Land-cover / Land-use Change and Carbon Fluxes in Central and Eastern Europe

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Goals

- Land-use/land-cover change and the carbon cycle
- Land-cover change includes forest loss, forest gain, agricultural abandonment, and agricultural intensification
- Historical land use change
- The satellite era
- Carbon bookkeeping model
Physiographic Setting

- Rich in physiographic provinces
  - Topography partially determines land-cover and use
- Mountains
  - Caucasus, Carpathian
  - Dominated by forests
- Low relief plains
  - Dominated by agricultural lands and grasslands
- Large water bodies
- Major rivers
Historical Setting

- Over 3000 years of settled history
- Agriculture plays a dominant role
- Region of “conquests”
- Major migration routes
- Raw materials for wars (wood) and later industrial development
- Industrialization
- Soviet revolution
- Independence
Current Trends

- Demographic
  - Slow growth
  - Urbanization
  - Migration

- Economic and Industrial
  - European integration
  - Manufacturing hub and construction industry
  - Agricultural activities

- Natural
  - Forest harvest/re-growth
  - Mixed climate change signal
Research Questions

- How do recent drastic socioeconomic changes affect forest cover?
  - Forest loss / forest gain
- What are the best methods for monitoring these changes remotely?
  - Remote sensing, historical perspective
- What are the impacts of these changes on the regional terrestrial carbon budgets?
  - Carbon release; carbon uptake
Forests of the region

- Forests dominate high elevation areas
  - Large forest area compared to central and western Europe

- Changes are location specific:
  - Hungary – privatization/renewable energy
  - Romania – privatization
  - Georgia - fuel wood
  - Ukraine – commercial extraction
Forest change (Romania)
Carbon budgets associated with land change
Carbon book-keeping model

- Originally developed by Richard Houghton et al. (1983)
- Calculates the carbon emissions and uptake over time associated with land change events
- Events may include i) forest harvest, ii) conversion to cropland, iii) abandonment of farmland, etc.
- Makes use of forest inventory data for growth rates, age distributions and average biomass
- Includes the effects of decomposition of forest products
Carbon book-keeping model

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\begin{align*}
\text{Atmosphere} & \\
670 & \xrightarrow{80} 190,000 \text{ Biomass} & \Delta = -220 \\
170 & \xrightarrow{} 11,300 \text{ Products} & \Delta = 160 \\
& \xrightarrow{} 10,500 \text{ Slash} & \Delta = 90 \\
& \xrightarrow{} 352,000 \text{ Soil} & \Delta = -60 \\
& \xrightarrow{390} & 480 \\
& \xrightarrow{130} & 800 \text{ Gross uptake} \\
& \xrightarrow{830} & 830 \text{ Gross release} \\
& \xrightarrow{190} & 30 \text{ Net release}
\end{align*}
\]
Animation 1: Event/disturbance
Afforestation or forest regrowth on abandoned farmland. 50 km$^2$ of forest planted every year between 2001 and 2010.
Animation 2: Event/disturbance
Clearing of forest, no forest regrowth. 50 km² cleared every year between 2001 and 2010.
Animation 3: Event/disturbance
Harvest. Forest replanted after harvest. 50 km2 harvested annually 2001-2010.

Year 2000
Undisturbed ecosystem
Romania
Historical and Current Land Use

- Historical rates from records of forestry statistics
- Areas of stable and changing forest 1990-2000, and 2005-2010 mapped using Landsat data
- Vast areas of forest converted to farmlands historically
- Harvest rate dropped dramatically after collapse of Soviet Union
- But 60% harvest increase from 1990-2000 to 2005-2010
Carbon Fluxes

- Carbon book-keeping model run using historical and current rates of forest loss, gain and harvest
- Carbon implications of restitution small compared to terrestrial emissions from logging during 60s and 70s
Future Carbon Fluxes

- Model run for future scenarios based on current logging rate and regrowth of forest on current abandoned or fallow farmland (2.9 million ha)
Ukraine

Changes in forest cover were mapped in a previous study (Kuemmerle, T., et al., Forest cover change..., *Remote Sensing of Environment* (2009), doi:10.1016/j.rse.2009.02.006)
Historical total forest cover

Estimated land use change rates from 1900
Carbon fluxes modeled using observed rates of land use change

Net flux under different scenarios
Conclusions: Ukraine

- Widespread change in forest cover 1988-2007
- Unsustainable logging (but probably no deforestation)
- Natural reforestation on abandoned farmland
- Slight net increase in forest cover 1988-2007
- Carbon sink now and in the future
Animation 4: Example from Georgia
Forest clearing, afforestation and harvest from 1800 to 2100
Future

- Include large area agricultural land abandonment rates into this analysis
- Carpathian Basin 200-year change maps – can we move to spatial version of carbon accounting?
- Will the abandoned lands continue to be left out of production?
- Past is important but the future is important too: i.e. EU policies and implications for carbon?
Forest transition in the 1930s

- Habsburg management and War, agricultural expansion
- Abandonment of marginal areas, reforestation plans
Thank you

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