CHANGE DETECTION ANALYSIS OF FORESTED AREA IN THE TRANSITION ZONE AT HUSTAI NATIONAL PARK, CENTRAL MONGOLIA

Uudus Bayarsaikhan[1,2], Bazartseren Boldgiv, Kyung-Ryul Kim[1] and Kyeng-Ae Park[1]

[1] School of Earth and Environmental Science, Natural Science College, Seoul National University, San 56-1, Shillim-dong, Gwanak-gu, Seoul, 151-742, Korea
[2] Department of Ecology and Conservation Biology, Faculty of Biology, National University of Mongolia, Ulaanbaatar, Mongolia
(bayaraa_u@yahoo.com, kapark@snu.ac.kr)

ABSTRACT

One of the widely used applications of remote sensing studies is environmental change detection and biodiversity conservation. The study area Hustai Mountain is situated in the transition zone between the Siberian taiga forest and Central Mongolian arid steppe. Hustai National Park carries out one of several reintroduction programs of takhi (wild horse or *Equus ferus przewalskii*) from various zoos in the world and it represents one of a few textbook examples of successful reintroduction of an animal extinct in the wild.

In this paper we describe the results of an analysis on the change of remaining forest area over the 7-year period since Hustai Mountain was designated as a protected area for reintroduction to wild horses. Today the forested area covers approximately 5% of the Hustai National Park, mostly the north-facing slopes above 1400 m altitude. Birch (*Betula* platyphylla) and aspen (*Populus tremula*) trees are predominant in the forest. We used Landsat ETM+ images from two different years and multi temporal MODIS NDVI data. Land types were determined by supervised classification methods (Maximum Likelihood algorithm) verified with ground-truthing data and the Land Change Modeler (LCM) which was developed by Clark Labs.

Forested area was classified into three different land types, namely the forest land, mountain meadow and mountain steppe. The study results illustrate that the remaining birch forest has rapidly changed to fragmented forest land and to open areas. Underlying causes for such a rapid change during the 15-year period may be manifold. However, the responsible factors appear to be the drying off and outbreak of forest pest species (such as gypsy moth or *Lymantria dispar*) in the area.

KEYWORDS: remote sensing, forest change detection, takhi – wild horse, Mongolia

INTRODUCTION

Mongolia is a land-locked country which covers an area of 1 564 118 square kilometers on the southernmost fringe of the Great Siberian boreal forest and the northernmost Central Asian deserts and vast steppes bordering the Russian Federation in the north and the China in the east, south and west. Mongolia is country of upland, with about 85 % of its area over 1000 m (above sea level), most between 1000 and 1500 m. The lowest point (552 m) is the salt lake Huh – nuur in the Ulz basin in the East. In the important mountain ranges vast plateaus stretch between 1500 and 2000 m, but more frequently between altitudes of 2000 and 3000 m (Gunin 1999). Mongolia can be divided into 6 natural zones: the Alpine, Taiga, Mountain Forest Steppe; the Steppe, Arid zone Steppe, Desert zones. Grasslands and arid grazing make up approximately 80 percent of the land area.

The location of major mountain systems defines its climate. Mountain barriers at the West and North – Wets intercept atmospheric flows carrying moisture from the Atlantic side. The Pacific monsoon fades rapidly and only can be traced to 110 – 120 ^{0} E. In addition Mongolia is practically completely open for the dry Central Asian Desert winds from the South. As a result, Mongolia has a severe continental climate with large daily and seasonal temperature amplitudes, and with very intensive solar radiation values reaching 1500 K Wt/hour/sq.m or more (Gunin 1999; Hilbig 1995).

Mongolia's growing population and changing lifestyles are intensifying pressures on the country's fragile ecosystems. Overgrazing is degrading significant areas and displacing wildlife from its habitat.

Over 18.3 million hectares (ha) of Mongolia - or 11 percent of its area – are covered by forests. Coniferous forests which are part of the Siberian Taiga, over north – central mountains. Saxual trees are found in the south –

southwest deserts. During last century, Mongolia lost approximately 4 million ha of forests, averaging 40.000 ha annually. As a result of this ongoing loss and degradation, only 13 million ha of forests are closed canopy, relatively remote forests. Much of the other 5.3 million ha of forests are fragmented and degraded (Corsi et al. 2002).

Remote Sensing technology is one of the fastest growing in the Mongolia last two decades. Since the beginning 1980s, many organization of the Mongolia have attached great importance to the development of Remote Sensing technology and applications (Badarch 1995). During the past years, Remote Sensing applications are widely used for mapping, monitoring and evaluating the various natural resources and environment management in the country such as water, forest agriculture, land, and minerals resources. Modis and NOAA/AVHRR data have been widely used for estimating herbaceous biomass accumulation in grasslands and steppes (Javzandulam et al. 2005; Karnieli et al. 2006). Analyzing an individual date remote sensor data to extract meaningful vegetation biophysical information is often value (Jensen 2000).

Study area

The Przewalski horse (*Equus przewalski poliakov* or 'Takhi' in Mongolian) is the last surviving wild ancestor of the domestic horse. It was last seen in the wild in 1968 in the southwest of Mongolia on the border with China. After more than 90 years in captivity two IUCN members, the Mongolian Association for the Conservation of Nature and the Environment (MACNE) and the Foundation Reserves of Przewalski Horses (FRPH), returned the first groups to their original habitat in Mongolia. Since then 84 horses were reintroduced which resulted in the establishment of a population nowadays of around 142 Takhi (Bandi and Wit).

The study area is located in the area of Hustai Nuruu which located is Hustai National Park. It was made a reserve in 1993 and designated a National Park in 1999. Hustai National Park (HNP) is a mountainous forest steppe area of 50.600 ha in the lower spurs of the South-western range of the Khentei mountains, situated some 100 km to the south-west of Ulaanbaatar, the capital of Mongolia. The south-western part of the park extends into the valley and the flood plain of the Tuul River. Hustai National Park is under a continental climate, altered by effects of altitude. Climatic conditions are harsh and meteorological extremes lead regularly to "natural disasters". Annual average temperature is 0,2 centigrade. Average monthly temperatures vary between - 23 centigrade in January with coldest temperature of - 40 - 50 centigrade, and + 20 centigrade in July with warmest temperature of + 31 + 42 centigrade. Average rainfall is 270 mm, 80% of which falls during the short growing season which lasts from May till September.

Vegetation of Hustai Nuruu was studied relatively well enough. In 1996, Walls and others studied vegetation of the forest steppe region of Hustai Nuruu. They recognized eleven vegetation types, comprising four steppe communities, two meadow communities, a tussock

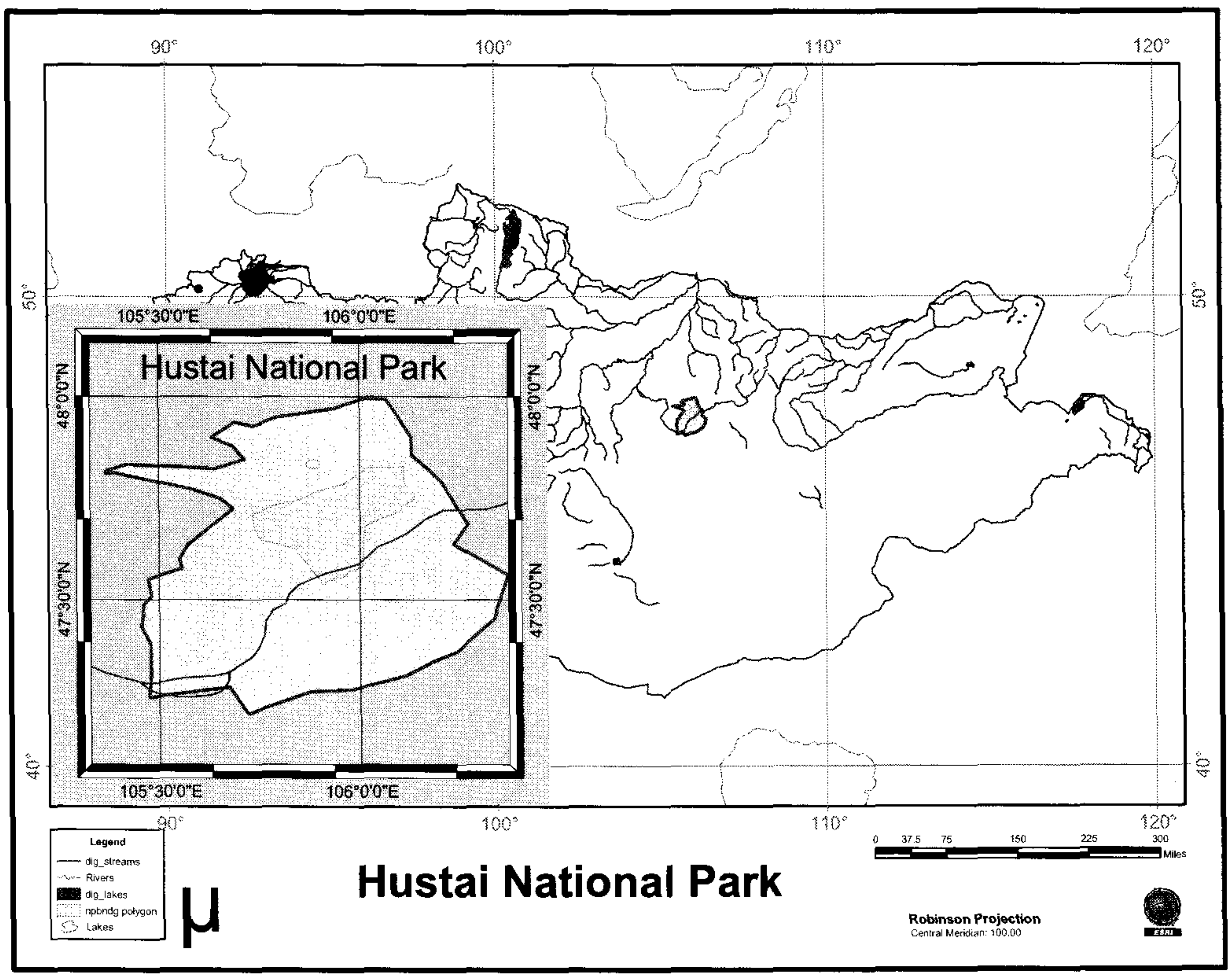

Figure 1 Study area, Hustai National Park

grassland, two shrub communities, a scrub community and a woodland community.

Data and Equipments

1. Existing map of 1969 at scale of 1:100, 000 produced by Department of Defense.
2. Landsat TM color composite image, 7 bands at a scale of 1:32,000 acquired on September 12, 1994 (Federal 2004).
3. Landsat ETM + color composite image, 7 bands a a scale pf 1:32,000 acquired September 20, 2000 (Federal 2004)
4. DEM SRTM – 90 m (SRTM 2004)

Methods

The first attempt was to classify the various land uses in ENVI v4.03 and image processing software using supervised classification techniques. The ISODATA algorithm computes the minimum distance between spectral signatures to identify clusters of pixels with similar spectral characteristics (Joy et al. 2003). Visual Interpretation of 1994, 2000 Landsat TM, ETM + image was performed to extract forest existing area from other land use categories. The hard classifier called MAXLIKE was used to re-classify each pixel. MAXLIKE assigns each pixel in the image to the class that it has the maximum likelihood of belonging to.

Ground control points and field observations collected in the Buffer zone, Hustai National Park of the study area during June, August 2006, June, August 2004 using a Garmin Global Positioning System 12 XL. Each GCP, the geographic location (with accuracy of 5–12 m) and the altitude above sea level recorded, with description of the vegetation cover of the sample site (a range of 10 X 10 m).

We are using this studies Change Detection Model which developed by Clark's Lab. The Land Change Modeler (LCM) for Ecological Sustainability is an integrated software environment for analyzing land cover change, projecting its course into the future, and assessing its implications for habitat and biodiversity change.

Results

Nevertheless, after more than 6 years of forest area was decreasing, forest is still the most important land-cover class present throughout the study area.

The replacement of forested areas with mountain steppe was the most predominant land-cover change observed in the entire study area. Most of this change corresponded to a replacement of forests is unclear.
Forested area classified into three different land types, namely the birch forest, mountain meadow and mountain steppe (figure 2, 3). The study results illustrate that the remaining birch forest has rapidly changed to fragmented forest land and to open areas especially to mountain steppe.

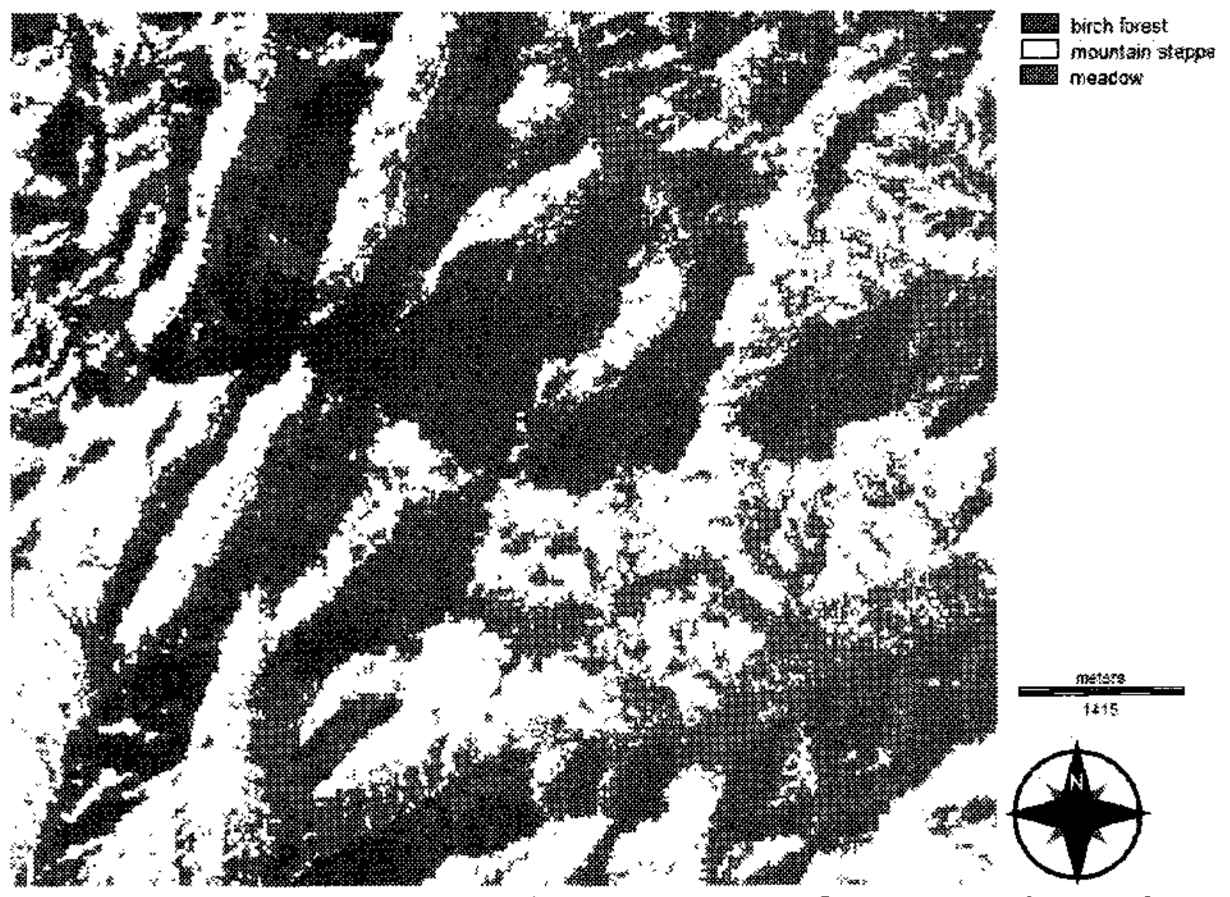

Figure 2 Forest area classification for Hustai National Park, Landsat TM, 1994

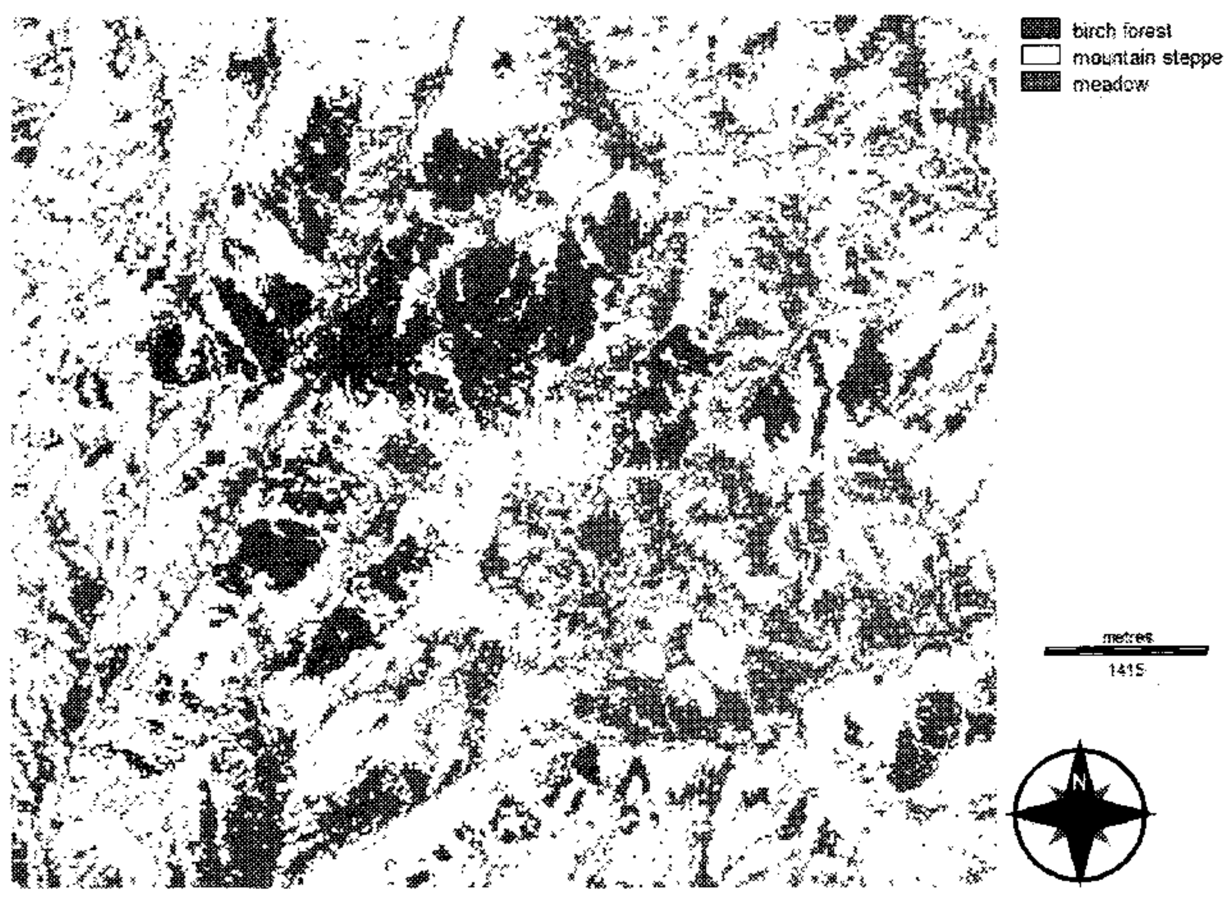

Figure 3 Forest area classification for Hustai National Park, Landsat ETM +, *2000.*

Results obtained from the study can be described in below table.

Table 1 Change detection result between 1994 and 2000

	Year, sq/km	
	1994	2000
birch forest	18.29	9.51
mountain steppe	24.83	41.98
meadow	21.43	13.07
Total (sq/km)	64.55	64.56

1. Existing forest areas of 1994 and 2000 were 18.29 km^2, 9.51 km^2 respectively.
2. Deforestation area during 1994-2000 was about 9km^2 or forest depletion rate was 1.5 km^2/year.

Underlying causes for such a rapid change during the 6-year period may be manifold. However, the responsible factors appear to be the drying off and outbreak of forest pest species (such as gypsy moth or *Lymantria dispar*) in the area.

In Hustai Nuruu birch (*Betula platyphylla*) woodlands are concentrated in two locations. They occupy the north slopes from 1400 m upwards in a mosaic together with *Festuca sibirica* mountain steppes. In the woodland sites, which are often littered with granite blocks, the permafrost layer reaches closest to the soil surface (Wallis de Vries et al. 1996). It dominated by *Betula platyphylla* and *Populus tremula.* The shrub layer (5-50% cover) consists predominantly of *Cotoneaster melancarpa, Spiraea media* and *Rosa acicularis.*

One of the main factors related to the ungulates species distribution and population numbers change. Early researchers studied wild ungulates occur mainly above 1500 m, where livestock pressure is low. Three species are present: red deer *(Cervus elaphus)*, wild boar *(Sus scrofa)* and roe deer *(Capreolus capreolus)* (Wallis de Vries et al. 1996). In 2005 there were 384 of them counted in Hustai National Park. In 1996 and 2002 respectively even 437 and 454. In 1993 only 54.

Conclusion

The study has demonstrated the utility of a RS / Image Processing System to monitor changes in the forest cover. An ideal RS system for such an analysis should have built-in support for raster and vector analysis. This is particularly pertinent in our country, where data are scarce.

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