Second Annual Report

EFFECTS OF THE DEVELOPMENT OF THE BAIKAL-AMUR MAINLINE RAILROAD ON PATTERNS OF CARBON FLUX IN SOUTHERN SIBERIA

NASA Grant Number NAG5-6045
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August 15, 1999

(Note: Report by Co-PI H. H. Shugart follows)

1. Introduction

This document is the second annual report for Grant Number NAG5-6045 from ERIM International, Inc, titled *Effects of the Development of the Baikal-Amur Mainline Railroad on Patterns of Boreal Forest Cover and Carbon Fluxes in Southern Siberia.* During the second year of this project, ERIM activities were focused on three technical areas, as well as preparation of journal articles to document the results to date. These include: a) the BAM corridor: alternate coarse-resolution imagery and ancillary datasets (fire, carbon); b) analyses of land cover change in the Chuna River intensive site, Krasnoyarsk region; c) analyses of fire activity in the Gursky intensive site, Khabarovsk region and greater Russian Far East; d) Preparation of Tynda site data for analysis; and e) one published article and working outlines for two additional articles in process.

2. BAM Corridor

As reported in the year one annual report, the overall project was refined to focus primarily on several intensive sites along the BAM. This change in research strategy was a result of a review of the available Landsat image archives that revealed a significant scarcity in the availability of historical high-resolution imagery for the entire BAM corridor. We have, however, compiled some alternative data, which does cover the entire BAM corridor. This will provide a) a broader geographic context using coarse resolution imagery for our fine resolution intensive site analysis, and b) ancillary fire and carbon information also for the larger geographic region. AVHRR composites for the length of the BAM have been assembled for 1990 and 1995 using the available 10-day composites. Fire location data has been received for Krasnoyarsk Krai for 1987-1998 and the entire BAM for 1998 and 1999. An above-ground carbon map based on the IBFRA WHRC 1997 Forest Stand Carbon in Russia map (in turn based on forest stand carbon from Alexeyev and Birdsey, 1994) has been added to our database, and we are in the process of obtaining a soils database as well. These should allow us to have a much better regional context for fire and carbon studies at the intensive sites and to investigate some preliminary scaling up of our findings for the intensive sites to the larger region

3. Land Cover Change in Chuna River Site

The Chuna River Site, just north of the BAMRR and on the Chuna River in Krasnoyarsk Krai, is our focal site in the Biryusa River Basin (see first year annual report). This site was chosen because it is representative of the human and natural land cover disturbance in the region, specifically logging, insect damage, and fire. We were also able to assemble a good time-series dataset composed of multiple types of US and Russian imagery for this site.

The goal of our research at this site is to document the change in forest cover and carbon stocks due to human and natural disturbance, using multiple sensor time-series datasets. The remotely sensed dataset for the Russian Boreal forest necessitates the development of hybrid datasets and furthermore, of hybrid methodologies for analyses. We have: a) identified the types and sources of de-classified and civilian datasets which can form the most comprehensive time-series of remotely sensed data for the Chuna site 1965-1994; b) acquired these data and become familiar with them in terms of their spatial, spectral, geographic and time coverage qualities; c) extracted land cover change information using combined manual and automated processes; d) implemented new change detection algorithms (change vector analysis or CVA) on the time-series dataset; e) documented forest change 1965-1990 for this site; and f) combined this with data of above-ground carbon information.

The above analyses will allow us to create two unique data sets: (1) patterns of anthropogenic deforestation between 1965 and 1995 at 5 to 10 year time increments. Patterns of forest regrowth on areas that were deforested between 1965 and 1990. Note that validation data sets on the patterns of reforestation are being provided by our Russian collaborator on this project, Slava Kharuk of the Sukachev Forest Institute of the Russian Academy of Sciences. In turn, we are working with our collaborators from the University of Virginia (led by H. Shugart) to use this information in the development of an integrated carbon balance model.

4. Fire Activity and Change at the Gursky Site

In1998 one of the BAM intensive study sites, the Gursky region, was at the center of a historically significant fire season. Large fires occurred directly along the BAMRR. In addition to delineating and documenting the fires in our study area, we investigated the larger event in the Russian Far East using NOAA AVHRR data. The impetus for this scaling up was greater understanding of the causes, magnitudes (in terms of area burned), and severity, of fires occurring in the Russian far-eastern boreal forest and in our test site. This research was presented in an article, and demonstrated that boreal forest fires in Russia in 1998 covered a much larger area than originally reported by Russian statistics. Furthermore, they may have been mostly crown fires, which release more greenhouse gases into the atmosphere than surface fires. Our investigated area represented a significant portion of the Russian Far East and burn estimates stood at 5.7 million ha of fire scars. Initial government estimates of total fire area for the *entire* Russian boreal forest was 2.65 million hectares. This discrepancy generated considerable interest in the global fire community. Researchers working with AVHRR data downloaded at the

Irkutsk receiving station established by NASA have provided us with estimates of up to 8.3 million hectares burned for the greater Russian far east (Minko, Space Monitoring Center, Irkutsk, Russia). We will follow up this work by focusing on the carbon released at our Gursky site during from 1995 to 1999. We are in the process of compiling these data through working with a second Russian collaborator, Anatoly Sukhinin, who is using AVHRR data downloaded at the Krasnoyarsk receiving station established by NASA.

5. Land Cover Change at the Tynda Site

We have acquired Landsat TM and MSS data for the Tynda Site. We are in the process of accurately georeferencing these five images to scanned Russian 1:200,000 topographic maps. Upon accurate co-registration we will perform change detection analysis similar to those done for the Chuna River site.

6. Publications

This year we produced one published article and have working outlines for two additional articles.

a. "Satellite Imagery Gives Clear Picture of Russia's Boreal Forest Fires," Eos, Transactions, American Geophysical Union, Vol. 80, No. 13, March 30.

b. "Observations of Boreal Forest Cover Change in Central Russia Using Multiple Satellite Imagery." (In preparation).

c. Forest Regrowth in the Central Russian Boreal Forest: A Comparison of Remotely Sensed and Modeled Pathways 1965-1994 At a Site on the Baikal-Amur Railway. (In preparation with UVA).

7. Next Steps

The next steps we will focus on are:

a. Continue the investigation on the Chuna and Gursky sites. The results of the ERIM work will be combined and compared with the UVA modeling.

b. Investigate the remaining intensive site: the Tynda site.

c. Investigate BAM corridor information contained in AVHRR, carbon, and fire occurrence datasets.

d. Complete the journal article on land cover and carbon change at the Chuna River site using time series, hybrid remote sensing data.

e. Complete our part of the journal article on combined remote sensing and modeling methodologies for assessing human and natural-induced forest successional and carbon change over time in southern Siberian boreal forests.

f. Prepare final report and participate and present at annual meeting.

PROGRESS REPORT

Title of Grant

Effects of the Development of the Baikal-Amur Mainline Railroad
On Patterns of Boreal Forest Cover and Carbon Fluxes in Southern Siberia

Type of Report
Annual Report

Principal Investigator
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Period Covered by Report
8/1/98-7/31/99

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Grant Number
NASA NAG5-6043

Date Report Submitted
February 23, 2000

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We are modeling land cover and land-use change of boreal forests around the Baikal Amur Magistrate (BAM) railway at varying spatial resolutions, from stand to regional scales, to develop a nested set of models that can simulate potential changes in the structure/composition and mosaic patterns of boreal forests in response to continued development. A key element of the model is to incorporate species-specific physiology, morphology, and life history traits, as well as larger scale influences such as disturbance and climate change. This multiple-scale problem is approached using our nested set of models that can each contribute to assessing the land cover change at multiple scales, from individual trees to regional vegetation patterns, as these are influenced by climatic conditions, successional history, disturbance patterns.

The primary level of the model uses the individual-based model FORSKA2 (modified by DF Clark and derived from Prentice & Leemans) which is driven by climatic conditions and highly detailed individual species parameters. This model is a mechanistic forest gap model that was produced specifically for high latitude boreal forests in Scandinavia and has been applied to other boreal regions, in particular Canadian boreal forests. The output at this level includes numerous stand-specific attributes such as basal area, biomass, productivity, tree density and leaf area. These outputs are used to define composition and structure of forests at the stand level. We are running the FORSKA2 model at different locations within our study region where local climate profiles and potential species assemblages are used at each point to develop a better understanding of the successional dynamics of these forests. As we continue to produce data on the successional characteristics of the different forest regions, we are utilizing our local contacts in Siberia (e.g. Slava Kharuk) to help calibrate the model outputs. This step is critical since we often lack the specific forest inventory data that is typically used to verify model outputs. Model outputs at this level describe common forest successional trajectories as well as climax assemblages that occur in the various locations (i.e. major bio-climatic units) over the entire study region. These results are presently being produced and collated and will be fed into the next hierarchical model level, which operates at the landscape/regional scale.

Considering the scale involved in simulating forest cover change it is more practical to utilize stand-specific results from our mechanistic individual based model and use this as inputs into a regional-scale empirical land cover change model. Our regional-scale model uses differential equations to simulate succession, for example, vegetative cover categories (from juvenile to mature Sylvestris pine) were devised and vegetative cover is transferred from one cover state to another. Rates of change and transfers among cover states were established from model outputs at the primary level and then verified by available sources in the scientific literature as well as our local contacts as described above. We have also included other important ecological events such as disturbance from forests fires and insect outbreaks (i.e. Siberian silkworm). Fire parameters such as the fire frequency, fire severity and area burned are being used. The insect outbreaks are modeled using the following parameters: frequency, mortality (when possible) and severity (% relative defoliation). The empirical model and the mechanistic model described above are generally used in a serial fashion, however, we plan to couple the models directly so that they can be used more effectively in tandem.

Preliminary results from this model have been presented at various venues including the Ecological Society of America Annual Conference and at meetings by H.H. Shugart in Moscow. Future plans involve developing a proper coupling of the individual-based model with the regional scale model, continue to calibrate and validate model results and complete papers associated with this work. We are looking forward to presenting our modeling results in conjunction with the work of our collaborators at the LCLUC meeting this April 2000.