Impacts of Land Use/cover Changes on Net Primary Productivity in the Sanjiang Plain, China

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Outline

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- Study area
- Data and methods
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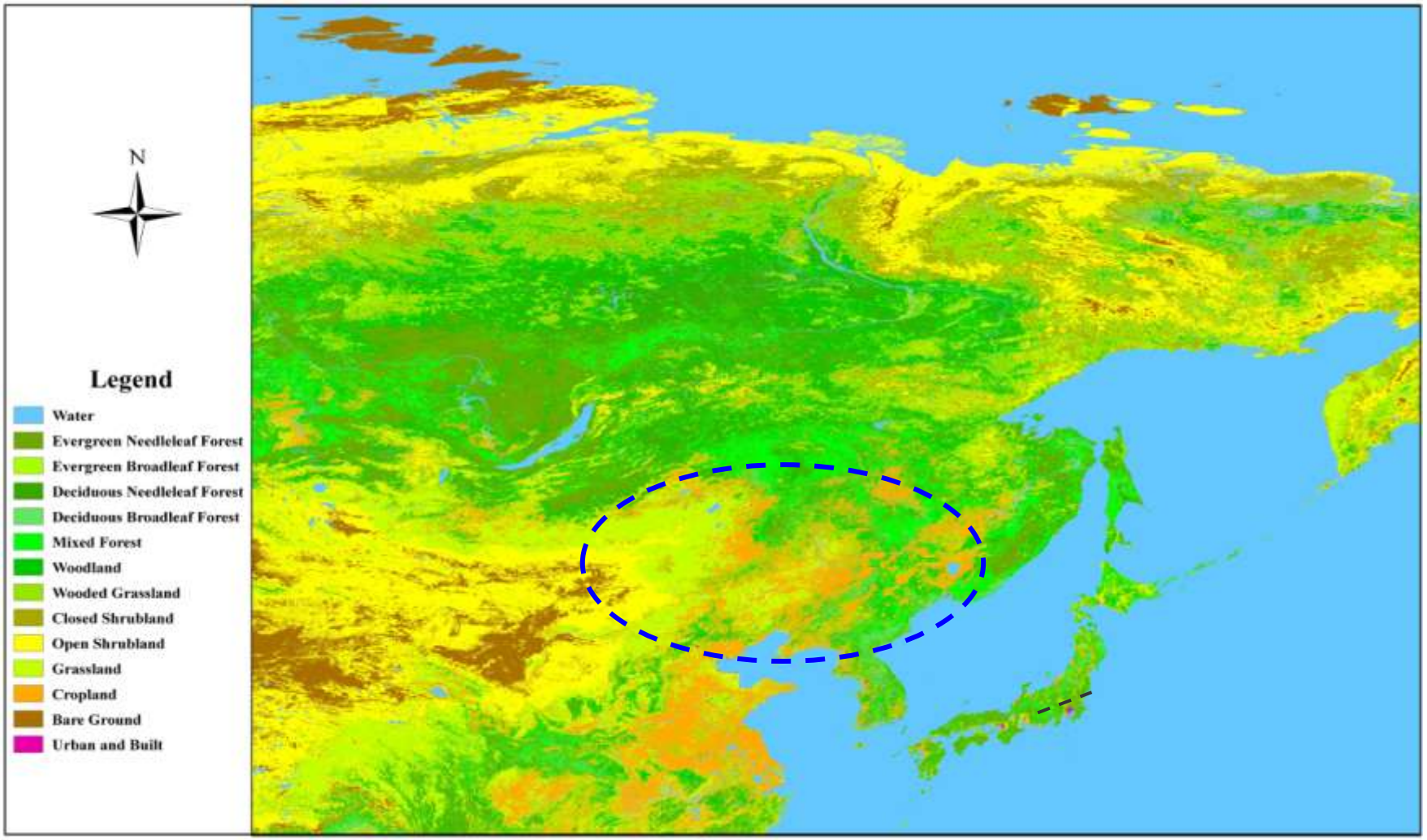
- Effects of land use/cover changes on NPP
- Conclusions

Northeast China → the Amur River Basin → Northeast Asia

Northeast Asia



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Introduction

■ Land use/cover changes result from the alterations of the earth's surface by human beings (Turner II et al., 1994). Land-use and land-cover changes play a vital role in environmental and ecological changes. They are the primary sources of soil degradation, and by altering ecosystem services, they affect the ability of ecosystem to support human needs (Vitousek et al., 1997).

■ In this paper, we focus on regional ecosystem net primary productivity (NPP). The energy flow in ecosystems starts at solar energy fixed by primary production of plants through the process of photosynthesis, and between 10% and 55% of the annual products of photosynthesis are appropriated by human beings (Rojstaczer et al., 2001). NPP is the primary source of food for humans and other heterotrophic organisms.

■ The objectives of this study are:

(1) to validate MODIS NPP products in Sanjiang Plain;

(2) to examine the impact of land use/cover changes on variation in regional net primary productivity during 2000-2005.

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Introduction

As an important parameter of ecosystem functioning and the carbon cycle, NPP could be used as a "common currency" for quantifying the impact of land transformation across a broad spectrum of issues in earth science and global change research (Imhoff et al., 2004). Estimating NPP at landscape, regional, continental and global scales under the influence of land use/cover changes is crucial not only for carbon cycle research but also for government decision-making and regional management.

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Introduction

During the past century, Sanjiang Plain suffered environmental degradation:

■ **From the early 1900s to 1930, Russian invaders（俄国侵略者）robbed large numbers of forest resources and led to ecological degradation.**

■ **From 1931 to 1945, Japanese invaders (日本侵略者） robbed all kinds of natural resources, colonize, and led to severe environmental issues.**

■ **From the end of the 1950s to early of 1990s, a number of large farms were built concomitant with the loss of wetlands. Now, it is one of the main food and agricultural bases of the nation. Due to Large-scale agricultural development, nearly 80% of freshwater wetlands in Sanjiang Plain had been reclaimed during the past decades.**

■ **From the end of 1990s to nowadays, many environmental restoration projects were conducted.**

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Introduction

Forest distribution in the Sanjiang Plain during the past half century

1898

1954

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Introduction

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Introduction

Wetlands reclamation (1950s)

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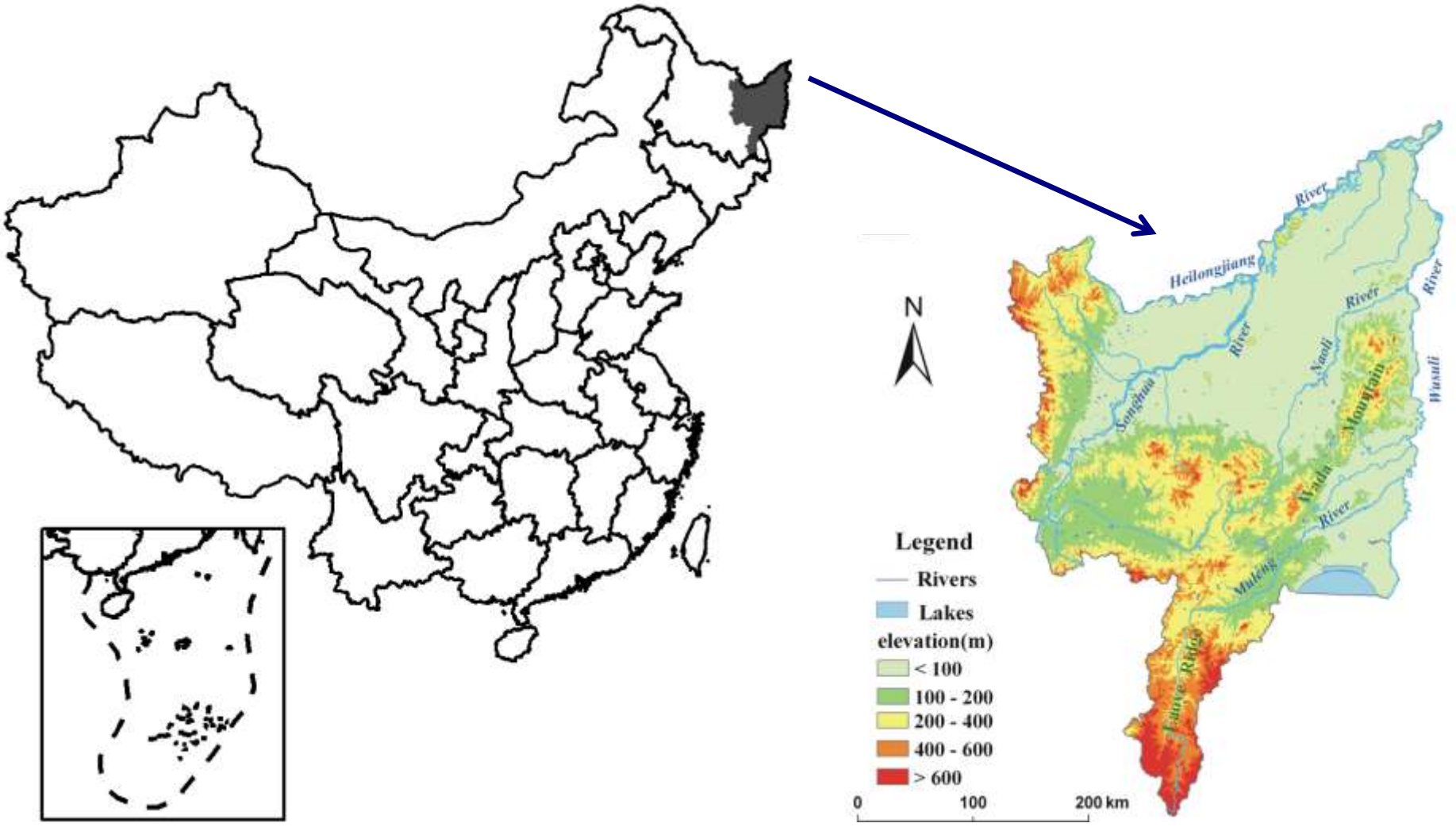
Study area



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Study area

■ **Sanjiang Plain (Three-River Plain) lies 129° 11′ E to 135° 05′ E, and from 43° 49′ N to 48° 27′ N, with a total area of 108 829 km^2. Its elevation in the southwest is higher than that in the northeast. The climate in this area belongs to the temperate humid or sub-humid continental monsoon climate.**

■ **The mean annual temperature ranges from 1.4 to 4.3 ° C, with average maximum of 21-22 ° C in July and average minimum -18 ° C in January. The mean annual precipitation is 500-650 mm and 80% of rainfall occurs between May and September. The frost-free period is 120-140 days.**




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Data and methods

■ **Land-cover in 2000 was acquired from 12 scenes of cloud-free Landsat Themetic Mapper (TM) data. Land-cover information in 2005 was acquired from cloud-free 26 China-Brazil Earth Resources Satellite (CBERS-1) data with a resolution of 23 m.**

■ **Land cover maps for 2000 and 2005 were derived showing seven land cover types: (1) marsh, (2) cropland, (3) woodland, (4) grassland, (5) water body, (6) residential land, and (7) barren land. The accuracy of the two land cover maps interpreted from remote sensing images exceeded 87% (89.7% for 2000, and 92.6% for 2005). The results indicate that more than 94% of the polygon boundaries show a shift less than 1.5 pixels (45 m) from the real boundary (Song et al., 2008).**

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Data and methods

■ **Maps of net primary production (NPP) (MOD17) were derived from moderate-resolution imaging spectrometer data (MODIS) at website of http://edcimswww.cr.usgs.gov/pub/imswelcome.**

■ **The MOD17 products are freely available as part of the NASA Earth Observing System (EOS) along with several other global vegetation products (Running et al., 2004). With the completion of MOD17 v4.5, several improvements (most importantly, higher-resolution climatology inputs) are apparent, and the data have greater utility for regional- and local-scale studies. MOD17 v4.5 has been tested and used for numerous applications (Running et al., 2004; Zhao et al., 2005; Turner et al., 2006).**

$$\frac{APAR}{PAR} \approx NDVI = \frac{NIR - Vis}{NIR + Vis}$$

$$GPP = LUE \times NDVI \times PAR$$

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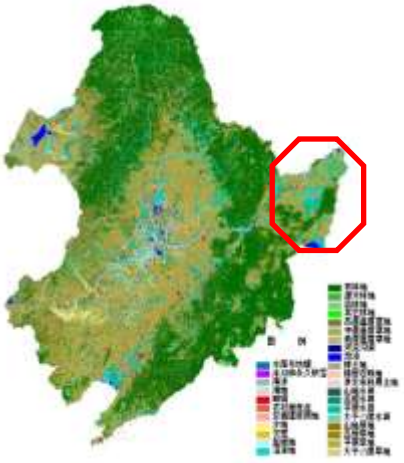
Land use detection

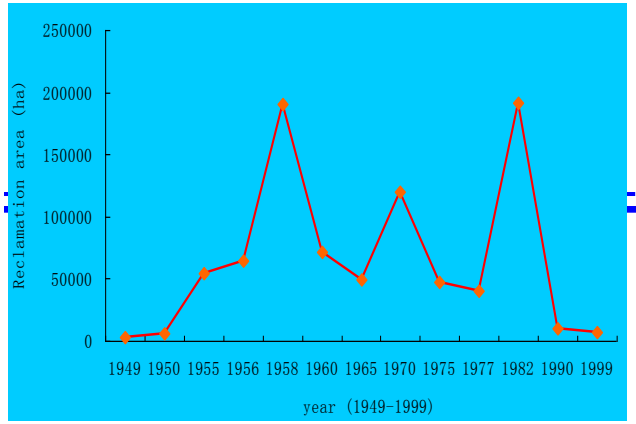
■ Results indicated that, cropland was the largest land use type in the study area. During the period 2000-2005, cropland, residential land and barren land increased, while woodland, grassland, water body, and marsh had decreased correspondingly, among which woodland, grassland and marsh had the most dramatic decrease.

■ During 2000-2005, cropland had an area increase of 43.28×10^4 hm^2 or a change ratio of 7.8%. In contrast, the area of woodland, grassland and marsh decreased by 15.04×10^4 hm^2, 13.98×10^4 hm^2 and 14.88×10^4 hm^2. It was concluded that the considerable increase in the cropland area resulted mainly from the unreasonable reclamation of woodland, grassland, and marsh.

	Cropland	Woodland	Grassland	Water body	Residential land	Barren land	Marsh
Area in 2000 (hm^2)	5568845	3442328	419992	280201	211433	1433	958716
Area in 2005 (hm^2)	6001600	3291915	280146	277978	217832	1806	809891
Change (hm^2)	432755	-150413	-139846	-2223	6399	373	-148825
Change rate (%)	7.77	-4.37	-33.30	-0.79	3.03	26.03	-15.52

Changes of each land use/cover type in the Sanjiang Plain（2000-2005）

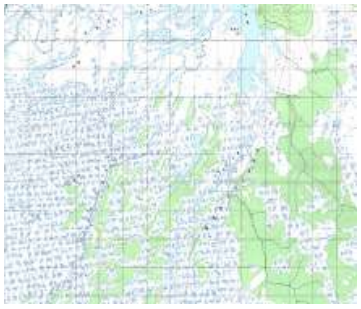


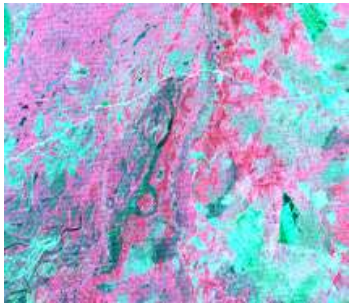


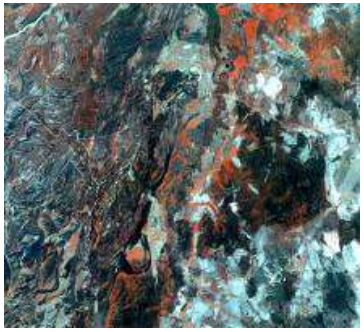
Reclamation area in the Sanjiang Plain

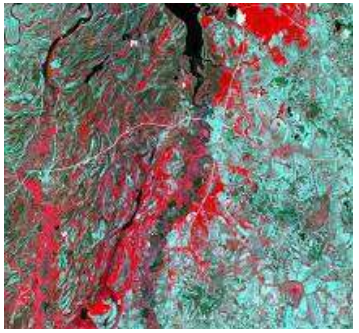
Natural wetlands

Reclaimed croplands





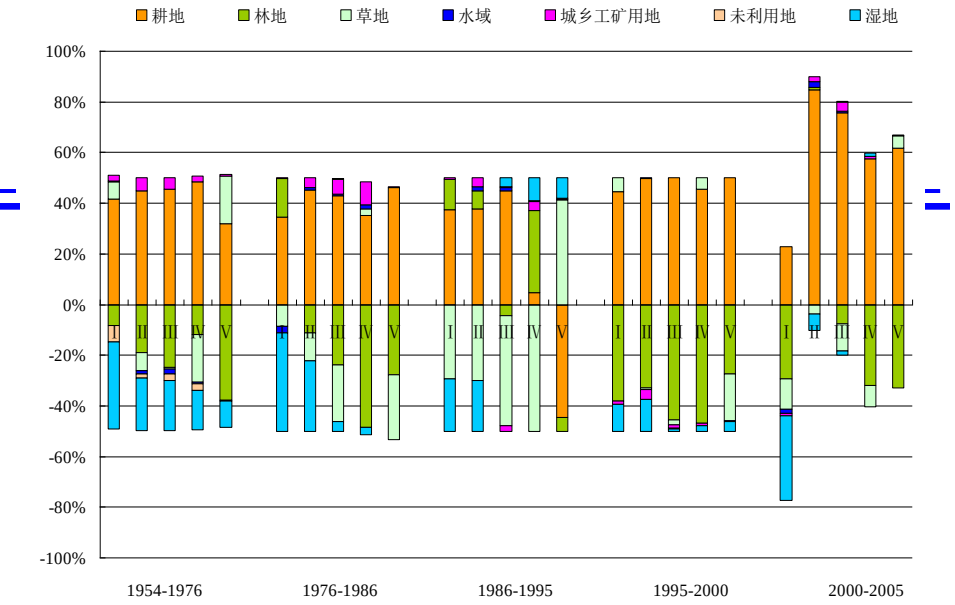




Data sources

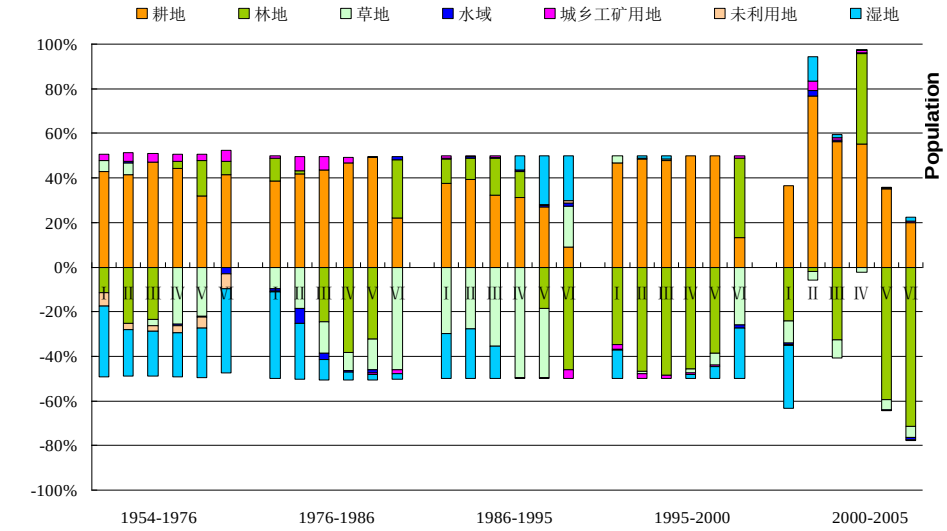
1954（a）、1976（b）、1995（c）、2005（d）

Landscapes of marsh and croplands



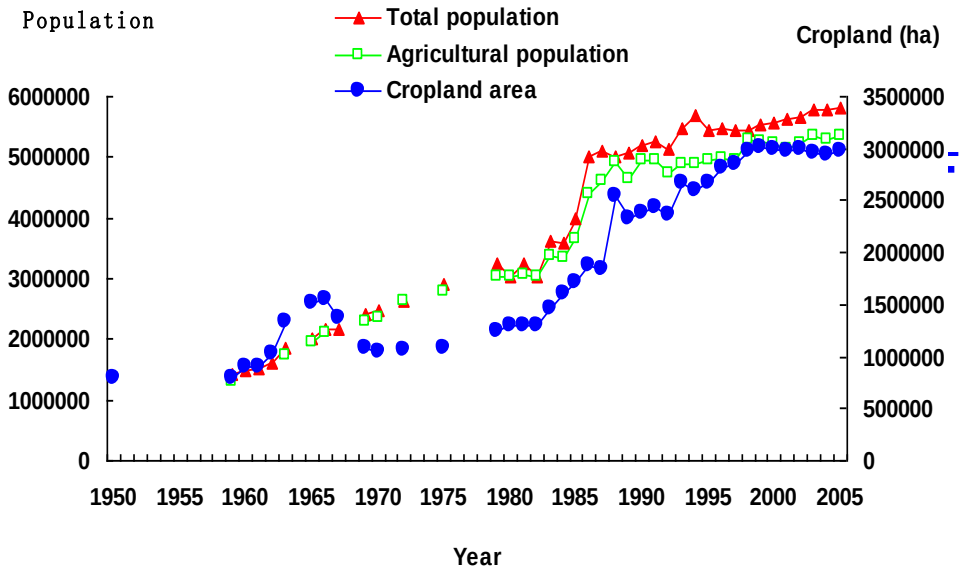
各时段内不同海拔高度区间各土地利用类型的变化趋势

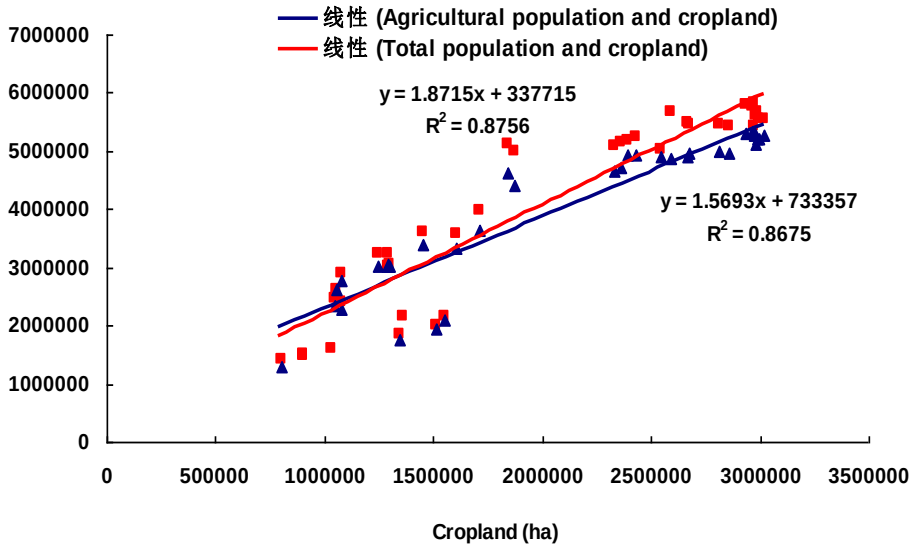
Ⅰ：0-100m；Ⅱ：100-200m；Ⅲ：200-300m；Ⅳ：300-500m；Ⅴ：>500m。



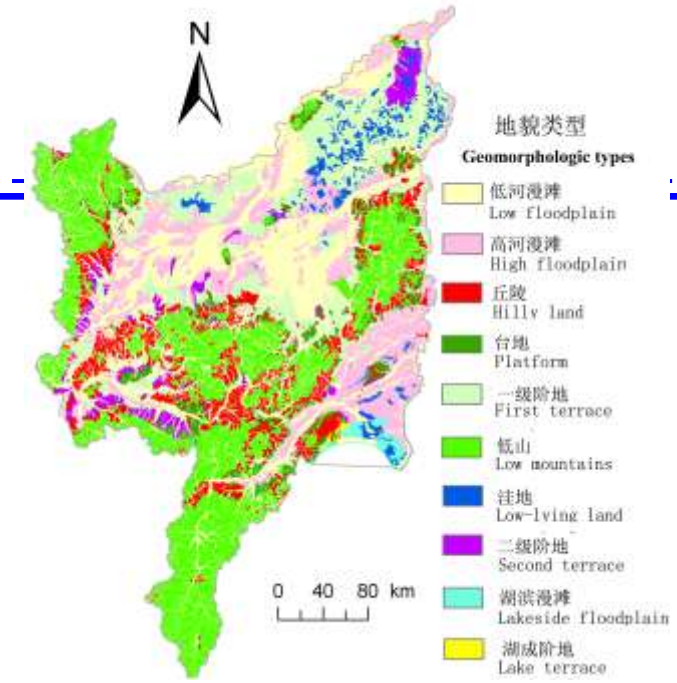
各时段内不同坡度区间各土地利用类型的变化趋势

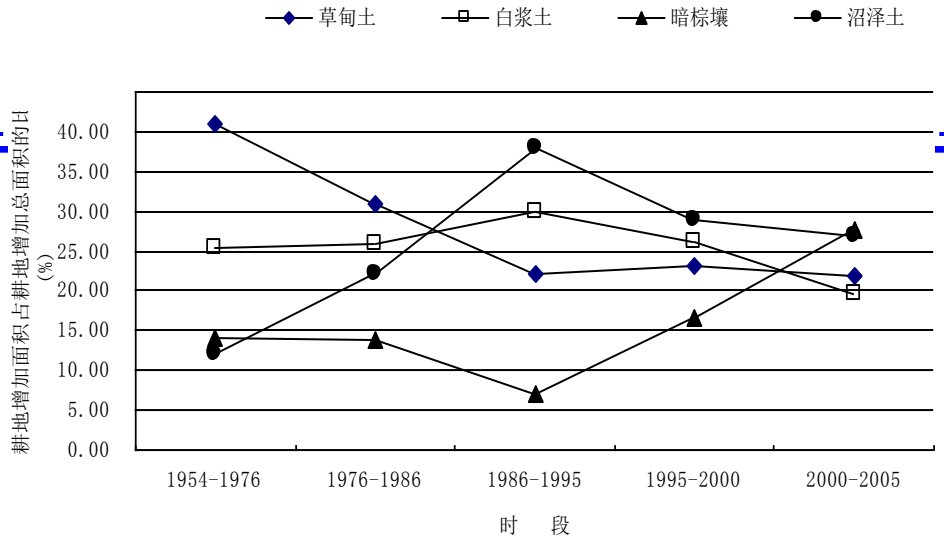
Ⅰ：0-1°；Ⅱ：1-2°；Ⅲ：2-5°；Ⅳ：5-10°；Ⅴ：10-15°；Ⅵ：>15°。



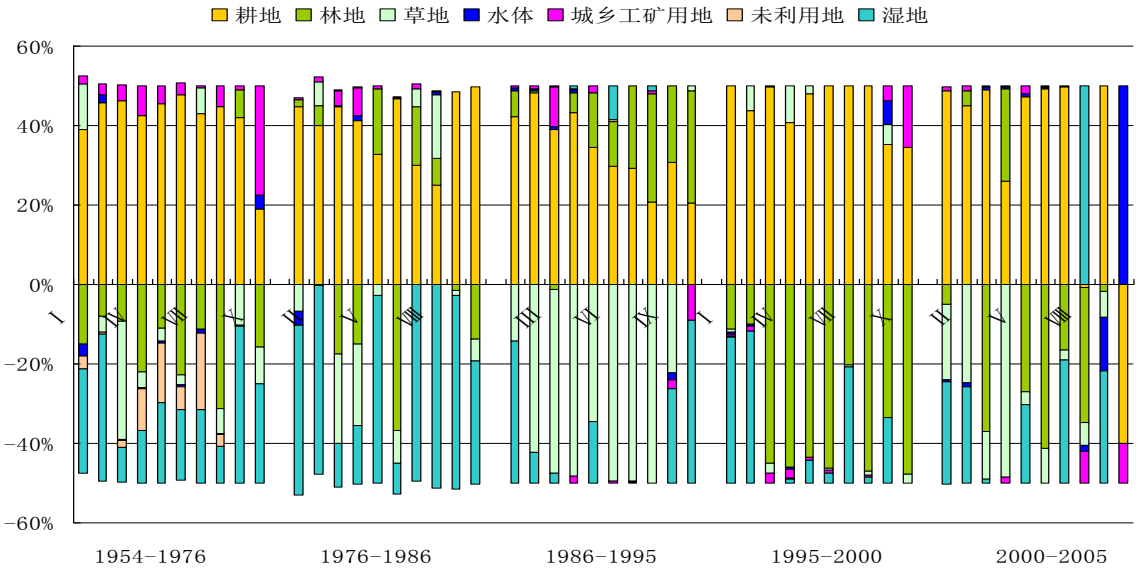


Natural and human factors affecting land use/cover changes





各时段内不同土壤类型上耕地增加面积占同期耕地增加总面积的比例



各时段内不同地貌类型上各土地利用类型的变化趋势 Ⅰ：低河漫滩；Ⅱ：高河漫滩；Ⅲ：丘陵；Ⅳ：台地；
Ⅴ：一级阶地；Ⅵ：低山；Ⅶ：洼地；Ⅷ：二级阶地；Ⅸ：湖滨漫滩；Ⅹ：湖成阶地

Effects of physiognomy and soil type on land use/cover changes

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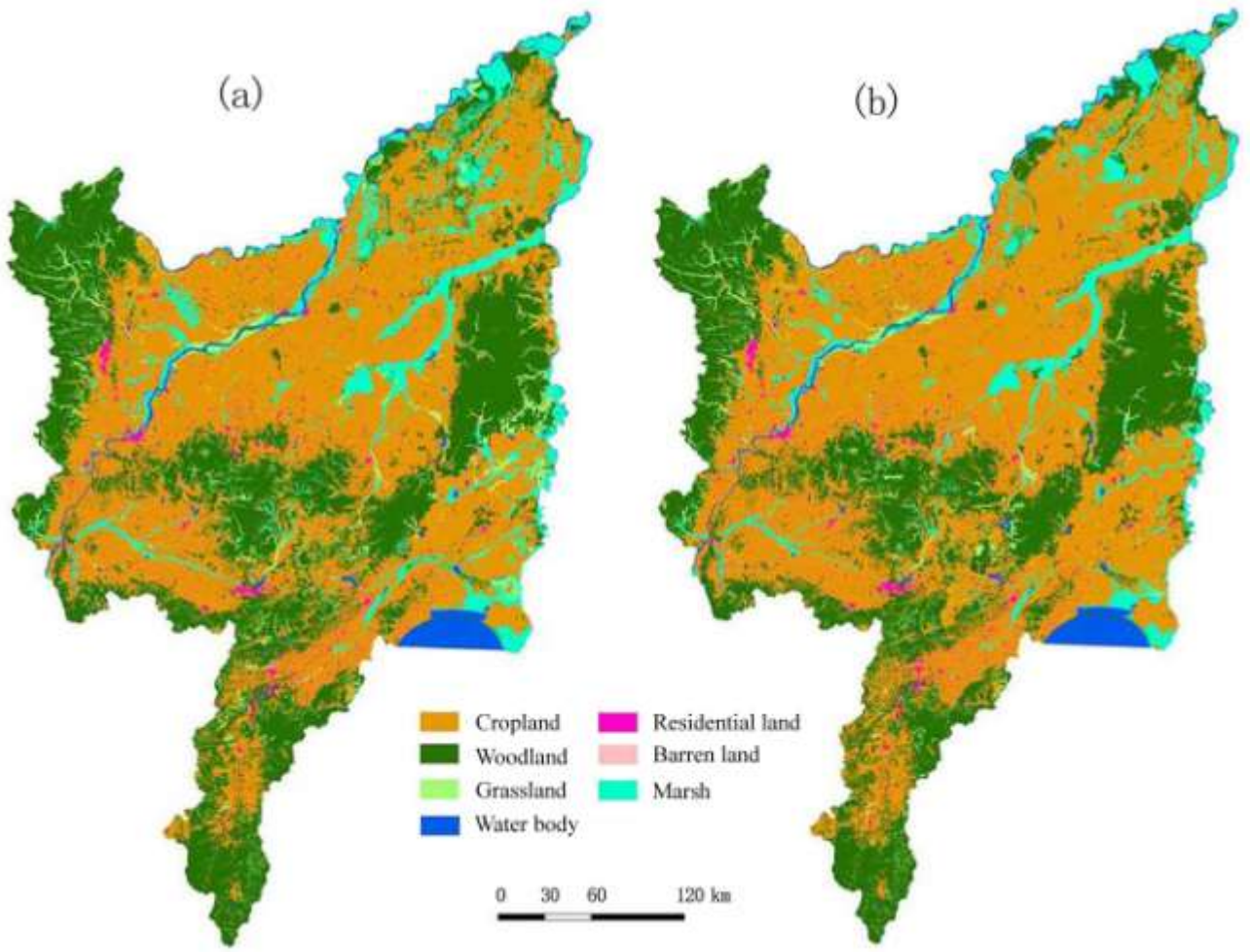
Land use detection



Land use/cover maps of Sanjiang Plain in (a) 2000, and (b) 2005

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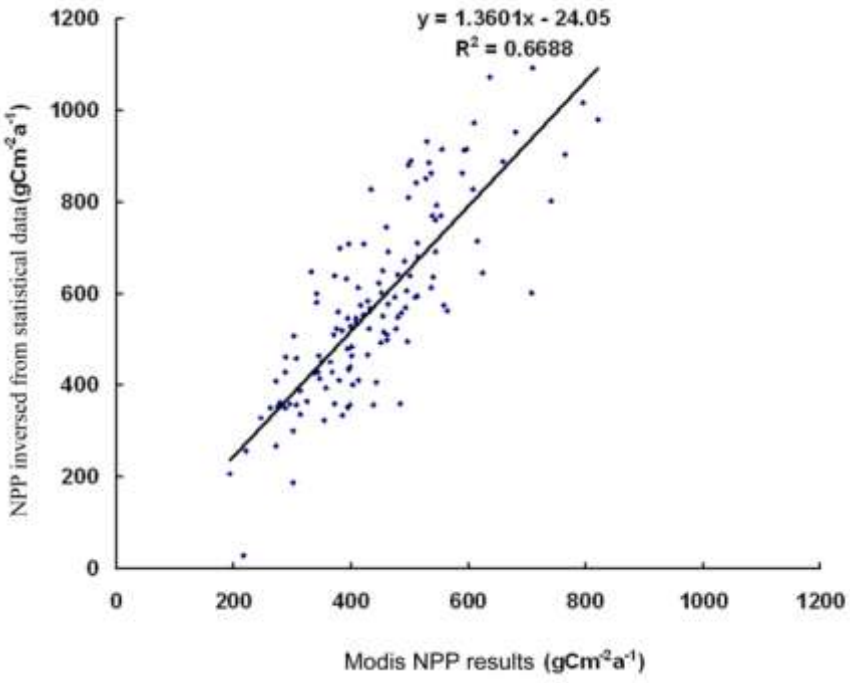
Effects of land use/cover changes on NPP

■ **NPP of woodland in the Sanjiang Plain in 2000 and 2005 was 499 g C m^{-2} a^{-1} and 489 g C m^{-2} a^{-1}, which was comparable with results obtained by Zhu et al. (2007) and He et al. (2007). NPP of grassland and marsh of the Sanjiang Plain was also comparable to similar former studies (Piao et al., 2004; Liu and Ma, 2002).**

■ **Regression results demonstrated that there was a strong relationship between estimates of cropland NPP from MOD17 data and those inversed from census at the county level (Figure 3; R^2 = 0.6688; p<0.05). The slope of this relationship was 1.36, indicating a multiplicative bias toward greater census-based cropland NPP vs. MOD17-derived values.**



Comparison between NPP from MODIS NPP modeling with NPP based on county statistics

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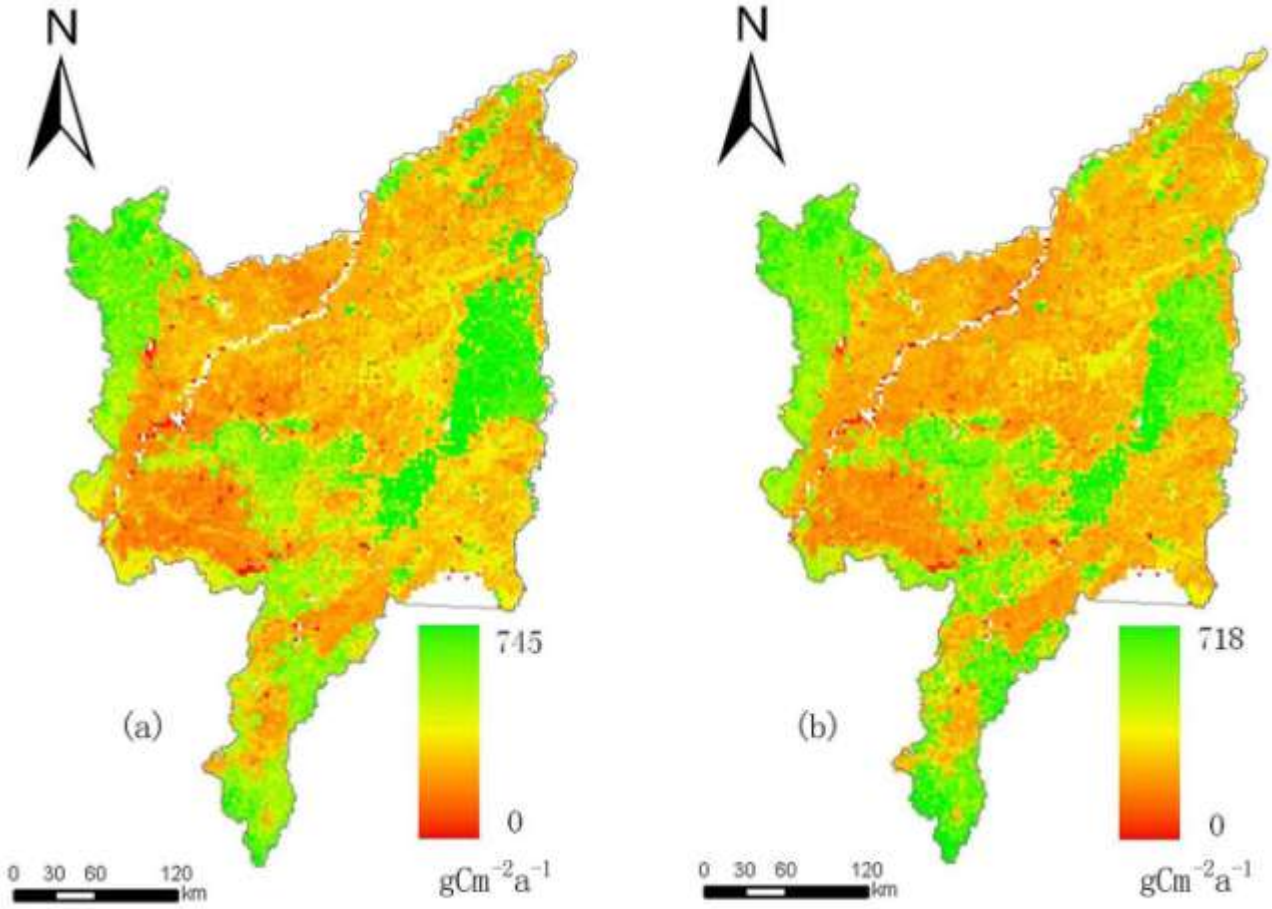
Effects of land use/cover changes on NPP



NPP distribution in Sanjiang Plain in 2000 (a) and 2005 (b)

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Effects of land use/cover changes on NPP

■ Results showed that, mean NPP of each land/cover type decreased during the 5-year period. The largest NPP loss (7.8%) occurred in marsh. NPP loss in cropland, woodland, and grassland was 24.2 g C m^{-2} a^{-1}, 10.0 g C m^{-2} a^{-1}, and 17.1 g C m^{-2} a^{-1}, respectively. Mean net primary production for the region decreased from 401.1 g C m^{-2} a^{-1} in 2000 to 377.5 g C m^{-2} a^{-1} in 2005.

■ In this period, net primary production in the whole Sanjiang Plain decreased from 4.37×10^4 G g C a^{-1} to 4.101×104 G g C a^{-1} (1G g = 109 g). Regional total primary production thus decreased by 2575.1 G g C a^{-1} or 5.9% of the net primary production in 2000.

Mean NPP（g C m^{-2} a^{-1}）	Cropland	Woodland	Grassland	Marsh	The whole region
2000	343.7	499	446.9	384.5	401.1
2005	319.5	489	429.8	354.7	377.5
Change	-24.2	-10	-17.1	-29.8	-23.6
Change ratio (%)	-7.0	-2.0	-3.8	-7.8	-5.9
Regional total primary production（G g C a^{-1}）					
2000	19140.1	17177.2	1877.0	3686.3	43651.5
2005	19175.7	16097.5	1204.1	2872.7	41076.4
Change	35.6	-1079.7	-672.9	-813.6	-2575.1
Change ratio	0.2	-6.3	-35.8	-22.1	-5.9

Mean and total NPP of the Sanjiang Plain in 2000 and 2005

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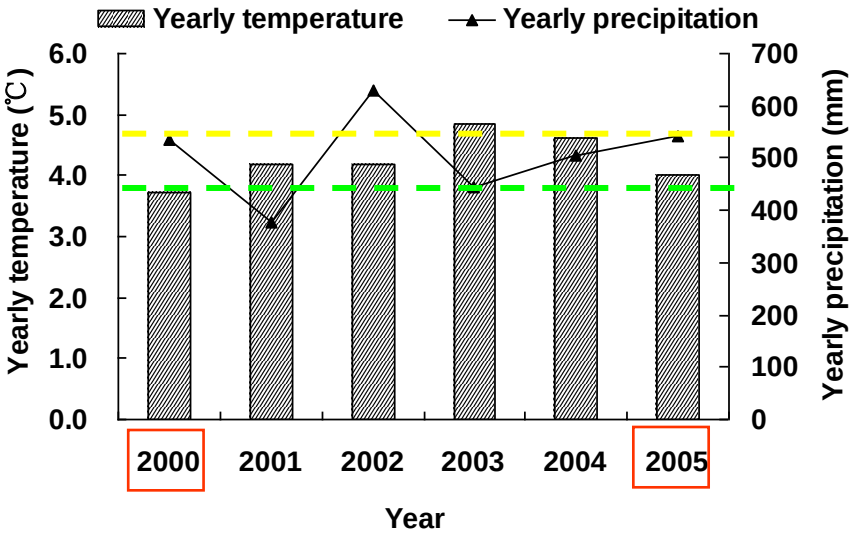
Effects of land use/cover changes on NPP

■ There are many factors which could influence the regional NPP, such as climate, land use and land cover, soil type, species characteristics and human disturbance.

■ As there was no obvious change in climatic factors in 2000 and 2005 (annual mean temperature were 3.72 ° C and 4.00 ° C in 2000 and 2005; annual precipitation were 534.6 mm and 542.9 mm, respectively), the most important reason for total NPP reduction were land cover transformation and human disturbance. As described above, the main characteristic of land use/cover changes in Sanjiang Plain during 2000-2005 was the transformation from woodland, grassland and marsh to cropland, which directly reduced regional net primary production due to lower mean NPP of cropland. Our results showed that mean NPP of the study region decreased nearly 6%.



Changing trends of annual air temperature and precipitation in Sanjiang Plain from 2000 to 2005

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Effects of land use/cover changes on NPP

■ **In the meantime, total population and agricultural population of the Sanjiang Plain increased by 3.75% and 2.25%, and the gross domestic production (GDP) increased by about 10% per year.**

■ **Human disturbances decreased regional net primary production, which influenced the food supply for human beings, and the situation should be given more attention, especially in important agricultural zones in developing countries.**

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Conclusions

■ **This study assessed the land use/cover changes on regional NPP in the Sanjiang Plain with remote sensing data. During the past 5 years, cropland, residential land and barren land increased, and meanwhile, woodland, grassland, water body, and marsh had decreased correspondingly. The transformation of natural ecosystems to cropland was the major form of LUCC. Regional NPP was reduced by 6% due to land use/cover changes and an increasing frequency and intensity of human disturbance.**

■ **Therefore, land use/cover changes produced negative impacts on carbon sequestration and food supply in the Sanjiang Plain. The results obtained in this study should be of interest to decision makers for planning land use and mitigating land degradation.**

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Thanks for your attention

07. 09. 2009