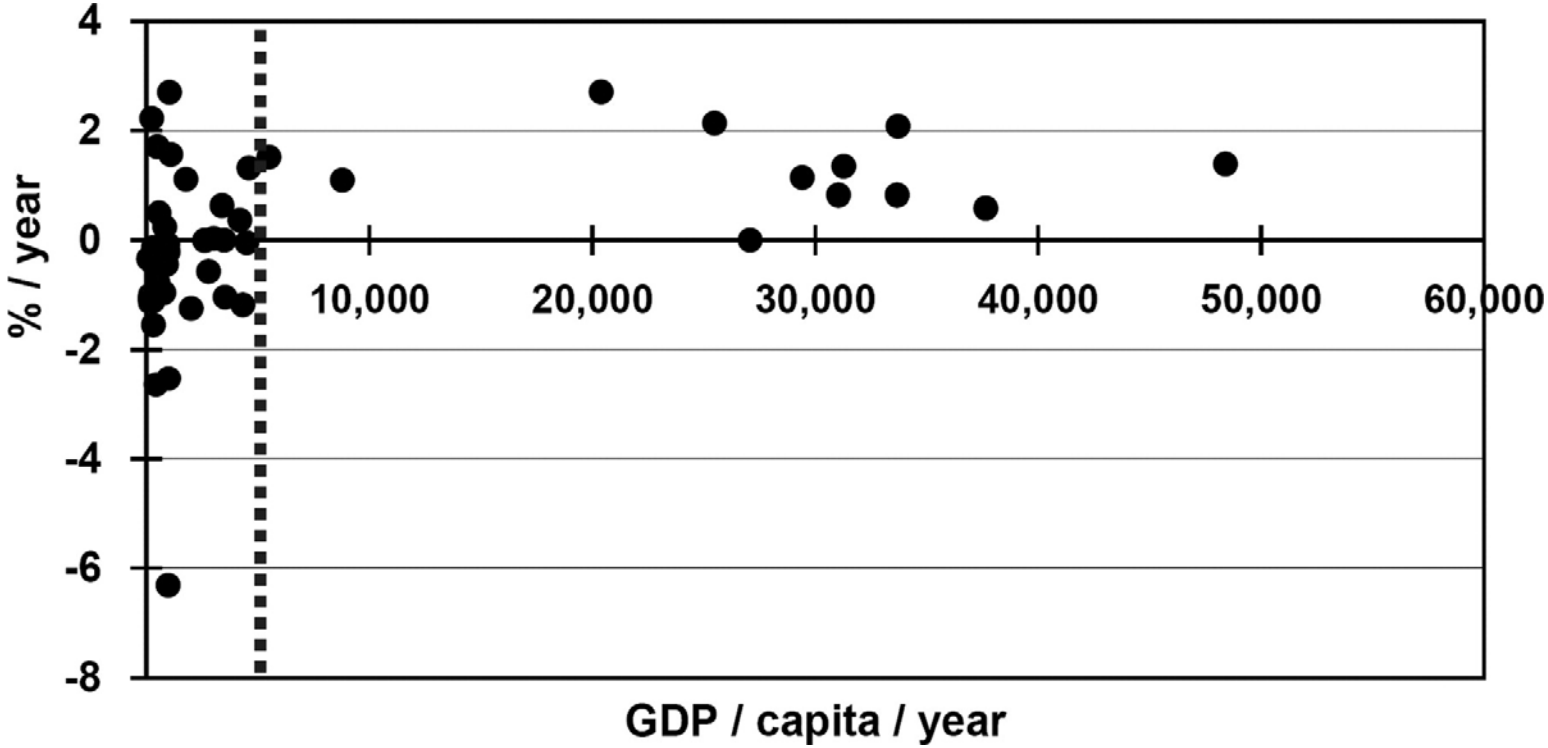
Deforestation and Development



In this graph, each point is a country, and the y axis shows the percent change in forest area. Note that the richest countries are adding forest area.

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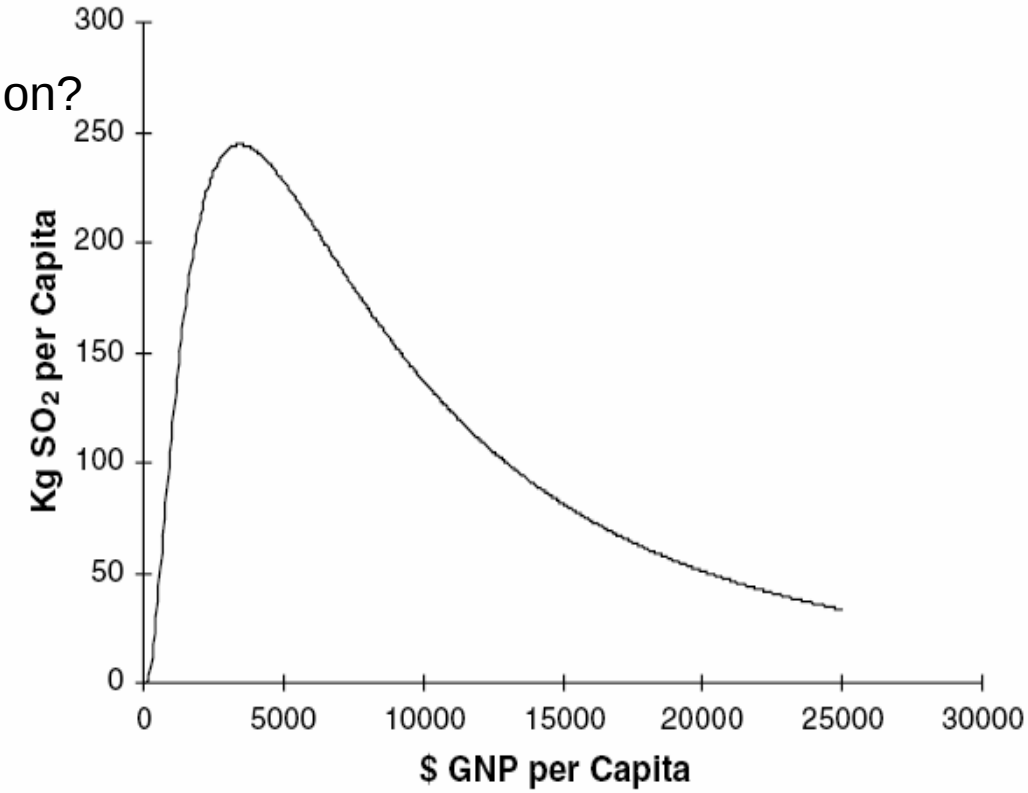
Environmental Kuznets Curve: Idea that human impact on the environment first increases with affluence (or economic development) and then decreases --

Does it apply in the case of forest cover?

Env degradation?



Affluence?

Figure 1. *Environmental Kuznets curve for sulfur emissions. Source: Panayotou (1993) and Stern, Common, and Barbier (1996).*

THE EFFECTS OF LAND USE CHANGE ON THE TERRESTRIAL CARBON BUDGETS OF NEW ENGLAND

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Background

- **New England Forest Change**

- **<u>17th~18th Century</u>- Large areas of forest were converted to agricultural land following settlement by Europeans.**

- **<u>Mid-Late 19th Century</u> – Agricultural abandonment. Regrowth & Urbanization**

- **<u>20th Century</u> – Fully recovered forest. Diversity of forest types**

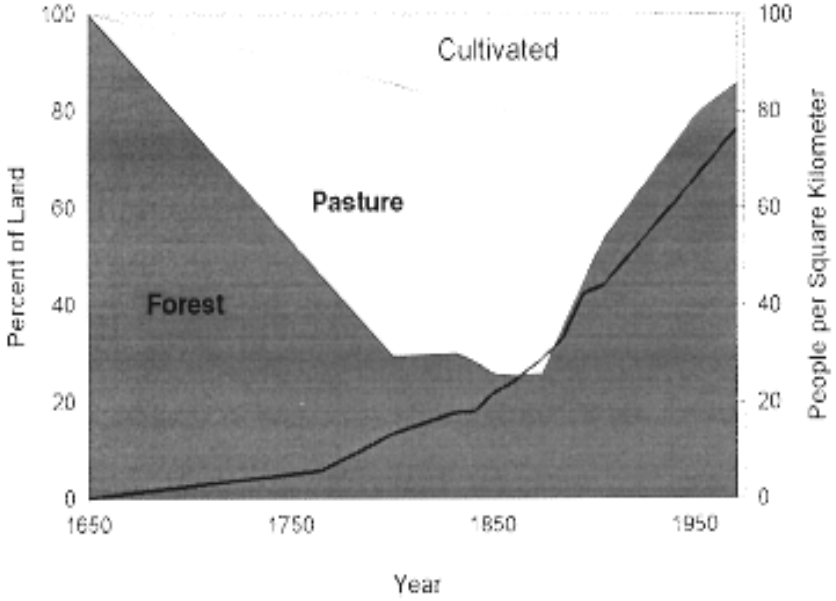


Fig1. Changes in land use and human population (dark solid line) through the historical period in central Massachusetts (Foster et al., 1997).

Study Area

- Connecticut
- Massachusetts,
- New Hampshire,
- Rhode island
- Vermont

The total study area is approximately 82,627km2.

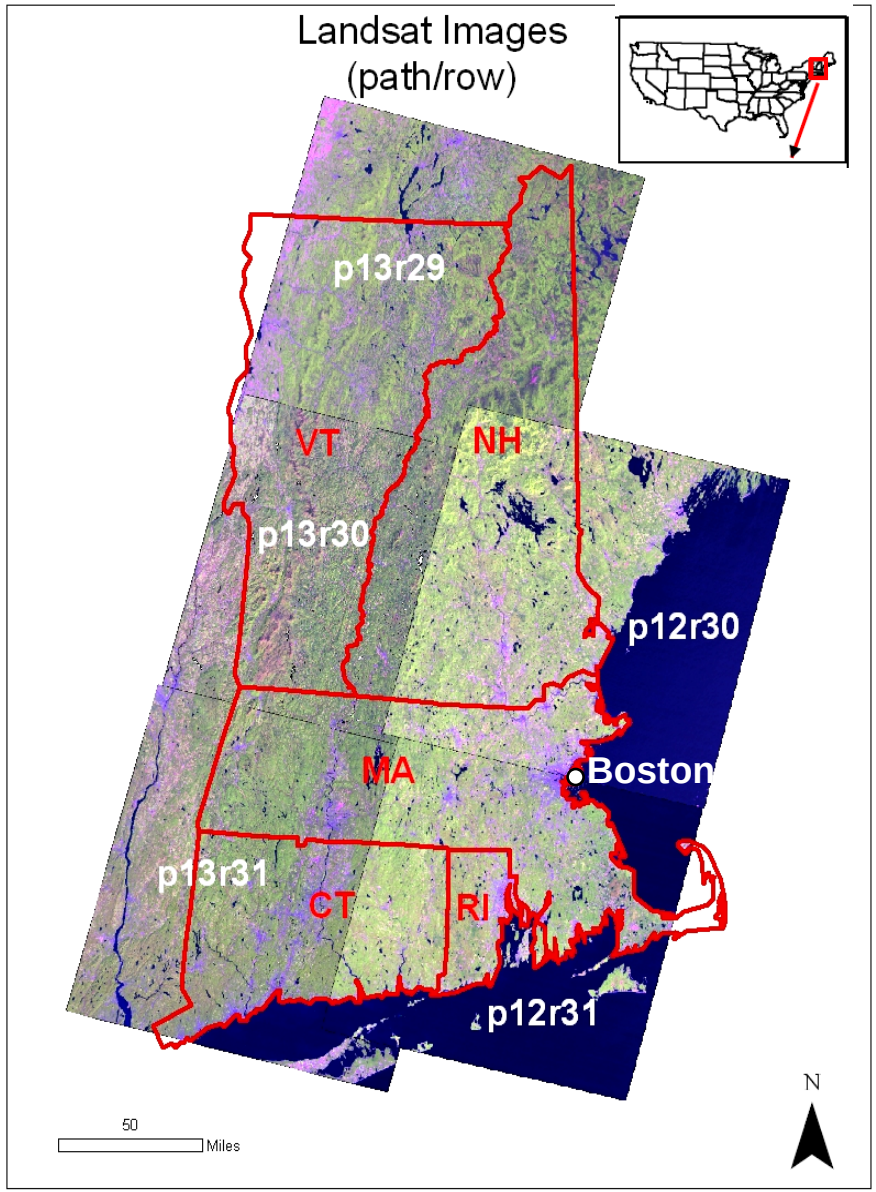
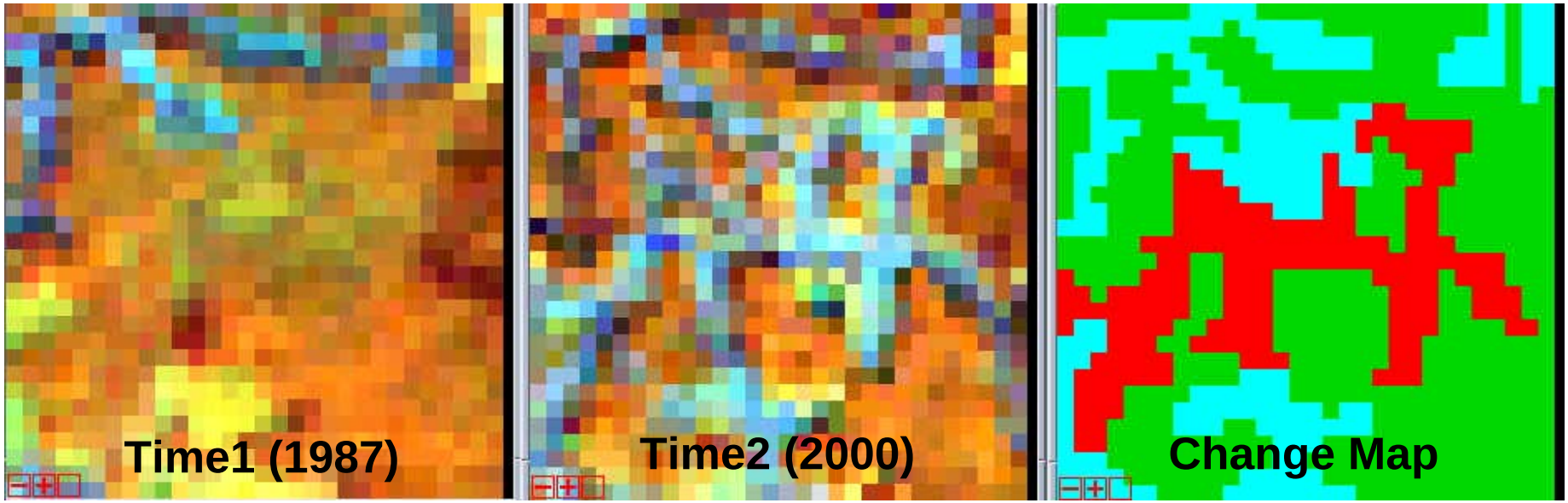


Fig3. Study Area

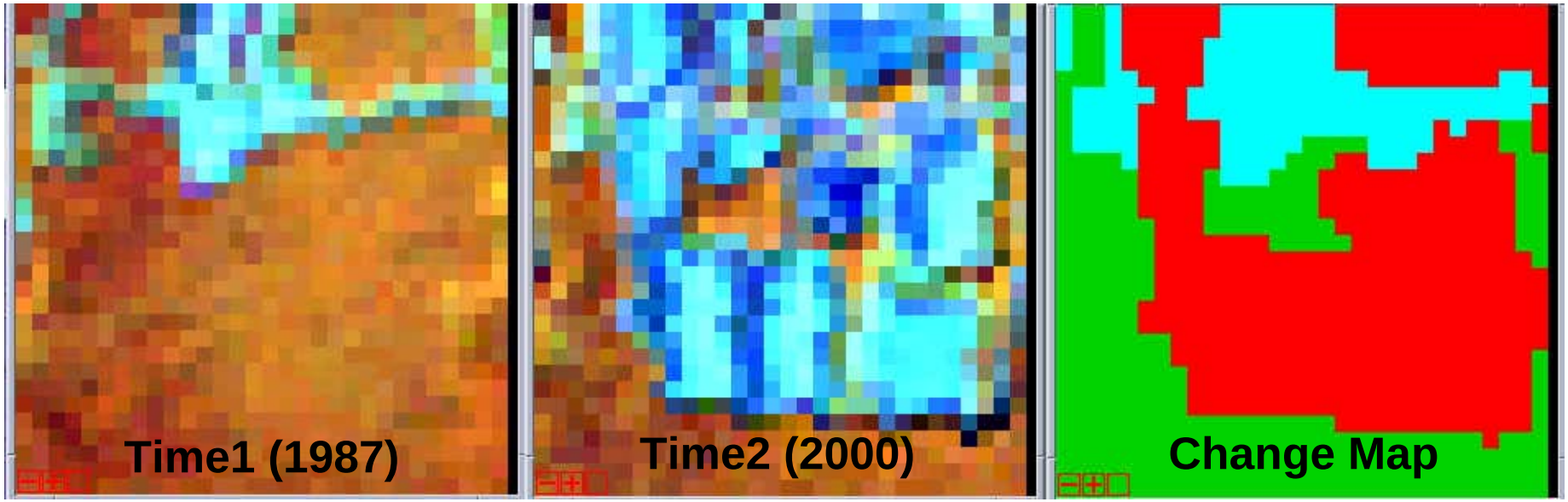
Residential Development. Norfolk County, MA (70 ha)



Google Earth (winter)

- Forest to nonforest
- Stable forest
- Stable nonforest

Commercial Buildings. Norfolk County, MA (70 ha)



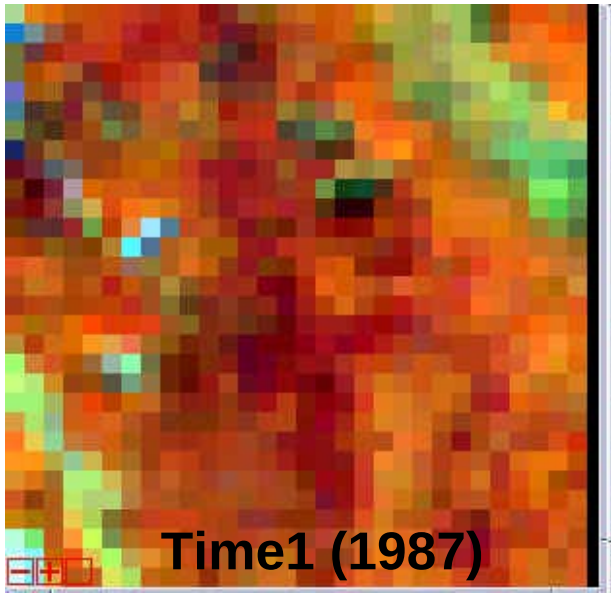
Forest to nonforest

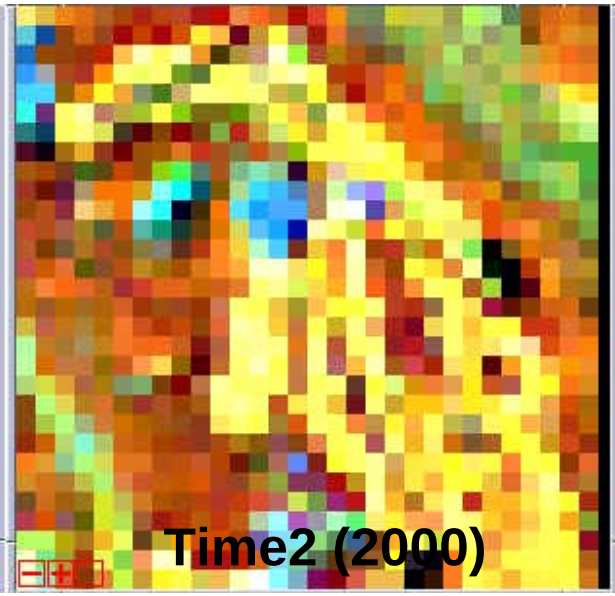
Stable forest

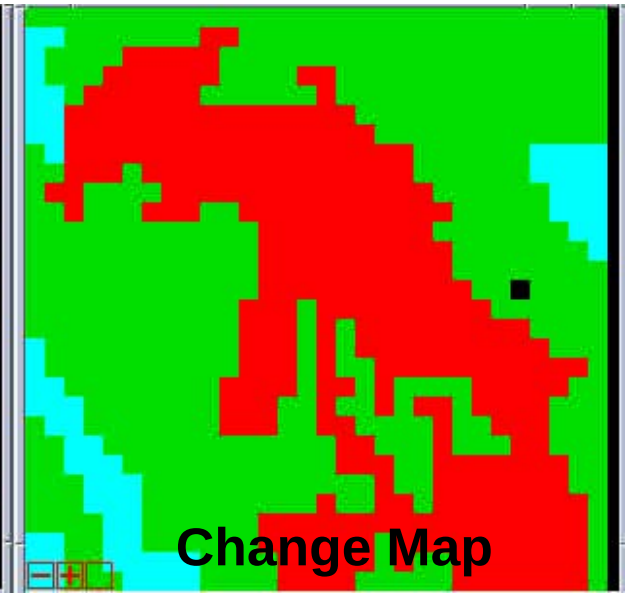
Stable nonforest

Google Earth

Golf Course. Norfolk County, MA (70 ha)

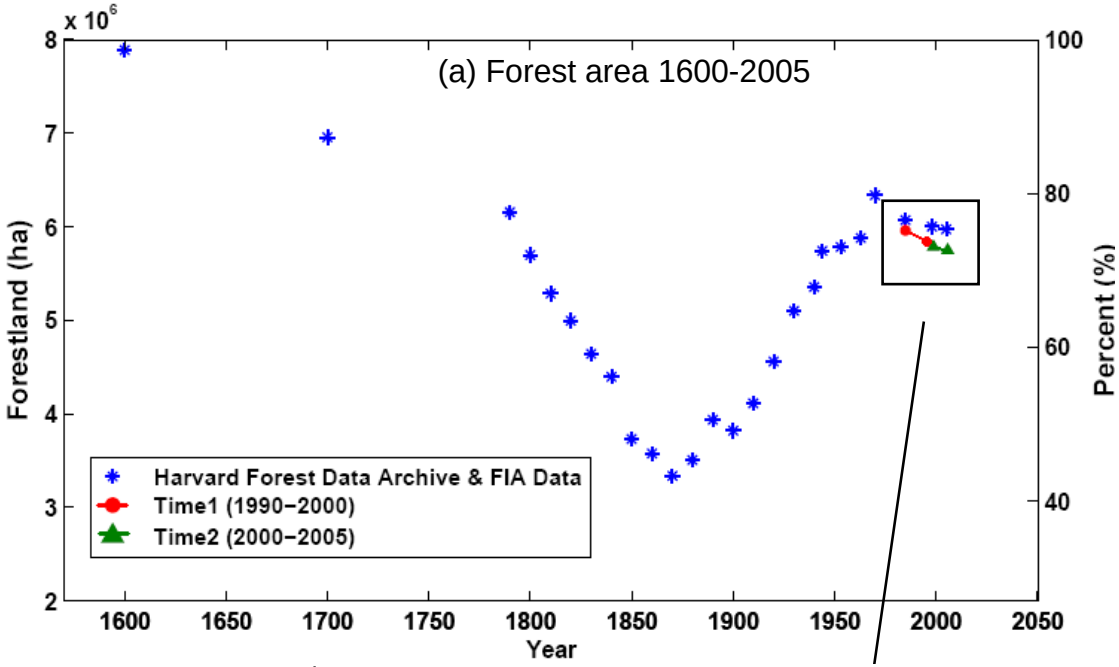


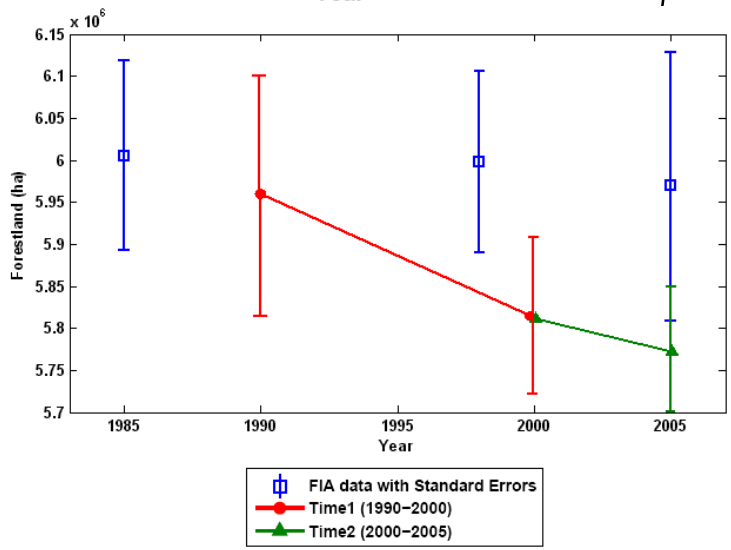




Google Earth

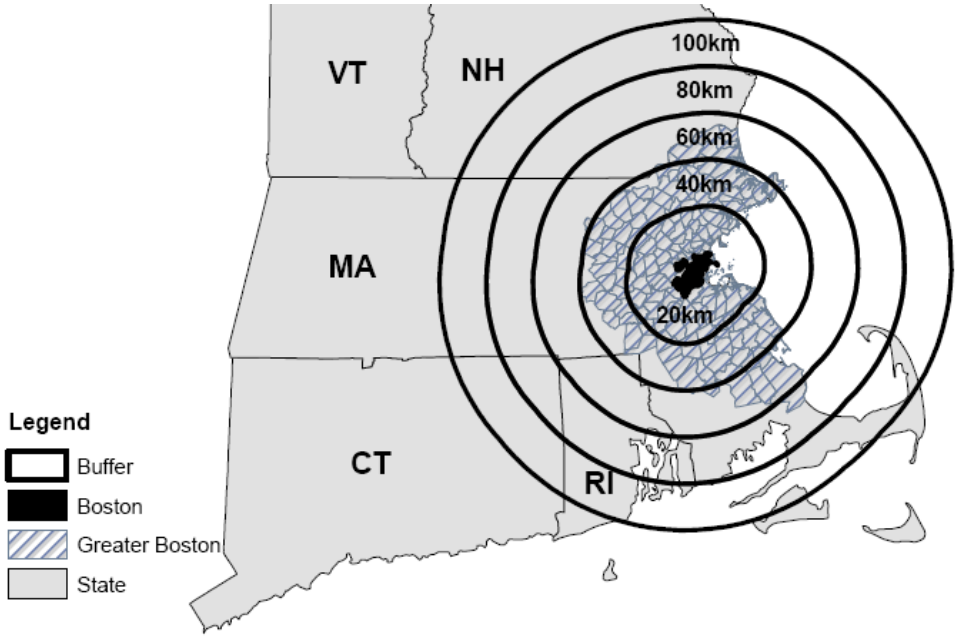
Trends in Forest Area (comparions with FIA)

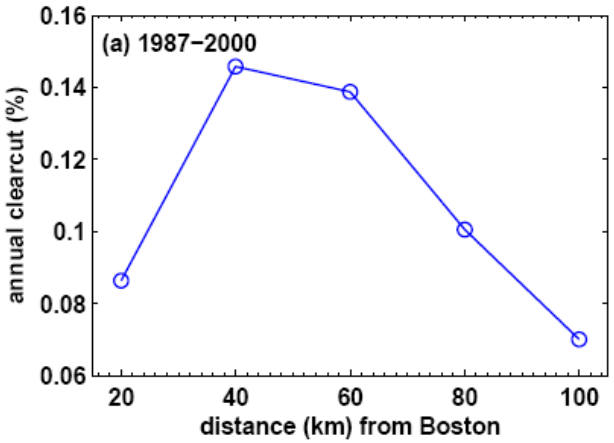




(b) Forest Area, 1985-2005

Spatial Analysis - Forest change rate (%/year) for Time1 and Time2 Buffer (20km) from Boston





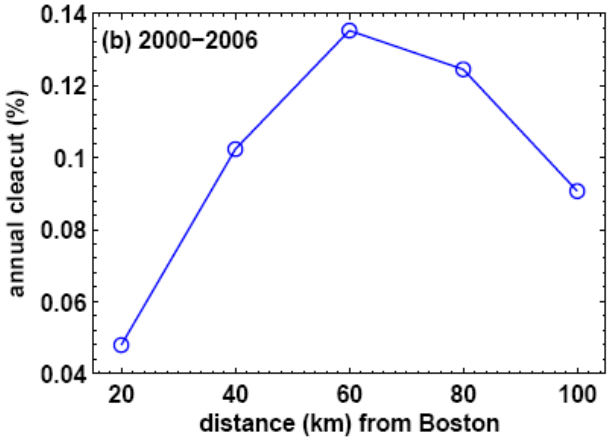
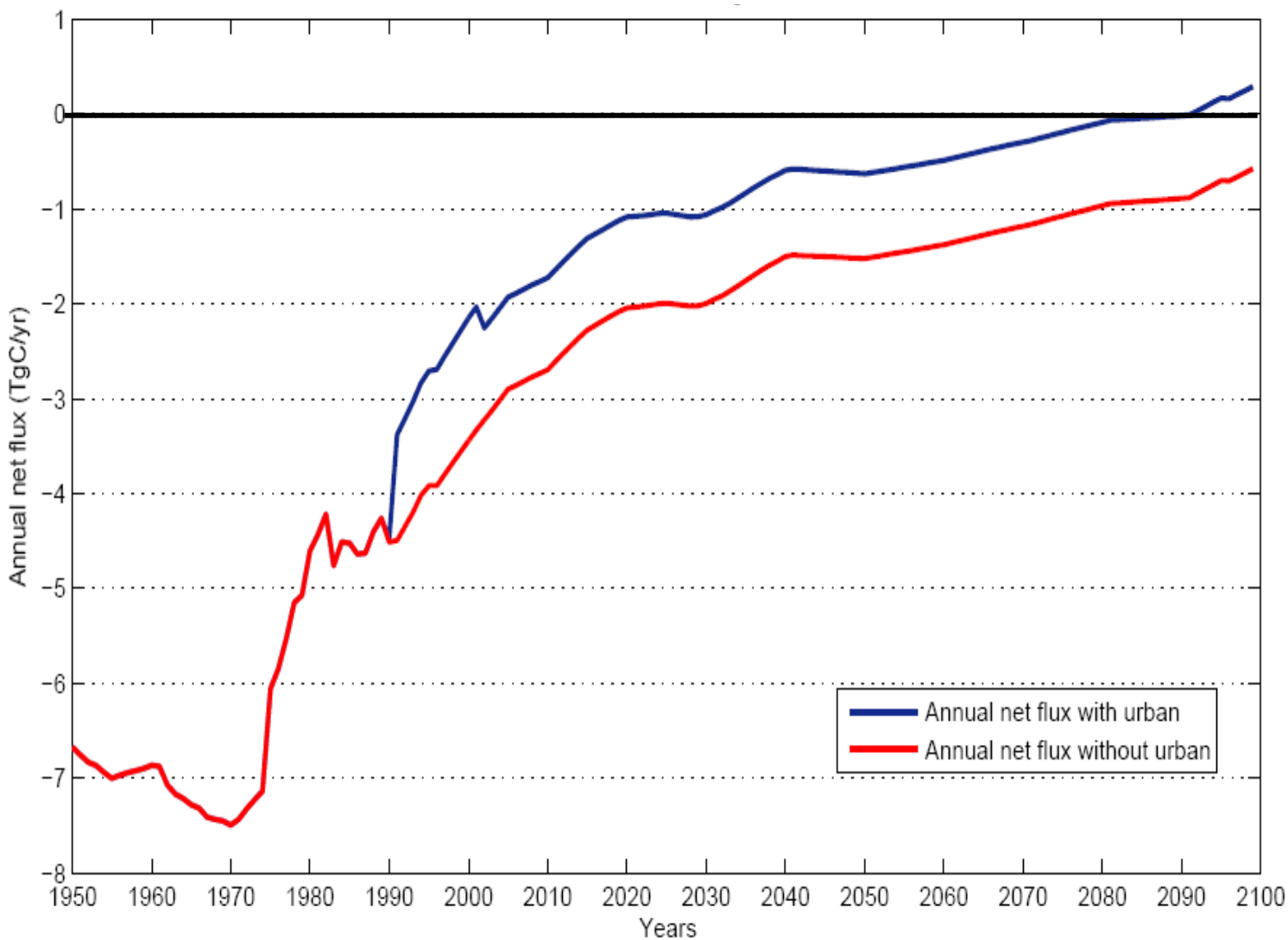


Fig5.

Recent Development Eastern MA

Annual net flux with urban and without urban (1950-2100)



Approximately 50% of remaining potential sink is being decreased by urban growth

Conclusions (New England)

1. The forest area of New England is decreasing due to urban growth.

- For the period 1990-2000, study area lost 10,219ha (0.23%) forest per year.
- For the period 2000-2005, study area lost 5,427 ha (0.13%) forest per year.

2. Urban growth is significantly reducing the ongoing terrestrial carbon sink in New England.

- The area converted from forest to human development for houses and commercial buildings released 17.3 TgC from 1990 to 2005 and approximately 50% of remaining potential sink will be decreased by urban growth to 2100 .

Is this new phase of forest loss simply urban growth or a form of postmodern deforestation?