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

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Abstract

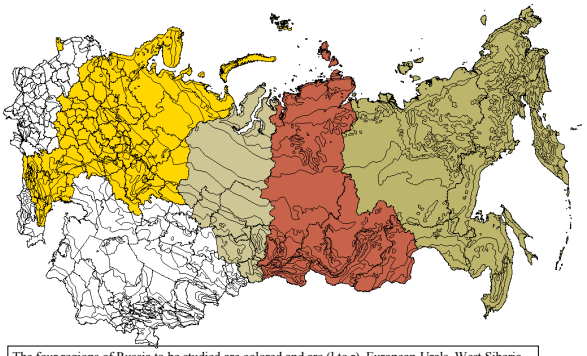
The carbon balance of northern mid-latitude terrestrial ecosystems is uncertain, yet important for predicting future rates of CO_2 increase in the atmosphere. Analyses based on atmospheric data and models show a net terrestrial sink that ranges between 3.5 and 0.7 PgC/yr in northern mid-latitudes (Tans et al. 1990; Ciais et al. 1995; Rayner et al. 1999; Bousquet et al. 1999a,b, 2000). Analyses based on forest inventories are lower but also variable, especially for Russia and the former Soviet Union, where estimates of carbon balance range between a source of 0.5 PgC/yr and a sink of 1.02 PgC/yr (review of 15 studies by Shvidenko et al. 1996). As Russia represents the largest political unit in the northern hemisphere and contains the largest stocks of terrestrial carbon (Apps et al. 1993, Dixon et al. 1994), it is important to determine the current carbon storage and the net flux of carbon for this country.

We propose to determine the current distribution of carbon storage in Russia and changes in that storage over the last decades with an approach that integrates forest inventory data, results of ecological studies, agricultural and forestry data on land-use change, and a combination of Landsat and MODIS data and products.

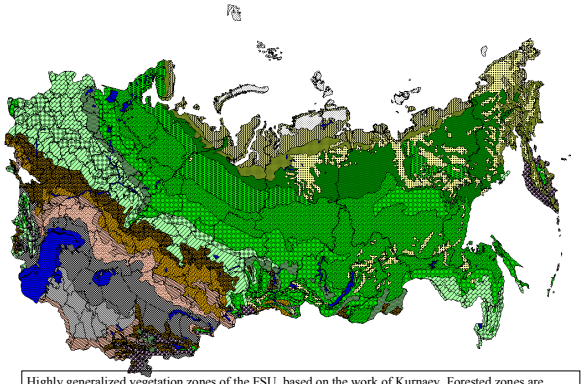
The forest inventory system in Russia has collected consistent and detailed stand level information on millions of hectares annually over the last decades. The large variation in carbon budgets based on these inventory data results from the manner in which the primary inventory data (data from individual stands) are aggregated for regional and country-wide estimates. We shall not use the aggregated totals but, rather, the primary stand data to calibrate Landsat TM scenes in 15 locations throughout the country. We will scale-up these Landsat classifications to the entire Russian territory with MODIS data, and use the coverage to determine the current rates of disturbance, based on the areas of disturbed forests (for example, clear-cut or burned) and rates of regeneration in each ecosystem.

We will also determine rates of land-use change for the period 1950 to 2000 with tabular data from Russian agricultural and forestry statistics and determine from forest inventory data and the ecological literature the average biomass and rates of growth and decay following disturbance of the major ecosystems of Russia. Finally, we will calculate with a dynamic bookkeeping model (Houghton et al. 1999) the annual flux of carbon between Russia and the atmosphere as a result of changes in land use and fire over the last decades.

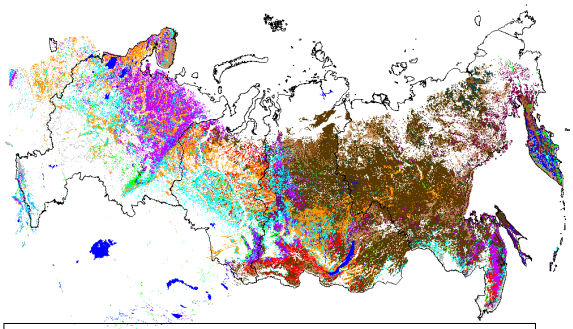
The proposed work addresses one of the priority issues of the USGCRP and a research area of the NASA ESE program for 2001 and beyond: Carbon Cycle Science. The work will identify, characterize and quantify sources and sinks for carbon (current and past) for a very large and important region of the world.



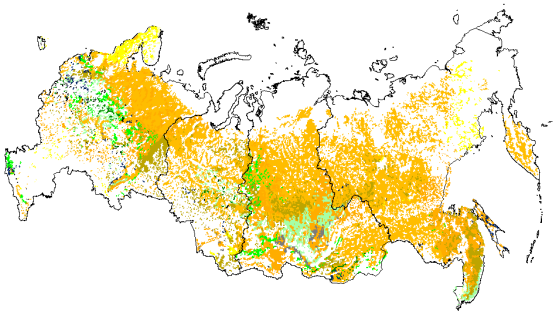
The four regions of Russia to be studied are colored and are (l to r), European-Urals, West Siberia, Central Siberia, and Eastern Russia. The white areas are parts of the Former Soviet Union. The west to east linear features are vegetation zones. Combining the regions and zones will be the basis for the stratification to used in the sampling.



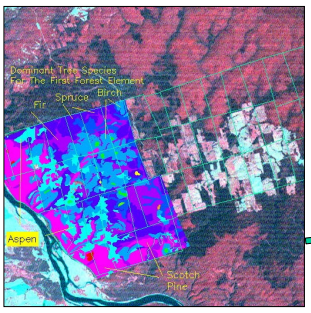
Highly generalized vegetation zones of the FSU based on the work of Kurnaev. Forested zones are green. The mixed forest (light green) and is common in European Russia and the Russian Far East. The brown zone is forest steppe(again mainly in European Russia) which grades south into steppe, Semi-desert and then the deserts of Kazakhstan (dark gray).



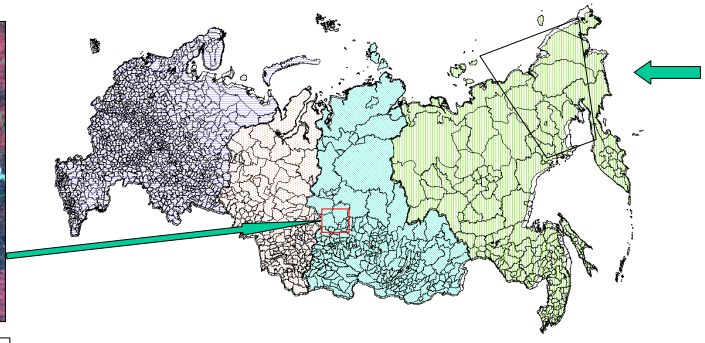
Forest cover map of the former Soviet Union (1990) adapted from Garsia. Primary species include Scots Pine (gold), Siberian Pine (red), Larch (brown), Spruce and Fir (magenta and purple), Birch (blue) and Aspen (green). Clearly, the vast majority of the forest of the former Soviet Union are in Russia, and the bulk of the Russian forest resource is in Siberia and is dominated by Larch.



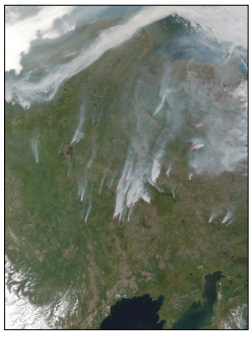
Forest stand carbon approximated by Alexeyev et al. In general, the darker the color the greater the carbon content of the forest. The data set was formed by merging the the forest cover map (left) with tree species data at the Kray or Oblast (territory) level from Alexeyev and Birdsey.



Landsat image with forest management polygons from Bolshoy Murta Leshoz, Krasnoyarsk, Siberia, Russia. Bright red areas in image are birch and aspen, dark areas are spruce and fir. Bright patches are recent clearcuts.



Fundamental data on forests of Russia are aggregated at several different levels. One level, the Leskhoz or forest management unit, divides Russia into about 2100 districts whose size varies, generally, with the value of the forest (stand volumes) and proximity to populations.



MODIS image of Khabarovsk, Magadan and Chukotka showing fires in a very sparsely forested region (Aug. 4, 2001)

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