MODELING SIBERIAN BOREAL FOREST LAND-COVER CHANGE AND CARBON UNDER CHANGING ECONOMIC PARADIGMS

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ABSTRACT

While change in political and economic structures is occurring in a number of countries worldwide, nowhere else recently has this occurred at the scale of the break-up of the state-controlled Soviet Union and its transition to a market economy. This event stands out in the magnitude of the change; it's rapid transition period, and the geographic extent and global impact of the potential effect, including its effect on the Siberian boreal forest. We hypothesize that these two different economic paradigms – state-controlled and market economy – may leave significantly different imprints on the land, and we propose to develop a case-study model of the contrasting economic drivers and of their past, present, and potential future consequences for land-cover land-use change and carbon in Siberia. **Goals and Objectives**: The goal of the proposed project is to develop a model of Siberian boreal forest land-cover land-use change and carbon that is linked to changing economic paradigms, and that is informed by remote sensing-derived analyses of change. To achieve this goal we will address four objectives: 1) develop an economic model of the factors affecting forests in Siberia over the past 70 years; 2) use time-series Landsat-derived datasets to develop land-cover land-use change matrices and transition probabilities, including their socio-economic spatial dependency; 3) add the carbon content to these land cover states through application of an ecosystems dynamics and carbon models; 4) combine these into an integrated model of land-cover land-use change in Siberia driven by rules associated with different economic paradigms. **Approach**: This project builds on previous work in remote sensing and modeling of Siberian forests specifically using time-series analyses and ecosystem models. We will build on this by using a new Landsat-7 dataset for three test sites in three of the most important administrative units in the Siberian forest sector: Tomsk Oblast, Krasnoyarsk Krai, and Irkutsk Oblast. We will derive land-cover transitions from time series remote sensing and link these to carbon content. We will develop models of the economic paradigms. Land-cover/use transition probabilities and associated carbon contents will be coded into a Markov-based simulation model and this model driven by different scenarios as based on the economic models. **Expected Results**: We will produce an economic model that expresses the institutionalized "rules" of the different paradigms that impact land-cover/use in Siberia. We will construct a time-series Landsat-7 dataset and different land-cover states at each time period and link these with carbon contents. We will integrate these model components into a new coupled model driven by the rules of the different economic paradigms. We will examine the model output in terms of land-cover land-use impacts of the different economic paradigms. This work will be useful for further understanding the relationships between land-cover land-use change and carbon, and economic policy in Siberia.

Keywords

Research Fields: Carbon Cycle, Change Detection, Forest Management
Geographic Area/Biome: Siberia, Far East, Boreal Forest
Remote Sensing: Landsat
Methods: Regional Scale, Time Series Analysis, GIS

A. NASA ESE Scientific Questions our project addresses all three of the following:
1) Changes in LCLUC, 2) Causes of LCLUC, 3) Consequences of LCLUC

B. Social Science Component:
25% of the project is directed at socioeconomic drivers of change in Central Siberian forests.

C. Themes Components:
Carbon – 25%, LCLUC Forest and Land-Cover Change – 50%, Socio-economic – 25%

D. Goals and Timeline for Year 1 and early Year 2 (U. of Michigan responsibility unless otherwise noted)

1. Remotely Sensed Data
- *a.* Identify and acquire time-series Landsat data for 3 case study sites. *Completed 1/02*
- *b.* Pre-process Landsat data. *Completed 4/02*
- *c.* Develop and perform classifications and forest land-cover change detection. *75% completed 7/02*

2. GIS Database for Spatial Analysis
- *a.* Digitize comprehensive GIS database for 3 case study sites from Russian 1:200,000 topographic maps: transportation, settlements, and hydrology. *Completed 7/02*
- *b.* Translate and attribute. *90% completed 7/02*
- *c.* Overlay accurately on satellite data. *Completed 7/02*

3. Socio-Economic Database
- *a.* Acquire socio-economic data for 3 case study sites. Acquire data from University of Michigan and Institute for Economics, Novosibirsk Akademgorodok. *Completed 8/02*
- *b.* Develop a database. *75% Completed 8/02*

4. Carbon
- *a.* Re-parameterize carbon models for Central Siberia (Shugart responsibility). *In-progress*

E. Issues:
Only one issue. Our thorough search of the Landsat database shows that there is not enough Landsat data for change analysis for the northern 1/2 of Irkutsk, Krasnoyarsk, Tomsk Oblast. We propose an alteration to our initial 3x3=9 case study sites per administrative unit, arrayed N-S.
- Focus on 3 regional case study sites, one in each Krai, each the size of a Landsat scene+.
- Instead of adding additional Landsat case study sites to scale over the region (we have chosen the best), we propose instead to scale more broadly by using MODIS data over the region of the three units. We will develop our plan to do this early in Year 2.

F. Approach/Methods and Modifications
a. Our case study site method that integrates time-series remote sensing data, GIS data for spatial analysis, and socio-economic data is working well for our 3 case study sites (each 185 km x 185 km)
b. Our hybrid Landsat (ETM+/TM/MSS) remote sensing change methods combining categorical and radiometric change analysis are working well and were presented at IGARSS 2002. These were developed by Bergen, Miller, and Kharuk.
c. Our data are being developed to be used in the TELSA/VDDT modeling environment and this is going according to plan.

Progress Narrative

Year 1 has focused on acquiring data, developing remote sensing, GIS, and socio-economic databases to form the basis for analysis, plus some preliminary analysis, especially of methods. We have developed the method we will use to perform forest and land-cover change analysis on hybrid (ETM+/TM/MSS) Landsat data 1975-2000. We have performed classification of all case study site land-cover for at least ETM+, part in cooperation with colleagues (Kharuk, Fedetova) at the Sukachev. We have presented these initial results at IGARSS 2002 Poster Session and IBFRA/GOFC. We have formed cooperative arrangements with our collaborators and both the Novosibirsk Institute for Economics and Sukachev Institute, and are actively working together. We have recently formed cooperative arrangements (with assistance of A. Shvidenko) with the regional forest management administration of Irkutsk Oblast. Prof. Bergen has arranged for two SNRE/CREES students to work on our NASA LCLUC project summer 2002 with the Novosibirsk group (Emmett, forest economics), and the Irkutsk group (Peterson, forest and ecosystem management). We have begun to code our model software (TELSA/VDDT) for forest dynamics, and our GIS and remote sensing data are close to ready to use for the spatial datasets.

Significant Progress:

- **New Infrastructure Product to Share:** Developed a comprehensive database of ALL usable Landsat scenes, 1972 to 2001 for Krasnoyarsk Krai, Irkutsk Oblast, and Tomsk Oblast (the most important forest sector units in Central Siberia) based on extensive searches of EDC and other data sites. We are actively developing this into a web-based database so that our colleagues (who have expressed interest) will have access to this.
- **New Potential:** Comprehensive, fine scale, GIS database of three case study sites in Central Siberia, developed from digitizing detailed 1:200,000 Russian topographic map series. Unusually rich database for spatial analysis on relationship between LCLUC and socio-economic and geographic infrastructure.
- **New Scholarly Product:** Development of a hybrid (ETM+/TM/MSS) method for change detection 1972-2000 using Landsat in Siberia based on one of our case study sites. **Manuscript for article in progress.**
- **New Scholarly Product:** Completion of a manuscript coordinated by Dr. Bergen and written by Bergen and ALL NASA LCLUC PRINCIPAL INVESTIGATORS WORKING IN RUSSIA plus primary Russian collaborators. Solicited article, under final review by **Journal of Forestry**. Review article of all LCLUC Russia projects, past and on-going (potential for outreach use; JOF has readership of 10,000 subscribers).
- **New Outreach Effort:** Dr. Bergen is the organizer of the GOFC Siberia/Far East Boreal Forest Workshop, held in our case study region in Krasnoyarsk, Siberia, August 2002 as part of the IBFRA conference.

Conclusions

We believe our GIS, remote sensing, and socio-economic dataset development has progressed according to plan and gives us a sounds database for Years 2/3 analysis and modeling. We hope that Year 2 will bring progress in the ecosystem/carbon modeling component of this collaborative study. Year 2 will also bring efforts in developing our integrated model for the case study sites. We have worked hard to build a research team that consists of U.S. faculty, students, and Russian collaborators at Institutes in Novosibirsk Akademgorodok, Krasnoyarsk, and Irkutsk. As an outgrowth of our LCLUC research we are involved in furthering the goals of NASA LCLUC/Carbon, GOFC, IBFRA, and NEESPI.

Peer-reviewed publications

Solicited article, under final review:

Bergen, K.M., S. Conard, R. Houghton, E. Kasischke, S. Kharuk, O. Krankina, J. Ranson, H. H. Shugart, A. Sukhinen, R. Treyfield. [2002]. NASA and Russian Scientists Observe Forest Land-Cover/Land-Use Change and Carbon in Russia. *Journal of Forestry*.