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"Driving Forces of Change in Regional Carbon Stocks: Comparison of the Western Oregon, USA and St. Petersburg Region, Russia"

Principal Investigator: Olga N. Krankina
Department of Forest Science
Oregon State University
Corvallis, OR 97331
Phone: 541-737-1780; Fax: 541-737-1393
E-mail: krankinao@fsl.orst.edu

Co-Principal Investigators: Mark E. Harmon
Department of Forest Science
Oregon State University
Corvallis, OR 97331
Phone: 541-737-1780; Fax: 541-737-1393
E-mail: harmonm@fsl.orst.edu

Warren B. Cohen
USDA Forest Service
Pacific Northwest Research Station
Forestry Sciences Lab
3200 SW Jefferson Way; Corvallis, OR 97331
541-750-7322 (phone); 541-758-7760 (fax)
E-mail: Warren.Cohen@orst.edu

Ralph Alig
USDA Forest Service
Pacific Northwest Research Station
Forest Science Laboratory
3200 SW Jefferson Way; Corvallis, OR 97331
Phone: 541-750-7267; Fax: 541-758-7760
E-mail: ralig@fs.fed.us

Joseph Donnegan
USDA Forest Service
Pacific Northwest Research Station
Portland Forestry Sciences Laboratory
620 SW Main Street, Suite 400; Portland, OR 97205
Ph: 503 808-2053; Fax: 503 808-2020
E-mail: jdonnegan@fs.fed.us

ABSTRACT

Our past 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) Analysis of changes in land cover and land-use in both study regions using a time series LANDSAT images forms the basis of our examination of changes in carbon stores and the impact of socio-economic drivers on those changes (*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 test the degree 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 10-20-30 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 50%. The proportion of other themes that are covered in this project: Carbon – 50%, GOFC (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. We will revise, parameterize, run, test, and integrate the models to be used in our proposed regional comparison. The main emphasis will be on integration of socio-economic and ecosystem models and on analysis and interpretation of model output. In addition, we will compare our estimates of change in regional C stocks with those based on forest inventory data and examine the potential for integrating the two approaches.

The major focus of PIs in Year 1 was on compilation, synthesis, and publication of the results from the earlier stage of this project. The following are the additional “milestones” for Year 1:

- Extend the mapping of disturbance through ca. 2000 in both regions (completed for Western Oregon, in progress for the St. Petersburg region).
- Evaluate the agreement between the remote sensing data and results of forest inventories in both regions. The team felt it was important to conduct this comparison early in the project because these two sources of data form the basis of the set of ecological and economic models, respectively. The comparison is mostly completed with first results prepared for publication. Additional analysis will continue into Year 2 of the project.
- Re-program and test LandCarb – the work is underway and the prototype version is expected to run before the end of Year 1.
- Define with Russian consultants of their assignments. The discussion was initiated and the assignments will be finalized during the planned visit to St. Petersburg of two PIs: Olga Krankina and Ralph Alig.

STATEMENT OF PROGRESS

1. Comparison of Remote Sensing (RS) and Forest Inventory (FI) Data:
For **Western Oregon** we compared total forest area, age-class distributions of forests, and the area of stand-replacing disturbances for each inventory method. Results of this analysis showed that RS data mildly underestimate the total amount of forest area when compared to FI data (6.38 and 6.12 million ha, respectively). Larger discrepancies occur in comparing the two in terms of age class distribution of forestlands. The largest discrepancy was found for age class 0-9 years. Several factors contributed: classification and estimation errors in Landsat image analysis and uncertainty in FI-based estimates for age classes that are only found in isolated areas and for forestlands that were not inventoried regularly (about 20% of the total forest area). We also compared the reported area of clearcuts that were identified by RS data to Oregon Department of Forestry (ODF) data that are compiled from Oregon tax records. This analysis showed very agreeable results between the two data sources. The differences that did occur can be attributed to the timing of the RS images in comparison to annual summaries of tax records done by the ODF.

For the **St. Petersburg region**, RS and FI-based estimates of the total forest area compared favorably (4.92 and 5.57 million ha, respectively). RS estimate is greater because it includes parks, resorts, orchards, and some other lands that have tree cover but are not considered “forest” for the inventory purposes. The estimates of total C store in live forest biomass modeled from Landsat imagery were consistent with estimates derived from the regional summary of FI data for early 1990’s (272 and 269 TgC, respectively). The analysis of age-class distributions found differences similar to those in Western Oregon.

The results of our analysis indicated that both RS and FI data have their strong and weak aspects. RS data are invaluable in large-scale analysis as each unit of analysis (pixel) is categorized, but have shortfalls in overall classification strategies and accuracy. FI data are very strong in detailed stand level information but lacks in its ability to identify the overall diversity of larger landscapes and to represent forest attributes spatially.

2. Modeling changes in forest biomass for the St. Petersburg region. Stand-level model StandCarb (initially developed for the PNW) was parameterized for Russia using local data. Model output agrees well with test data, which is a chronosequence, developed from 216 thousand stand measurements (Fig. 1). StandCarb was used to simulate C loss and accumulation following clear-cut harvest in forest stands of low, medium, and high productivity. To map the spatial distribution of productivity classes across the region we combined two spatial layers previously derived from Landsat TM imagery: forest biomass and forest age. The trend-line for biomass over age (for a random selection of 900 pixels) is well aligned with the test chronosequence data (Fig. 1). Biomass divided by age (mean annual increment of biomass or MAI) was shown to be a good predictor of stand productivity for stands older than 20 years (Gower et al. 2001). We used MAI and age to assign each pixel to one of three productivity classes for ages >20 years (Fig. 2). Next step will be to use StandCarb projections of net change in live and total forest biomass for the full range of forest ages in three productivity classes to map C sources and sinks across the region.

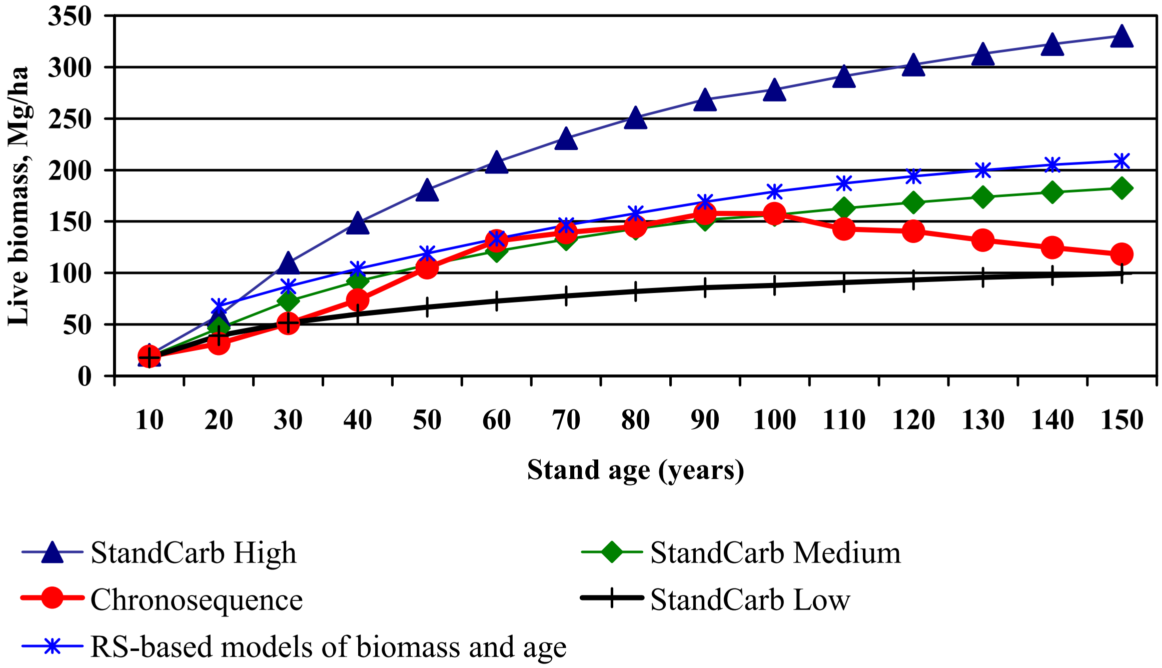

Fig. 1 Comparison of biomass estimates for the St. Petersburg region: StandCarb model (for high, medium, and low productivity levels), chronosequence of 216 thousand stand records (averages), and Landsat TM-based models of biomass and forest age (trendline from a scatter of 900 randomly selected pixels). All three estimates are independent from each other and appear to be in good agreement.

- New findings – we found good agreement between forest inventory and Landsat TM-based estimates of the total forest area in two contrasting study regions: Western Oregon, U.S.A. and St. Petersburg region in northwestern Russia. Forest inventories and remote sensing are the two principal data sources used to estimate carbon stores and flux for large forest regions. Reconciling the estimates from these two sources is the key to improving in large scale estimates of carbon stores and flux in forest biomes.
- New potential – StandCarb was parameterized and tested in a new and very different forest region. Now we have an operational tool for projecting changes of stand-level C stores for the St. Petersburg region similarly to what was done previously for Western Oregon
- New products – a map of forest productivity classes for the St. Petersburg region derived from two other Landsat-based models (forest biomass and forest age). In the absence of regional productivity maps, this product is critical for projecting changes in C stores.

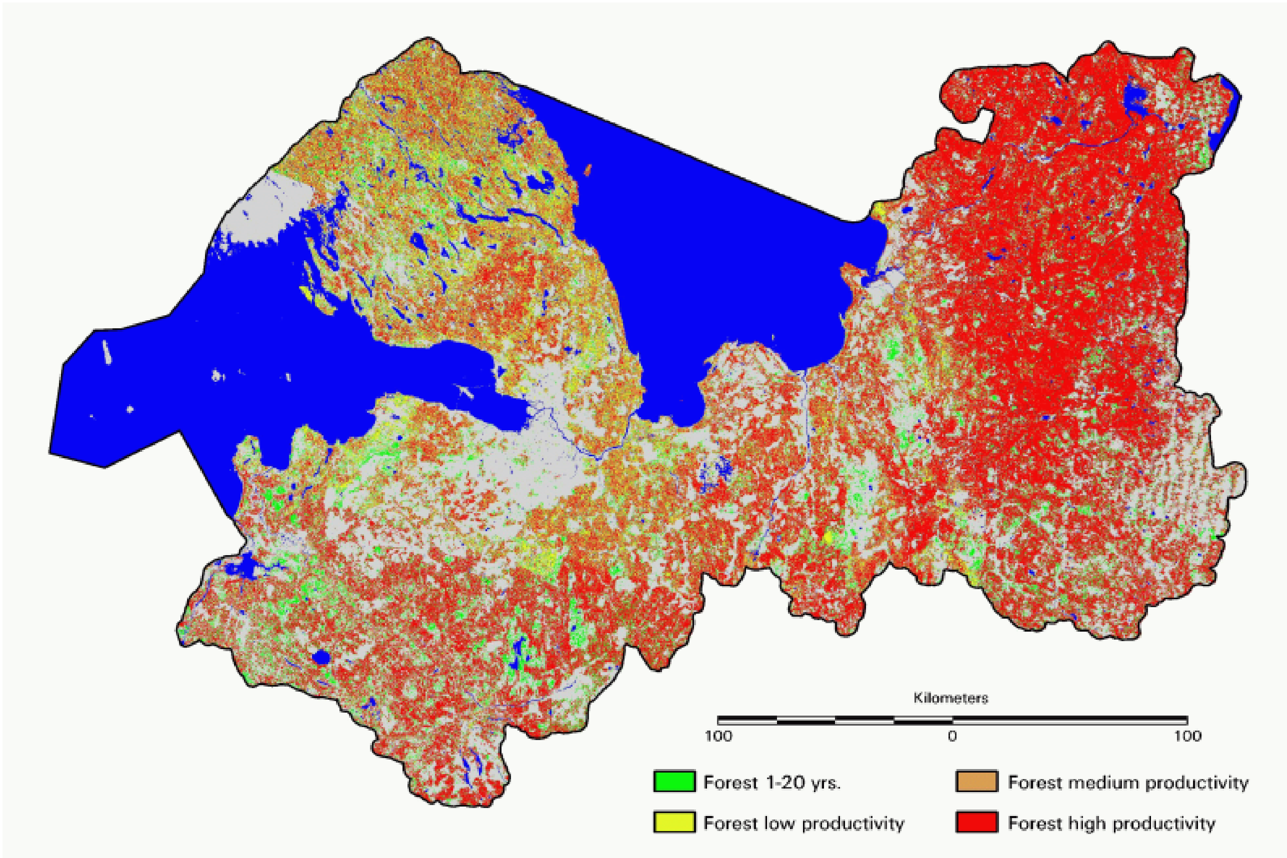

Fig. 2 Map of forest productivity classes derived from Landsat TM imagery. Mean annual increment of live biomass (MAI) was used as a measure of forest productivity for forests older than 20 years. Available ground data confirms relatively high biomass stores in the eatern part of the region. Full resolution map is available.

PUBLICATIONS

Cohen, Warren B., Thomas K. Maiersperger, Thomas A. Spies, and Douglas R. Oetter. 2001. Modelling forest cover attributes as continuous variables in a regional context with Thematic Mapper data. International Journal of Remote Sensing 22(12):2279-2310.

Cohen, Warren B., Thomas A. Spies, Ralph J. Alig, Douglas R. Oetter, Thomas K. Maiersperger, and Maria Fiorella. 2002. Characterizing 23 years (1972-95) of stand replacement disturbance in western Oregon forests with Landsat imagery. Ecosystems 5(2):122-137.

Harmon, M. E. and B. Marks. 2002. Effects of silvicultural treatments on carbon stores in forest stands. Canadian Journal of Forest Research 32:863-877.

Smithwick, E. A. H., M. E. Harmon, S. M. Remillard, S. A. Acker, and J. F. Franklin. In press. Potential upper bounds of carbon stores in forests of the Pacific Northwest. Ecological Applications.

D. P. Turner, S. Ollinger, M-L. Smith, O. N. Krankina, M. Gregory. Scaling Net Primary Production to a MODIS Footprint in Support of Earth Observing System Product Validation. International Journal of Remote Sensing (in review).

Alig, R. 2002. Global climate change, carbon, and forestry: Decision making in a complex world. In: Climate Change, Carbon and Forestry in Northwestern North America, eds. David L. Peterson and John Innes. USDA Forest Service Gen. Tech. Report (in progress). Portland, Oregon.

We also contributed to the paper that Kathleen Bergen is putting together for the Journal of Forestry: “NASA and Russian scientists observe land-cover/land-use change and carbon in Russian forests.”