

Annual Report for Year 2
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**“Driving Forces of Change in Regional Carbon Stocks:
Comparison of the Western Oregon, USA and St. Petersburg Region, Russia”**

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ABSTRACT

Our studies of carbon dynamics in forest ecosystems focused on two forest regions with contrasting land-use history and active ongoing changes in land management: Western Oregon, U.S.A. and St. Petersburg region in northwestern Russia. These regions represent distinct global trends in land-use, i.e. a move towards ecosystem management on public lands in developed market economies on one hand and on the other hand, the effects of profound macro-economic, institutional, and social transformation, that are common among economies in transition. The major goal of this new phase of research is to synthesize the results of past studies and to fully integrate the socio-economic drivers into the analysis of present and projected future LCLUC processes and associated changes in carbon stores. The hierarchical set of models that simulate regional carbon dynamics (StandCarb, MaxCarb, Harvest, and ForProd, all integrated in LandCarb) will be fully parameterized and tested in both regions. Then it will be linked with the Forest and Agricultural Sector Optimization Model (FASOM) using timber harvest as a primary link. We will use the linked models to analyze the effects of a recent decline in timber harvests in both regions with the emphasis on the temporal patterns of response of different ecosystem components and economic variables to change in land-use. Examination of how (and if) changes in driving forces of land-use during 1990's and in preceding decades manifest themselves in current and future regional carbon dynamics can provide important evidence on the ability of humans to manipulate the processes of terrestrial carbon cycling at the decadal time-scale. Further, we will compare the role of environmental and economic factors in defining the bounds of change in regional carbon stocks 10-20-30 years into the future under alternative economic development scenarios.

KEYWORDS:

1. **Research Fields:** Land Use, Carbon Cycle, Forest Management
2. **Geographic Area/ Biome:** Boreal Forest, Temperate Forest, Europe
3. **Remote Sensing:** LANDSAT
4. **Methods/Scales:** In-situ Data, Regional Scale, Time Series.

QUESTIONS, GOALS, APPROACHES:

* This research addresses all three NASA ESE scientific questions:

- a) We detect and analyze changes in land cover and land-use in both study regions using a time series LANDSAT images and use the results as a basis for examination of changes in carbon stores (*what are the changes in land cover and/or land use (monitoring/mapping activities)*)
- b) Understanding and modeling the economic causes of land-use is a particular focus of our new phase of research. Comparison between two contrasting forest regions will give an indication of uniformity of economic causes of LCLUC (*what are the causes of LCLUC?*)
- c) Examination of the effect of LCLUC on regional carbon stores and on economic welfare will be performed in both study regions with linked ecosystem and socio-economic models. The goal is to compare the role of environmental and social factors in defining the bounds of change in regional carbon stocks 10, 20, and 30 years into the future under alternative economic development scenarios (*what are the consequences of LCLUC?*).

The proportion of Social Science used in this study can be estimated (roughly) at 30%. The proportion of other themes that are covered in this project: Carbon – 50%, GOF (mapping/monitoring of forest cover, change detection) – 50%.

* The overall goal of the project is to examine the effect of ecosystem processes and socio-economic factors on spatial and temporal patterns of C stores and fluxes within our two study regions: Western Oregon and St. Petersburg region of Russia.

In Year 2 the PIs focused on the following major tasks:

- Comparison of the estimates of carbon balance derived from the remote sensing data and forest inventory data in the St. Petersburg study region.
- Mapping of disturbance for the St. Petersburg region from 1980's through ca. 2000.
- We hosted Russian trainee Mike Tarasov who tested parameterization of STANDCARB for the St. Petersburg region
- Programming and testing of the MAXCARB and the LANDCARB models is underway and should be complete within year 2.
- Compile statistical, economic, and survey data on land use change in the St. Petersburg region over the last 100 years. Plans for four Russian consultants were developed and their reports are due early in Year 3 of the project.
- A workshop for Russian collaborators (past, current, and potential future) was conducted at the St. Petersburg Forest Academy on August 29, 2002. Proceedings of the workshop were published by the St. Petersburg Forest Academy in Russian.
- Update estimates of land use changes, timber growth and yield, and timber harvest in western Oregon, for use in updating input sets in the FASOM model.
- Update projections of deforestation in western Oregon based on analyses of land use changes related to population growth and other socio-economic activities.

STATEMENT OF PROGRESS

1. Comparison of Remote Sensing and Forest Inventory Data was completed for the St. Petersburg region. The results were reported at the International Workshop Wengen-

2002 - Quantifying Terrestrial Carbon Sinks: Science, Technology and Policy. Wengen, Switzerland, September 25-27, 2002. A paper based on this analysis is in review (Climatic Change). For **Western Oregon** the progress was limited. We plan to put additional effort into this work and complete it in year 3.

2. Modeling. Analyses of carbon model projections for the Pacific Northwest were presented at Fourth North American Forest Ecology Workshop: Ecosystems in Transition p. 76. Oregon State University, Corvallis, OR (Disturbance and forest carbon balance: Temporal signals change from stand to landscape scale) and at 10th Cary Conference, April 29-May 1, 2003, Milbrook, NY (Disturbance and forest carbon balance: How temporal signals change from stand to landscape scale). In addition to the programming and testing of the MAXCARB and the LANDCARB models, we have been testing the methodologies to link the STANDCARB, LANDCARB, and MAXCARB models. We have developed a method to utilize species succession information generated by STANDCARB in the LANDCARB and MAXCARB models. We have also tested the relationship between the steady-state potentials predicted by MAXCARB and those that can be derived (at much greater computational cost) by the STANDCARB and LANDCARB.

3. Mapping of disturbance in the St. Petersburg region from 1980's - ca. 2000.

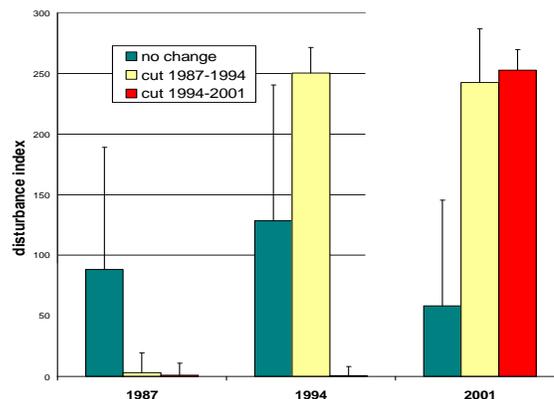
Tracking forest disturbance and mapping young forests is critical for estimating regional carbon dynamics. Change detection methods were first tested on a portion of Landsat scene 185/19 with imagery from 1987-2001. Each image was transformed into the tasseled cap (TC) indices of brightness, greenness and wetness, standardized with reference to its mean value and combined into a single "disturbance index" (see "new potential" below). The resulting image was filtered and despeckled to remove patches less than 1ha in size. Total area of detected disturbance (14.7 thousand ha in 1987-1994 and 22.5 thousand ha in 1994-2001) is consistent with harvest levels during the examined time intervals. Harvested area reported by the regional forest management agency was compiled for eventual comparison with detected clearcut area in the entire St. Petersburg region. The major impediment in change detection is the insufficient supply of suitable cloud-free Landsat imagery. We have purchased additional imagery and plan to complete change detection by January 2004.

4. Economic Analysis. We analyzed socio-economic variables (e.g., population growth) related to changes in land-use. Population and personal income were key driving forces of land-use change during the 1990's, when the rate of conversion of rural lands to developed uses (e.g., urbanization) increased by 50 percent. Deforestation was projected based on the statistical relationships, to facilitate examination of future regional carbon dynamics. Future choices of management or policy options should be assessed with consideration of dynamic interactions among climate, ecological, and socio-economic systems and attendant effects on agriculture, forestry, and natural resources. Further, to aid in science-based assessments of potential changes in regional carbon stocks 10-20-30 years into the future under alternative economic development scenarios, we updated input data sets for the FASOM model. These input sets include forest growth and yield based on regional forest surveys, timber harvest, and land cover changes. Associated future

projections by the FASOM model can support analyses of environmental, social, and economic costs and benefits, and implications of these interactions for integrating climate change response strategies in an equitable manner into broad sustainable development strategies.

- **New findings** – The long-term effects of landuse change in the St. Petersburg region apparently over-ride the impact of the more recent decline in timber harvest (from about 6 million m³/yr during the 1980's to 4.2 million m³/yr in 1994). This decline can explain only a fraction (less than 15%) of the increase in wood stock between 1988 and 1998 estimated from forest inventory data. Wood accumulation on the disproportionately large area of forest between ages 50 and 90 is likely responsible for the balance. To understand the origins of forest regeneration boom between 1900 and early 1950's it is necessary to examine changes in landuse over much longer period than initially envisioned in this project. The conditions of dramatic social perturbation and prolonged military conflict that occurred during this time were shown to cause extensive agricultural abandonment in other parts of the world and similar processes were likely responsible for forest expansion in the St. Petersburg region.
- **New potential** – Disturbance index = brightness - (greenness + wetness).

Mean disturbance index values (SD)



The index worked well for detecting clearcut harvest and burned forest. The use of this approach allows speeding up significantly the change detection process. A thorough analysis of index performance is planned.

- **New products** – a map of carbon sources and sinks in forest ecosystems modeled on Landsat TM scene (path 184, row 18 for 19 May 1992): (a) live forest biomass, (b) total ecosystem biomass (file attached). Virtually all forest lands were accumulating C in live biomass (mean rate 0.36 MgC ha⁻¹ yr⁻¹), however when the net change in total biomass store (live and dead) was considered, 19% of the forest area were a net source of C. The average net C sink in total biomass is quite weak (0.08 MgC ha⁻¹ yr⁻¹) and could be reversed by minor increases in harvest rates or a small decline in biomass growth rates.

PUBLICATIONS (peer reviewed)

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