

Land-Use Change in Temperate East Asia: Land Cover Changes Impacts on Carbon Fluxes and Land Productivity

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This is a new project with a starting date of August 1, 2001.

Introduction

Land cover and land use changes in Temperate East Asia (TEA, including China, Mongolia, Japan, North Korea, South Korea, Japan, Russia's Siberia and the Far East) play an important role in regional earth system dynamics and the sustainable development of the region. In this project we propose to integrate geo-spatial technology (remote sensing, geographical information systems, and global positioning systems) and a biogeochemical model (CENTURY agro-ecosystem model) to evaluate the impacts of land use change and climate variability on carbon storage and fluxes, land productivity and biogeochemical fluxes in a sub-region of TEA, which includes the Mongolian Plateau in Mongolia and China and fertile Northern China (Fig. 1). The Mongolian steppe and fertile Northern China constitute one of the most productive agricultural regions of the world. The "Open-door" policy and economic reforms in China since the late 1970s have resulted in rapid and substantial changes in land use and land cover in Northern China. Large political, socio-economic, and land use changes also took place in Mongolia. Our analysis will incorporate information of the socio-economic transition taking place in the region which affect changes in land use and food security, and in ecosystem dynamics of the region (Fig. 2).

The overall objective of the project is to evaluate inter-annual regional ecosystem dynamics, and to develop better understanding of the factors which influence changes in land productivity, carbon dynamics, and other greenhouse gas fluxes from cropping and pastoral systems. Our research will be organized along four related tasks:

1. Data fusion and integration;
2. Land cover and land use change from mid-1970s to early 2000s;
3. Seasonal and inter-annual dynamics of land productivity; and
4. Synthesis and integration for assessment of land use and cover change.

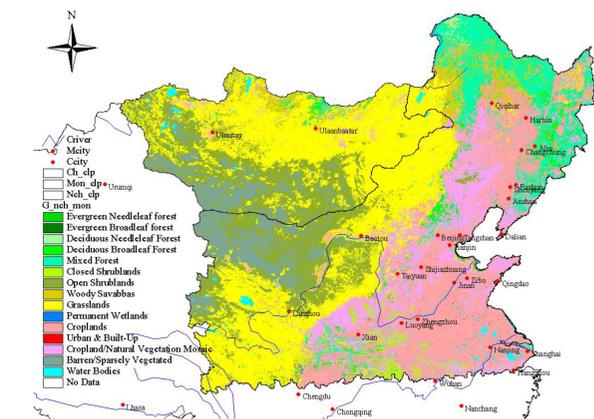


Figure 1. Map of Land Cover Classification in Northern China and Mongolia, which was derived from AVHRR data in 1992-1993 at the EDC.

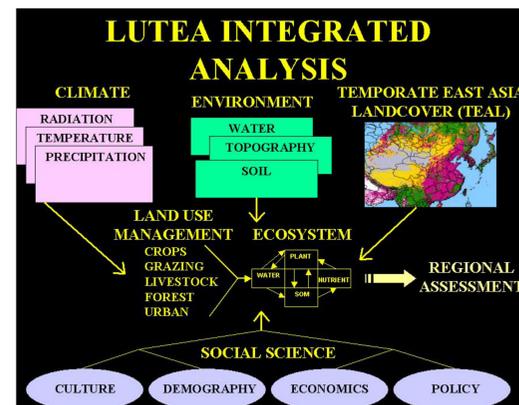


Figure 2. A schematic diagram for the integrated analysis framework

Data fusion and integration for developing a consistent geo-spatial database

We propose to use a geographical information system (GIS) to incorporate and manage remote sensing data, physical, ecological and social-economic information. The project will utilize the extensive information that exists on current land use practices and traditional land-use derived from existing research sites and databases of social-economic information and environmental gradients. Data will range from point data at specific sites through county-level statistics, to continuous data sets derived from satellite images of the region. Regional data layers will include historical demography (e.g., urban and rural population at county level), herding system, livestock and crop production values, and agricultural practice. Modifications to land use management due to policies, economic and market system will be incorporated into the regional data sets. Ecological datasets include digital elevation, land cover, soil, climate, vegetation, geology, grazing intensity, management, response of vegetation and soils to grazing. Site-specific data will come from the long-term ecological research sites in China and Mongolia and will include long-term records of weather and plant productivity, land use history and socio-economic trends.

Data availability will be facilitated through in-country collaborators at the Chinese Academy of Sciences (e.g., Institute of Geographical Science and Natural Resources, Institute of Botany), and the Mongolian Ministry of Nature and Environment. In addition to data exchange, international collaboration will also include joint field surveys and exchange of visiting scientists.

Available regional-scale datasets includes:

- (1). 1:1,000,000 scale maps for China, including Land Use Map, Grassland Resources Map, Vegetation Map, and Soil Map; Those maps were generated based on extensive field surveys in the 1970s and 1980s and interpretation of Landsat images and aerial photos.
- (2). county-level agriculture annual statistics in 1990 and 1995 for China.

We plan to provide gridded datasets (0.5 degree longitude and latitude) for transient climate, land cover, population change, land use statistics (e.g., area farmed, crop/livestock mixes, agricultural practice, yields, etc.), changes in land use, and economic factors for different agricultural enterprises. Climate change data will be developed for the region by applying monthly anomalies of recent general atmosphere-ocean circulation models (GCM) runs to the current weather data available for the region. The resultant climate change data will be used for projection of changes in land productivity of different land use types under a range of climate conditions.

We plan to distribute data products to the public through the internet, using the EOS-WEBSTER website (www.eos-webster.cs.unh.edu) that is a UNH-lead project under the support of the NASA Earth Science Information Partner (ESIP) Program.

Remote sensing analyses

Our objectives are (1) to provide consistent LCLUC datasets for initialization of biogeochemical models; and (2) to characterize seasonal dynamics and inter-annual variations of vegetation and grassland ecosystems with a focus on productivity and biophysical parameters. Image analysis and field work will be conducted at (1) intensive sites at the landscape scale, (2) along the IGBP Northeastern China Transect and (3) North China and Eastern Mongolia at the regional scale. Our remote sensing effort will include two related activities:

A. Land cover and land use change from mid-1970s to early 2000s

First, we will generate an updated baseline regional-scale database of land use and land cover for the year 2000 using multi-temporal image data from the SPOT VEGETATION (VGT) sensor. The database will also serve the Millennium Ecosystems Assessment. The VGT sensor provides daily images for the globe at 1-km spatial resolution and has four spectral bands: blue (430 - 470 nm), red (610 - 680 nm), near infrared (780 - 890 nm) and short-wave infrared (1580 - 1750 nm). We have already explored the potential of VGT data in 1999 for mapping and monitoring agriculture, grassland and forests in China (Fig. 3). We will also use MODIS data from 2001 for land cover mapping at 500m resolution.

Secondly, we plan to construct time series of LCLUC for selected sites, where rapid land cover changes have taken place over the last few decades. Fine-resolution Landsat images will be used for analysis, including Landsat (MSS, TM and ETM+) and ASTER images. One of those sites is the Xilin River Basin, Inner Mongolia, China (Fig. 4), where long-term ecological research has been carried out since 1979.

B. Seasonal dynamic and inter-annual variation of grassland productivity

We plan to use five-year VGT data from April 1998 to 2003 to characterize vegetation phenology, seasonal dynamics and inter-annual variation of land productivity. We will also explore the use of MODIS data in 2001 to 2003 to characterize vegetation phenology and seasonal dynamics of land productivity.

Image data acquisition plan:

- (1). Landsat MSS in mid-1970s; TM in late 1980s to early 1990s (centered in 1990); Landsat TM in mid-1990s; Landsat ETM in 1999/2000/2001 and ASTER in 2000/2001.
- (2). We already have VGT 10-day composite (S-10) data for the period of March 1, 1999 to November 30, 1999 for Asia and VGT daily synthetic product (S-1) data from November 1, 1999 to December 31, 2000 for the globe. We will acquire the VGT10-day composite (S-10) data from 4/1998 to 2/1999, 1/2001 to 12/2003.
- (3). We will acquire MODIS data in 1/2001 to 12/2003, including those standard products at daily, 8-day (MOD09A1) and 16-day (MOD43B4).

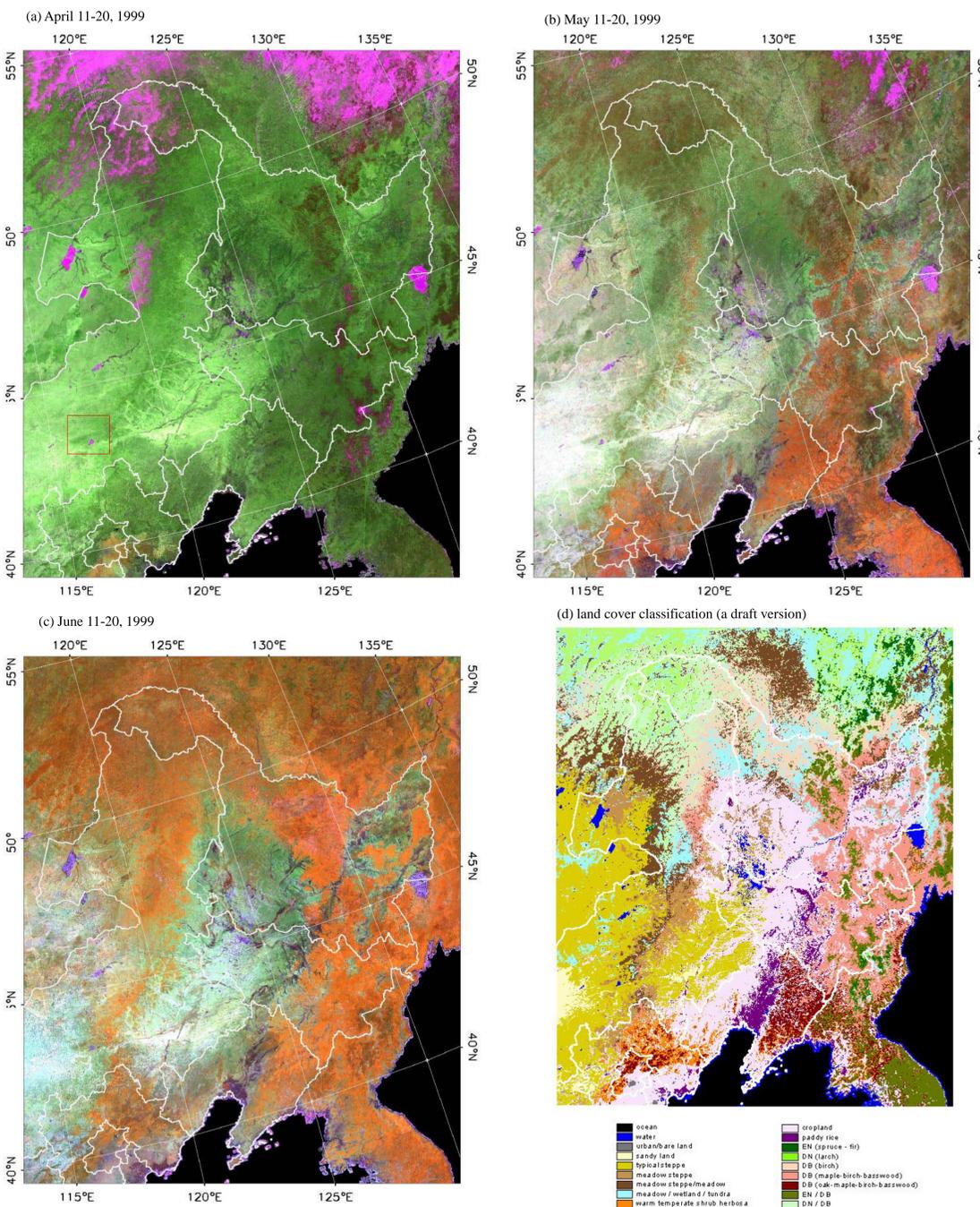


Figure 3. Seasonal dynamics of land cover in eastern Mongolia and North China, as illustrated by 10-day composites of VGT data in 1999. Figures (a/b/c) are false color composites: NIR - SWIR - RED bands (RGB). White polygons are the provincial boundary of China. The red box in (a) represents approximate location of the Xilin River Basin, Inner Mongolia, China. The IGBP Northeastern China Transect ranges from 42° N to 46° N and from 106° E to 134° E.

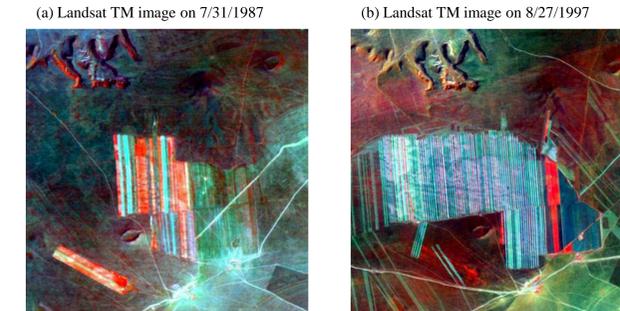


Figure 4. Land cover and land use change in a sub-region of the Xilin River Basin, Inner Mongolia, China from 1987 to 1997. These graphs are false color composites: TM4 - TM5 - TM3 (RGB). It clearly shows land conversion of grassland to cropland.

We also acquired a cloud-free Landsat TM image from 8/11/1991 and Landsat ETM+ image from 5/23/2000. We plan to classify those four images and quantify land cover change from 1987 to 2000 in the Xilin River Basin.

Long-term ecological research for grassland ecosystems in the Xilin River Basin has been carried out since 1979. Study sites include referenced plots for dominant grassland types in the region (*Lexmus chinense* formation, and *Stipa grandis* formation), recovery site and grazing sites of various livestock intensity). Accumulated long-term data of vegetation, productivity and soil will be used for parameterization and calibration of the CENTURY model.

Simulations and synthesis of biogeochemical models

We will use the CENTURY agroecosystem model to simulate plant production, soil fertility, water availability, livestock grazing effects, and agro-ecosystem dynamics at various spatial and temporal scales. Cropping and rangeland management practices are implemented by scheduling various management events during a simulation (Fig. 5). The events are scheduled to occur in a particular month. The suite of events simulated by the CENTURY model including planting, tillage, fertilizer applications, organic matter additions, irrigation, harvesting, weeding, burning, and grazing. The CENTURY model will be integrated with the GIS database; the resulting modeling framework will allow us to conduct analyses across spatial scales of site, landscape and region.

We plan to conduct a series of GIS-CENTURY simulations to match the identified major land use systems within agricultural and rangeland regions in our study area. The time period we plan to make the simulations will cover the past 30 years, which match the existing data available from country statistics and remote sensing observations. Comparison of seasonal dynamics of these different land use types to remote sensing observations from VGT and MODIS will be carried out to evaluate the contribution of different land use classes on spectral observations retrieved from the satellites.

In addition to simulation of contemporary land productivity, we will simulate the effect of potential climate change scenarios for the region. We will not attempt to project changes in land use practices directly, but will assess the response of a suite of likely land use practices within a region under the projected climate scenarios. The trends in the various land use systems will provide an indication of the climate-driven productivity in various regions of Asia. The evaluation will provide an indication of what land use systems will be more vulnerable or stable relative to different climate change scenarios.

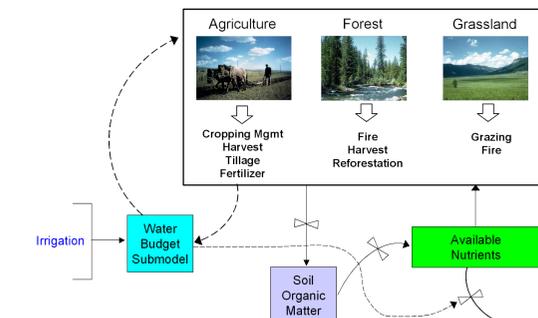


Figure 5. A simple diagram to illustrate various management practices that are already implemented by the CENTURY model.

Acknowledgements:

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Related Reference for analysis of VEGETATION sensor data:

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- Xiao et al., land cover classification of Northern China using multi-temporal SPOT 4 VEGETATION data (in preparation for Remote Sensing of Environment)