Annual Report for Year 1

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"Changes in Terrestrial Carbon Storage in Russia as a Result of Recent Disturbances and Land-Use Change"

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Annual Report for period 9/1/2001 to 8/31/2002

Objectives

The goal of the research is to determine the current distribution of carbon in Russian ecosystems and changes in that distribution over the last decades, using an approach that integrates forest inventory data, a combination of Landsat and MODIS data and products, results of ecological studies, and a carbon bookkeeping model. Investigators include R.A. Houghton, Tom Stone, Peter Schlesinger, and David Butman at the Woods Hole Research Center, Olga Krankina at Oregon State University, Warren Cohen of the US Forest Service, and Russian collaborators.

The project has three objectives. The first objective is to construct a map of forest biomass for the Russian Federation. The approach will use forest inventory data on wood volumes (biomass), at the vydel (or polygon) level, to calibrate Landsat data (30m spatial resolution). The forest inventory system in Russia has collected consistent and detailed stand level information on millions of hectares annually over the last decades. The large variation in carbon budgets constructed from these inventory data results from the manner in which the primary inventory data (data from individual stands) are aggregated for regional and country-wide estimates. The approach taken in this research will not use the aggregated totals but, rather, the primary stand data to calibrate Landsat TM scenes in 15 locations throughout the country. The 15 Landsat scenes will then be used to calibrate country-wide MODIS data (250m resolution). Theoretically, this will result in a biomass map for all of Russia.

The second objective is to construct a map of forest age. The approach will be similar to the approach for the first objective. Forest inventory data on age-since-last-disturbance will be used to calibrate Landsat TM data, and the latter will be used to calibrate MODIS data. The approach should yield a map showing where forests have been disturbed over the last 30-50 years. This approach based on inventory data will be supplemented with satellite data over 30 years that indicate the presence and persistence of stand-replacing disturbances.

The third objective is to construct a map of sources and sinks of carbon. For any particular set of environmental conditions, rates of carbon accumulation are a function of forest age (or current biomass). Age and biomass will be provided by the first two objectives Rates of forest growth following disturbance are being determined from forest inventory data, and rates of decay of dead plant material are being obtained from the ecological literature for the major ecosystems of Russia. These rates will be applied to the maps of forest ages and biomass to determine both the sinks of carbon in living vegetation (growth), woody debris (accumulation), and soil carbon development, and the sources of carbon from woody debris (decay) and soil organic matter following disturbance. A dynamic bookkeeping model (Houghton et al. 1999) will be used to calculate the annual flux of carbon to or from the atmosphere as a result of disturbances over the last decades. The work will identify, characterize and quantify sources and sinks for carbon (current and past) for this very large and important region of the world.

Progress in Year 1

Acquisition of data

"*It is amazing in how many ways a simple question*
can be misunderstood even when people speak
the same language...." Olga Krankina, June 10, 2002

The first step in this work was to determine the ground sites where forest inventory data and satellite data would be acquired. Three criteria are being used to select the sites: availability of ground data, availability of Landsat data, and coverage of the vegetation type (we want to sample those ecosystems with the greatest cover). We merged the Kurnaev ecosystem map with 4 simplified geographic regions to define 15 major types of ecosystems, in each of which we will select ground sites. This merged map is being combined with a map of Landsat data availability to try to identify sites that satisfy criteria 2 and 3; that is, ecologically significant sites where digital forest inventory can be acquired.

Olga Krankina visited The Woods Hole Research Center in November, 2001, to discuss the availability of ground data. The plan was to obtain Landsat data for the year 2000 at 15 sites throughout Russia and in earlier years for as many of the sites as possible. Olga has Russian collaborators with forest inventory data for the Kursk, Leningradsky, and Khabarovsky regions; additional data is being sought in Komi, Udmurtia, Magadanski, Olski, and Tyumenski regions.

Obtaining the Russian forest inventory data has been more difficult than anticipated. First, Russian foresters want a formal agreement that enables them to make certain data available. The negotiation of the agreements has taken time. Second, the first digital data to become available were not readable with *US Windows* operating systems because they had been written under the *Russian Windows* operating system, which uses

non-unicode fonts. It is not possible to decipher these fonts without a *Russian Windows* computer. We have arranged for subsequent data to come in Latin text characters

Processing of data

April 22 - 26, Houghton and Butman spent a week in Corvallis learning the procedure that Krankina, Cohen, and Oetter at Oregon State University used to map forest biomass for the St. Petersburg region. At the suggestion of Warren Cohen, we are in the process of looking at all the available and appropriate MODIS products to ensure that our choice of ground sites does not overlook a major forest or vegetation cover class. MODIS data have proven to be more difficult to work with than we had anticipated due to the constant influx of new and validated products. These products are the MOD09A1 surface reflectance, MOD43B4 BRDF product, and finally the MOD12Q1 land cover product. Butman worked closely with Doug Oetter of the Forest Science Laboratory at OSU to formalize the procedures for Landsat classification and continuous biomass modeling. Butman gained exposure to techniques in remote-sensing and regression analysis and established contacts at OSU that will be helpful as this project continues.

Upon returning to Woods Hole, Butman and Stone started the initial classification and regression analysis of the St. Petersburg region using available Landsat 5 TM data and available forest inventory data. This last effort is ongoing as more data become available.

Butman attended the June 3 – 4, 2002, 'MODIS Community Outreach On Land Cover' at the University of Maryland in College Park. It is our hope that we can clarify many of the current issues and discrepancies that have plagued our use of the MODIS Land Cover product thus far.

We have obtained all of the tiles for the provisional MODIS land cover product for Russia and mosaiked these together. We are also collaborating informally with Boston University's team and expect to receive from them, shortly, the validated release product. We are hoping to use this land-cover product to ensure that we are not missing important land covers in our selection of ground sites. Additionally, we have obtained all available tiles for MODIS surface reflectance data and are in pursuit of the provisionally validated bidirectional reflectance data to see if these data will be more useful than the surface reflectance data, regardless of resolution differences.

We have experienced significant difficulty in obtaining and processing MODIS data. The EDC archive is overwhelmed with data requests, and its data search system does not give consistent results. Searches must be conducted repeatedly for the same regions. Furthermore, trying to conduct research with provisional releases of MODIS is frustrating. When we think we have the proper version for the work, it is replaced by a new version, that requires the same amount of preparatory work as the product we just completed.

The MODIS re-projection tool (MRT) software for processing MODIS data has not been stable; MRT has undergone several critical revisions over the last year, necessitating our reprocessing of data. A new version, v. 2.3 was released in the last week of May. There is little support in the marketplace for the MODIS deliverable data format.

Participation in meetings

In mid-February, Peter Schlesinger attended a 3-day formal organizing session of the NASA-led Northern Eurasian Earth Science Partership Initiative (NEESPI) in Moscow and presented a talk on the status and plans of the NASA LCLUC science activity in Russia, as well as an overview of forest and carbon research products from research carried out on Russia at The Woods Hole Research Center over the last 10 years.

Immediately following the NEESPI meetings in Moscow, Peter Schlesinger attended the 5-day NASA Science Data Processing Workshop in Greenbelt, Maryland and gained a better understanding of the techniques for dealing with MODIS data files and their latest complex delivery formats (hierarchical data format -- HDF5). He was able to inform program leaders (apparently for their first time) of the need for MS Windows-compatible data processing products for Terra and Aqua images. At present, the only data processing software is operated exclusively under Unix.

Publications

We contributed to the paper that Kathleen Bergen is putting together for *Forest Science*: "NASA and Russian scientists observe land-cover/land-use change and carbon in Russian forests."

Work Proposed for Year 2

In Year 2 we will carry out the inventory – Landsat calibration in as many sites as possible --- we propose 10 (of the 15) sites.

The budget for Year 2 has not been changed from the budget initially agreed to: $266,109 for Year 2.

Problems that the program manager should be (and probably is) aware of:

There remain significant issues with the access and processing of MODIS datasets. The USGS Eros Data Center and other DAACs are swamped with data orders and cannot function in a timely fashion. There is much system downtime, and consecutive MODIS data searches, for example, give inconsistent results; we are working with EDC staff to try to improve DAAC search performance. As well, the web sites and information available about MODIS are so complex and redundant and differing across delivering agencies that finding the best and appropriate product for this NASA work is very difficult. Images released on NASA websites imply that high resolution data are available for those locations, but those same images in formats accessible to the user community cannot be found in the EDC archive. This remains a difficult situation. Projection issues of MODIS data (in Integerized Sinusoidal format) remain problematic. While there are a couple of US government-supplied software programs now that have been released to deal with this issue, only 2 off-the-shelf software vendors currently support the MODIS map projection.

Also of significance is the lack of appropriate digital linework and other map data for Russia LCLUC activities. For example, to date, there are no digital administrative boundary data sets available to NASA scientists at an appropriate resolution for working even with MODIS data. This is problematic because scientists are working with imagery appropriate to scales of 1:50,000, yet can only publicly access administrative data available at scales of 1:3 million. The World Vector Shoreline Plus product exists at 1:1,000,000 scale and finer, but it has not been married with an appropriately scaled Russian administrative boundary product to be useful for work in former Soviet regions.