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

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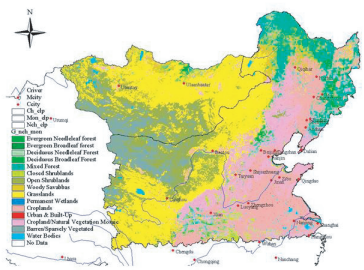
ABSTRACT

Land use/cover changes in the Temperate East Asian (TEA) region play an important role in regional earth system dynamics and the sustainable development of the region, therefore, accurate determination of land cover in the region is critical. Current concerns about the environmental degradation and their impact on human welfare are the focus of analysis and research in this project.

Our overall objective is to evaluate inter-annual regional ecosystem dynamics in the temperate East Asian region of northeastern China and Mongolia, and to develop a better understanding of the factors which influence changes in land productivity, carbon dynamics, and other greenhouse gas fluxes from cropping and pastoral systems. In this study we are integrating remote sensing technologies; spatial and temporal analysis of physical, ecological and social-economic information; and modeling to evaluate the impacts of land-use changes and climate variability on carbon fluxes, land productivity, and biogeochemical fluxes in a subregion of Temperate East Asia.

The analysis incorporates information about the socio-economic transitions taking place in the region, which affect land-use, food security, and ecosystem dynamics of the region. The region of study extends from the Mongolian plateau in Mongolia and China to the fertile northeast China plain.

STUDY AREA NORTHERN TEMPERATE ASIA



OVERALL OBJECTIVE

Our overall objective is to evaluate inter-annual regional ecosystem dynamics in the temperate East Asian region of northeastern China and Mongolia. and to develop a better understanding of the factors which influence changes in land productivity, carbon dynamics, and other greenhouse gas fluxes from cropping and pastoral systems. Specific objectives include:

•Assess changes in land-cover and use on carbon fluxes in managed and less managed ecosystems relative to demographic and socio-political conditions in northeastern China and Mongolia regions.

•Analyze the implications of land-use change on food productivity, carbon storage and fluxes, climate dynamics, and ecosystem integrity which affect sustainable social welfare in the region.

RESEARCH TASKS

The integrative analysis of remote sensing, ecosystem modeling, climate variability, and land-use management provides a method to study the complex interactions. Our research will be organized along three related tasks:

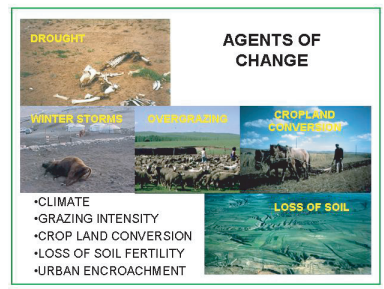
1) land-cover and land-use changes at fine spatial resolution from 1970s to early 2000s: use of TM data for land-use change detection in China and Mongolia;

2) seasonal and inter-annual dynamics of land productivity from various land use systems of the Mongolian Plateau using MODIS and AVHRR data sets and ecosystem modeling for the region.

3) synthesis and integration for assessment of land-use and cover changes: assessment of global environmental and policy related impacts on land productivity and ecosystem responses of the region.

AGENTS OF CHANGE

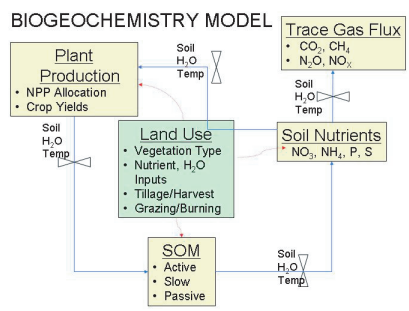
This region of Asia experiences high variability in weather patterns resulting in losses due to drought or winter storms. In addition, recent events during the past decade have altered the economic and policy decisions in the region and may constrain nomadic movement patterns or enhance movements due to changing availability of technological assistance. Grassland conversion to dryland and irrigated cropland have taken place in various parts of the region. These policies not only reduced the amount of rangeland available for livestock production, but they have also increased grazing intensity. Cultural integrity and traditional land-use practices used historically have been diluted or destroyed with this influx of non-indigenous people.



Due to increasing population, industrialisation, and urbanization; the demand for land resources has been growing. During the past century, natural ecosystems such as forest, grassland and wetlands have been encroached by farmland and other man-made ecosystems on a very large scale. In addition, rapid development of industrial economy and expansion of urbanization in North China Plain have reduced cropland areas. This has also generated a tremendous demand on water resources, which has caused a further shortage for agricultural irrigation, resulting in a decline of irrigated land since the late 1970s.

MODEL

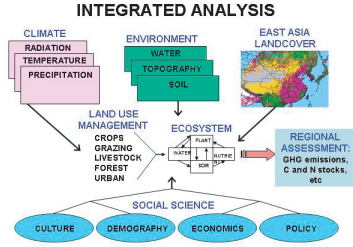
In order to study the factors controlling land productivity, soil organic matter and agro- ecosystem dynamics of different land use systems, the CENTURY and DayCent models are being used. Cropping and rangeland management practices are implemented by scheduling various management events during a simulation. The events are scheduled to occur in a particular month. The suite of events simulated by Century (and in DayCent) include planting, tillage, fertilizer applications, organic matter additions, irrigation, harvesting, weeding, burning, and grazing. For each of the management practices, options can be defined that represent differential effects of various user defined alternatives. The DAYCENT ecosystem model simulates exchanges of carbon, nutrients, water, and trace gases among the atmosphere, soil, and plants. DAYCENT is the daily time step version of the CENTURY model. Daily resolution is necessary to accurately simulate trace gas fluxes to and from soils because the processes that are responsible for trace gas fluxes respond non-linearly to important controls such as soil water content.



INTEGRATED ANALYSIS

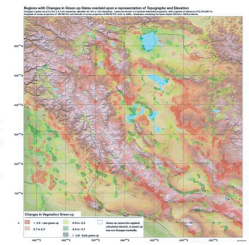
We have model-data framework to provide several sets of products which will be useful to the scientific community and policy makers alike. The types of products fall into the category of data fusion products, remote sensing analysis over space and time, model analysis of land productivity, and methodological approach for integrating this set of information which can be used by scientists and policy makers. The data fusion products will provide a set of physical, ecological, and social data sets which will serve as the basis of our analysis of land use change. The data products will of themselves be an important source of information on changes in the region.

INTEGRATED ANALYSIS



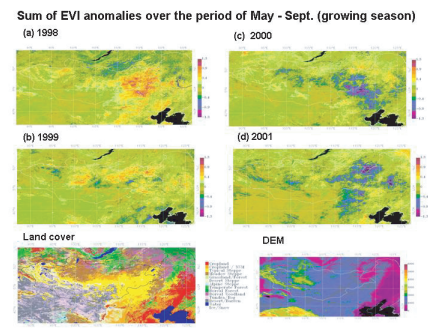
SEASONAL SHIFTS BASED ON NDVI

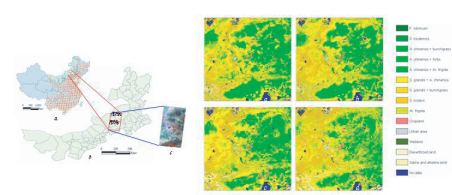
Seasonal shifts in ecosystem dynamics are detected using 20 year data sets of AVHRR. It appears that many of the Mongolian grassland ecosystems are experiencing later green-up especially on the south-facing slopes of mountain ranges.



INTERANNUAL CHANGES IN ECOSYSTEM DYNAMICS BASED ON EVI ANALYSIS

Calculations of EVI using VGT data are useful to indicate interannual changes in ecosystem dynamics associated with productivity over the North Asian Plain. The drought of 2000 and 2001 are dramatically detected in the images on the left.





Optimized Land use/land cover classification (14 classes) of Xilin River Basin
Data source: Landsat TM/ETM+ sensor data, band 1, 2, 3, 4, 5, and 7
a. Jul 31, 1987; b. Aug 11, 1991; c. Sep 27, 1997; d. May 23, 2000

Land use/cover type	1987	1991	1997	2000	1987-2000 Change in area (km²)	1987-2000 Change rate (%)
F. Sibiricum steppe	713.6	561.1	273.7	188.1	-525.5	-73.6
S. baicalensis steppe	388.9	370.0	253.5	187.4	-201.5	-51.8
A. chinensis + *forbs* steppe	5281.2	4604.3	3191.2	2942.6	-2338.6	-44.3
A. chinensis + *bunchgrass* steppe	2631.8	2373.5	2035.5	1805.7	-826.1	-31.4
A. chinensis + *Ar. frigida* steppe	463.2	714.6	1874.4	1436.5	973.3	210.1
S. grandis + *A. chinensis* steppe	4065.5	4076.3	4068.9	4309.1	243.6	6.0
S. grandis + *bunchgrass* steppe	2330.5	2136.3	2210.9	2238.1	-92.4	-4.0
S. krylavii steppe	3196.4	3813.4	4109.6	4479.1	1282.7	40.1
Ar. frigida steppe	952.1	1317.5	1597.7	1997.7	1045.6	109.8
Cropland	114.3	154.3	296.1	332.1	217.8	190.5
Urban and residential area	25.2	29.2	33.6	43.6	18.4	72.6
Wetland	177.5	154.9	205.2	60.5	-117.0	-65.9
Desertified land	246.0	282.3	447.1	554.9	308.9	125.6
Saline and alkaline land	139.4	138.0	128.3	150.3	10.9	7.9

CONCLUSION

Large changes are detected in grassland and cropland areas in the Northern Asia due to high climate variability. Changes in land use and economic policies have exacerbated the situation by altering the land use intensity and grazing intensity of the region. Desertification, sedimentation of rivers, and degradation of natural resources have resulted in response to this land use intensification in this region.

Remote sensing and model analysis provides a regional methodology to evaluate the impact of climate variability and land use on ecosystem productivity.

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