MONITORING FOREST DYNAMICS IN NORTHEASTERN CHINA IN SUPPORT OF GOFC

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Principal Investigator: Dr. Guoqing Sun
Department of Geography, University of Maryland, College Park, MD 20742
Phone: 301-614-6655, Fax: 301-614-6695, ENAIL: gsun@glue.umd.edu

Co-Principal Investigators:
Dr. Darrel L. Williams
Biospheric Sciences Branch - Code 923, Goddard Space Flight Center, Greenbelt, MD 20771
Phone: 301-614-6692, E-mail: darrel.williams@gsfc.nasa.gov

Dr. J. Masek
Biospheric Sciences Branch - Code 923, Goddard Space Flight Center, Greenbelt, MD 20771
Phone: 301-614-6629, E-mail: jmasek@ltpmail.gsfc.nasa.gov

Co- Investigators and Collaborators:

Dr. K. J. Ranson
Biospheric Sciences Branch - Code 923, Goddard Space Flight Center, Greenbelt, MD 20771
Phone: 301-614-6650, E-mail: jon@taiga.gsfc.nasa.gov

Dr. Zengyuan Li
Institute of Forest Resource Information Techniques, Chinese Academy of Forestry, Beijing 100091
Phone: 86(10) 62889164 E-mail: lizy@info.forestry.ac.cn

Dr. Shuwen Zhang
Northeast Institute of Geography and Agricultural Ecology, Chinese Academy of Sciences, Changchun, China
Phone: 86(431)5542229, E-mail: zhangshuwen@mail.neigae.ac.cn

Prof. Lingli Tang
Remote Sensing Satellite Ground Station, Chinese Academy of Sciences, Beijing
Phone: 86(10) 62553662, E-mail: lltang@ne.rsgs.ac.cn

ABSTRACT

Some 30% of China's forest resources are concentrated in the northeastern provinces of Liaoning, Jilin and Heilongjiang, and the northeastern part of Inner Mongolia Autonomous Region. This area has seen tremendous change during the 20th century, ranging from widespread clearing for agriculture and timber in the early part of the century, to ambitious reforestation programs beginning in the 1970's, and the Natural Forest Conservation Program (NFCP) established by Chinese government following the disastrous floods of 1998.

To monitor the dynamics of the forests, this project is to map current forest cover using satellite remote sensing data, track the changes in forest cover during the 1990's, and initiate a GIS-based monitoring system to provide updated forest cover maps in the future. Remote sensing data (Terra-MODIS, Landsat) was used to map the current extent of forests in Northeastern China. The new forest cover maps from multi-temporal classification of MODIS data agree with aggregate statistics provided by the Chinese Academy of Forestry. We have also used Landsat imagery from 1990 and 2000 to estimate rates of forest clearing and regrowth. Our results suggest that during the decade of the 1990's forest cover in Northeastern China remained roughly stable, possibly decreasing by about 0.2% per year.

Significant deforestation has occurred locally, such as a result of agricultural conversion within foothills along the perimeter of the Manchurian (Northeast) plain and the grass-forest transition area on the west side of Da Xingan Ling mountains. Fire protection measures implemented after the 1987 fire have dramatically reduced the fire disturbances in this region.

The time-series of MODIS data in 2002 is being analyzed. The forest/land-use maps from different sources (Landsat, MODIS) and different methods will be compared and final base map will be established. The quantification of effect of forest change on carbon storage and cycle is also being analyzed.

OBJECTIVES

- Map current extent of forests in Northeast China using remote sensing data (MODIS, Landsat and SAR)
- Track the changes in forest cover during 1990's
- Initiate a GIS-based monitoring system to provide updated forest cover and change maps
- Quantify the potential effects of the forest changes on the carbon cycle during this period

QUESTIONS TO BE ANSWERED

- What are the changes in forest cover in NE China during last decades?
- How do the forest ecosystem respond to disturbances?
- What are the causes of the forest cover changes in this region?
- What is the impact of these changes on forest carbon storage in this region?

SIGNIFICANT RESULTS

Forest Type and Coverage Mapping with TERRA-MODIS, and Landsat-7 Data

MODIS 500-meter resolution, 16-day NDVI composites from June 2000 to November 2002 (MOD13A1 product) were acquired and re-projected for this region, and NDVI time series was used to classify forest extent. The MODIS product from 2000 and 2001 often contained bright and/or dark artifacts. To rectify these anomalies, several 'smoothing' methods were used. The temporal NDVI data from 2000 to early 2001 were classified into 255 clusters using ISODATA with 20 iterations. These clusters were then labeled by referring to 1:50,000 forest maps, Landsat-7 images, the Atlas of Forestry in China, and The 1:1000,000 Vegetation Atlas of China.

Land use maps from Landsat-7 ETM+ (slide 1), prepared by the Northeast Institute of Geography and Agricultural Ecology, Changchun China, were used to evaluate the accuracy of the MODIS forest cover classification (slide 2) in terms of the forest cover areas, and is was found that the classification accuracies are 92.63%, 79.01%, 69.00% and 87.87% for ever-green needle, deciduous needle, deciduous

broadleaf, and needle-broadleaf mix, respectively. The overall accuracy for forests is 79.76%. We also used the average mutual information (AMI) to compare the forest distribution patterns between the two maps. AMI is expressed as a percentage of the entropy of one map, representing how much information in the map can be predicted by another map. The results show that the MODIS classification and the L-7 ETM+ land-use maps share 86.4% of information on forest distribution patterns.

The MODIS data in late 2001, and 2002 have been reprocessed using new version of the re-projection tools, and are being explored for forest type and attribute mapping using phonological information.

Forest coverage within a 500m pixel was also mapped using multiregression model of MODIS 500m 16-day composite data (NDVI and MIR reflectance). The forest coverage map aggregated from ETM+ 30m land use map was used to test the results. The comparisons of 2400 random samples (800 each at north, south, and center regions) gives:

$F\_etm = 0.04+1.16\ F\_modis \qquad R^2=0.94$

where F_etm and F_modis are forest coverage from ETM+ and MODIS respectively. The F_etm tends to be high because ETM+ land use map was manually interpreted and every forest pixel was assumed of 100% coverage (Slide 3).

Forest Dynamics from Landsat data

Two approaches were used to examine rates of forest cover change during the 1990's for this study. First, the land-use maps for 1990 and 2000 from Landsat-5 and Landsat-7 multispectral images were used. The original 30-meter resolution maps were aggregated to a resolution of 25 Ha (500 x 500 m), with the numeric value of each pixel recording the percentage of forest-cover within each 25 Ha cell. Subtracting the two images reveals that forest area in Northeastern China reduced by about 2% during the 1990's (Slide 4). Expansion of agriculture from the central plain to the foothills, fueled partly by population migration from Southern China, has led to significant clearing in these regions. Large-scale clearing is particularly pronounced along the eastern edge of the Da Xingan Ling mountains, where entire hillsides have been deforested to make way for farming. In contrast, forest expansion is concentrated in the Chang Bai and Longgang mountain regions near the North Korean border. This region, which includes the Chang Bai Forest Preserve, is a locus of plantation forestry, where small plots of hardwoods and softwoods are continuously harvested and reseeded. Thus, there are systematic differences across the study area both in terms of the total area cleared, as well as the mean patch size of clearing.

As an alternative to the land-use map analysis, we have independently carried out radiometric change detection for a subset of the Landsat imagery in the Northeast China study region. Orthorectified Landsat-5 TM and Landsat-7 ETM+ images, roughly spanning the 1990-2000 epoch, were calibrated, processed to surface reflectance, and then radiometrically rectified using histogram matching . Radiometric change detection was carried out for each pixel, with "change" being discriminated by using the spectral angle between the two dates for that particular pixel. Deforestation and regrowth/afforestation were separated according to the direction of the spectral trajectories in the visible and shortwave-infrared bands. This analysis has been carried out for two regions: the Da Xingan Ling range near the border with Russia and Mongolia (Slide 5a), and the Chang Bai mountains near the Korean border (Slide 5b).

The net change calculated from both methods agrees well for both the Da Xingan Ling and Chang Bai regions (Table 1). Again, the Chang Bai region shows significantly lower rates of forest loss than the Da Xingan Ling region.

Table 1: Comparison of spectral-angle (radiometric) change detection with the land-use map analysis for the Da Xingan Ling and Chang Bai regions. All values are area of change (gain, loss, and net) in thousands of hectares.

	Spectral Angle Analysis			Landuse Map Analysis		
	Gain	Loss	Net	Gain	Loss	Net
Daxinganling	34.7	-133.8	-99.2	26.9	-139.7	-112.8
Changbai	33.8	-59.7	-25.9	174.8	-159.9	14.9

In summary, it appears that during the decade of the 1990's forest cover in Northeastern China remained roughly stable, possibly decreasing by about 0.2% per year. Significant deforestation has occurred locally, however, as a result of agricultural conversion within foothills along the perimeter of the Manchurian plain. It should be noted, however, that the results presented here only partly reflect the recent National Forest Conservation Program, which has led to decreased harvests in the Northeastern region since 1998. A follow-up study is required to assess the effects of the NFCP on forest cover since then.

PUBLICATIONS

Sun, G., L. Rocchio, J. Masek, D. Williams, and K. J. Ranson, Chracterization of Forest recovery from fire using Landsat and SAR data, Proceedings of IGARSS'02, June 24-28, 2002, Toronto, Ontario, Canada.

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