Vegetation mapping in the Gobi Gurvan Saykhan National Park and the Great Gobi B Strictly Protected Area – a comparison of first results

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Abstract

This paper describes the mapping of vegetation patterns in two southern Mongolian protected areas, namely the Gobi Gurvan Saykhan National Park and the Great Gobi B Strictly Protected Area. Both areas were mapped individually. Field-sampling followed a modified Braun-Blanquet approach, relevés were classified with phytosociological methods. Training areas were assigned to phytosociological units, and were enlarged using various algorithms such as red-green-blue images, NDVIs, Tasseled Cap, and unsupervised classifications. The enlarged training regions were used as ground truth data for a supervised classification of Landsat ETM+ scenes. The classifications were performed with a maximum likelihood algorithm and made more homogenous by applying a nearest neighbor filter with a 7x7 pixel range.

Accuracy was checked with additional reference data sets taken in the field. The overall accuracy was well above 90%. Misclassifications occurred mainly due to the ecotonal character of some plant communities, or due to the occurrence of mixed pixels. In order to make results accessible for park management and administration, the final data sets were implemented in a GIS that includes other thematic information such as country and districts boundaries, wells, rivers, lakes, as well as a high resolution digital elevation model.

The mapped areas represent two out of five protected areas in Mongolia that are situated in the southern Gobi. In this paper, they are for the first time compared with respect to their community composition and their vegetation distribution.

Keywords Vegetation mapping, phytosociology, remote sensing, Gobi.

Introduction

The Gobi (semi)-desert is a region of extreme climatic fluctuations in temperature and precipitation with a relatively species-poor flora and fauna. Yet, several of the occurring species, especially large mammals, are highly endangered and many vegetation types are sensitive to disturbances. However, human influence has been present for thousands of years, including extensive grazing by livestock, firewood collection, and hunting. The Mongolian Gobi is regarded as being still relatively intact and within the last decades several nature reserves were established in the region in order to protect this ecosystem. Since these cover very large areas and contain a wide variety of different habitats, the management of these parks faces tremendous problems due to the lack of information.

Knowledge on the distribution of the fauna is largely restricted to large mammals (see Schaller, 2000). Information on the distribution of vegetation types is merely available on a coarse scale (Anonymous, 1990; Gumin & Vostokova, 1995), though detailed data on community composition has been published within the last decade (Hilbig, 1990, 1995). Thus, the aim of the two projects presented in this paper was to acquire comprehensive spatial information on the vegetation patterns of two nature reserves in the Gobi desert of southern Mongolia. Because vast areas had to be covered a combination of extensive ground-truthing and subsequent use of remote

1 Results of the Mongolian-German Biological Expedition since 1962. No. 250.
sensing data was applied, as traditional ground survey techniques would have been far too time-consuming. The first steps included plot-based vegetation sampling and classification of plant communities with a phytosociological approach. Classified plots were used as training areas to perform supervised classifications of Landsat 7 satellite data (Alexander & Millington, 2000; see also Dymond et al., 1996; Reese et al., 2002). However, the question remained whether vegetation mapping of the sparse steppe and (semi)-desert vegetation with remote sensing is possible at all and whether the results gained from both areas are comparable and representative for the northern Gobi.

The following paper will highlight similarities and differences between the two parks thereby allowing an assessment of the accuracy of the vegetation maps and a comparison of the phytosociological systems. Preliminary results are compared, followed by an outlook that describes the idea of a final comprehensive GIS for all nature reserves in southern Mongolia.

Study area

Both reserves are situated in southern Mongolia, with a minimum distance of some 450 kilometers between each other (figure 1). As they are both part of the huge Gobi (semi)-desert area the reserves have several similarities but also some important differences outlined below.

Geology and landforms

The mountains are mainly based on ancient bedrocks. In the Tertiary, the collision of the Indian sub-continent with the Asian continent formed the Himalayas and lifted the Tibetan plateau. This uplift also faulted the Altay mountain range and lifting still continues today as indicated by neo-tectonic earthquakes in the southern part of Mongolia. The Great Gobi B Strictly Protected Area (GGB SPA) is situated just south of the Altay main thrust, which climbs to altitudes of
well above 4000 meters asl., and forms an impressive natural border north of the GGB SPA. Its southern border follows the inter-state boundary to China and is marked by three mountain ranges. The pediments on the Mongolian side of these ranges extend from 1800 meters asl. into depressions around 1000 meters asl. The southern Chinese side of these mountains lies much lower; as a consequence the southern flanks are comparatively steep and fall to depressions well below 600 meters. Thus, the political border follows a clear-cut natural border.

The Gobi Gurvan Saykhan National Park (GGS NP) is named after the three eastern mountain ranges of the Gobi Altay, which form green islands in the otherwise dry surroundings (‘Three Beauties of the Gobi’). However, the park also includes several other ranges all belonging to the Gobi Altay system.

Both protected areas are characterized by large pediments in their foot zones that connect the hills and mountains with the flat depressions. Mountain ranges, pediments, and depressions span a huge altitudinal gradient in both reserves (<1000 m to >2500 m). The pediments are mostly deflated; the endorheic flow regime is characteristic for arid environments.

The main difference between both areas is the influence of the large rivers draining southwards out of the Altay into the Great Gobi B SPA. Such (semi-)permanent rivers and widespread fans are absent from the Gobi Gurvan Saykhan. In the GGS NP, sands form the 150 kilometers long dune range of Khongoriyn Els, whereas flat sands are relatively rare in the area. A 30 kilometers wide (in north – south direction) sand belt is also found in the northern part of the GGB SPA. Although the sand covers mainly pediments, it is also found in the lee of the northern hills, where it influences the vegetation distribution up to the highest peaks. Large sand dunes as in the GGS NP are absent from the GGB SPA.

Climate and weather

The northern Gobi is a (semi-)arid ecosystem. Its continental character becomes more pronounced eastwards, and governmental climatic stations generally receive around 100–150 mm mean annual precipitation. However, all of them are situated in basins, and mountains are generally held to receive higher amounts of rainfall than the pediments (Endlicher & Weischet, 2000). Interannual variability in precipitation is potentially huge, e.g. in the summer of 2001 we recorded no rain at all during the survey of the GGS NP, while in 2003 survey work had to be interrupted for three days due to heavy rainfalls. This corresponds to the interannual variability in the vegetation density as water is the decisive factor for plant growth in summer. In autumn, intense clouds might screen radiation resulting in lower temperature and therefore a shortened growth period.

The climate is mainly influenced from three directions. From the south-east, the south Asian monsoon sometimes passes with cyclonal disturbances over the Himalayan range and the Tibetan plateau. Other disturbances originating in the Mediterranean occasionally cross over Persia and pass from the west into the Dzungarian Gobi. These cyclonal disturbances weaken towards the east and are therefore stronger in the GGB SPA than in the GGS NP. Some disturbances pass the Altay mountain range and cause higher temperatures in the GGB SPA due to ‘Fön’ effects. In winter, both regions are influenced by the Siberian anticyclone (Endlicher & Weischet, 2000). Since the region is more continental in the east, the GGB SPA probably has wetter and warmer winters than the GGS NP.

Methods

Plot sampling followed a modified Braun-Blanquet approach (Mueller-Dombois & Ellenberg, 1974). All relevés were 10 x 10 meters in size, corresponding to the minimum area of all plant communities found in the GGS NP (Miehe, 1998). Plant cover was estimated directly in percent, as normally used scales are too coarse for the sparse vegetation of the Gobi. Additional 'fast
plots’ were taken en route, where only few characteristic species as well as some important environmental factors were recorded. The positions of all relevés were located with a handheld GPS. The GGSNP was covered by five Landsat scenes, while the GGBSPA area extended over four scenes. Unsupervised classifications and red-green-blue pictures were taken as hardcopies to the field and were used to guide selection of sample sites. Nevertheless, hills and mountains were always sampled, as were all oases.

In the field, plots were assigned to a preliminary phytosociological classification. Plants were preliminarily identified with a standard flora (Grubov, 2001) and later checked in the herbarium of the University of Halle-Wittenberg with the help of additional literature (Gubanov, 1996; Grubov, 2000 ff). Both national parks were mapped individually. Thus, for each park a separate phytosociological system was created. A first assessment of communities was made using TABWIN (see Mueller-Dombois & Ellenberg, 1974, for details on the general principle). Further statistical analysis were made with EXCEL (Version Office XP), SPSS Inc. (Version 10.0) and PCORD (Version 3.15). DCAs of the two data sets were performed separately (Jongman et al., 1995). In a second step, sub-data sets were created based on the main community groups derived from the phytosociological classification. These subsets were analyzed with a PCA, if lengths of multivariate gradients were below 3 to 4. Rare species occurring only once were excluded from the analysis. Both reserves were kept separate in statistical analysis because of their huge distance from each other and because plant communities differed between both study regions.

For the classification of the satellite data, RGB-mosaics were created for both reserves. Within these mosaics, all plots were inserted in vector format. Each plot was assigned to a community within the phytosociological system. Each scene was classified individually to guarantee a data structure which is modified as little as possible regarding the absolute spectral values. By analyzing the scenes separately the raster data sets remained unchanged, whereas merging of all scenes would have undoubtedly changed the data values obscuring differences between the scenes.

The sun-angle of all scenes was corrected manually with the software package ERMAPPER (1999). A topographic correction was not employed since the data sets were already Ig-corrected. An atmospheric correction was not possible since most scenes lacked open water bodies necessary for calibration. More sophisticated corrections were also impossible since the required climatic data was not available.

A Landsat pixel has a size of 28.5 x 28.5 meters. To match this, the training areas were enlarged in a first step to the size of the designated pixels in order to provide sufficiently large data sets for the supervised classifications. Enlargement was done manually and aided by analyzing images with several algorithms. Dense vegetation (> 50% vegetation cover) such as salt meadows, Takyr communities, and Juniper patches were enlarged by using simple RGB-pictures with a stretched contrast (Liu, 1990). Plots covered with a relatively dense vegetation (> 20% vegetation cover), e.g. mountain communities, were enlarged based on NDVI-scenes. The Tasselled Cap algorithm was used in drier conditions, especially for plots located in beds of temporary rivers and for sand dunes.

Enlargement of plots was checked additionally with unsupervised (Isoclass) classifications containing a high number of groups (> 120, channel combination 12345 or 34). Moreover, spectral signatures were checked for consistency within the enlarged plots by using scattergrams that directly depict spectral emission values.

The final classifications were made with a Maximum Likelihood algorithm, which is much more powerful than Minimum Distance or parallelepiped approaches (Campbell, 1996). A Nearest Neighbor Filter was applied prior to the classification (Lillesand & Kiefer, 1994), in order to make the data more homogenous and thereby facilitating the interpretation of the final maps (final scale 1:100,000–1:300,000). Another advantage of this generalization is the correction of single misclassified pixels that are likely to occur wherever a pixel contains more than one plant community and emits a mixed signal. Accuracy was checked with additional plots taken as a
reference data set (Congalton, 1991, done for GGB SP A and GGS NP) or recorded earlier by S. & G. Miehe in the GGS NP in 1996. After scene-wise classifications all scenes were finally merged into one raster data set for each national park.

The available vector data (topographic information) was morphed into the same projection as the raster data because the raster data sets should be manipulated as little as possible. Additionally, a digital elevation model was created from the SRTM-data sets that are available in the internet free of charge (see www.terrainmapping.com for an overview of the data used). All data sets were integrated in one GIS, which provides baseline information for further studies, nature conservation, and resource management.

**Results**

Here, the data are compared under two aspects; namely plant community composition (phytosociology), and reliability of the supervised classifications. The discussion then concentrates on the spatial patterns of the vegetation and the ecological insights gained during the classifications.

**Plant communities**

Detailed descriptions can be found elsewhere (Wesche et al., in review; von Wehrden, 2004), so this chapter will give just a brief overview.

**Gobi Gurvan Saykhan**

The vegetation of this national park can be divided into six community groups (Wesche et al. in review). The first group contains extrazonal vegetation of moist mountain sides. *Betula microphylla*-forests, *Populus laurifolia*-forest, *Kobresia*-mats of the upper slopes and meadow steppes are rare and restricted to northern exposures in the moistest mountains in the eastern part of the park. All other mountain sites are covered by dry mountain steppes and related units (group 2) such as the *Hedysarum pumilum-Stipetum krylovii*, *Achnatherum inebrians*-community, *Artemisia santolinifolia*-community, and the *Artemisia rutifolia*-community.

*Caragana leucophloea*-scrub and *Stipa gobica*-steppes are the principal vegetation of the upper pediments (group 3). The *Amygdalo pedunculatae-Caraganietum leucophloeae* and the *Stipa gobica*-community are mainly found on the upper pediments of the Gurvan Saykhan mountain ranges, whereas they are almost absent from the drier, western mountain ranges. On drier sites these are replaced by *Stipa glareosa-Allium polyrrhizum*-steppes or even drier vegetation. At lower elevations, semi-desert vegetation (group 4) dominates wide areas. The most prominent communities are the associations *Stipo glareosae-Anabasietum brevifo- liae, Salsola passerinae-Realumietum soongoricae, Potaninio mongolicae-Sympegmetum regelii, Eurotio ceratoides-Zygophylletum xanthoxylii*, and communities with *Haloxylon ammonodendron* (saxaul). The latter plant covers wide areas in the depressions. Though saxaul can grow in a tree-like fashion, it was mainly found forming small multi-stemmed shrubs. Deflated sand areas are also largely dominated by *H. ammonodendron*. Flat sands that are not deflated but frequently move are colonized by the *Caragano bungei-Brachantheretum gobici*-community and the *Psammochoa villosa*-community.

Basins or other regions with a water surplus are covered by salt-tolerant extra- or azonal vegetation (group 5). Typical communities bordering open water are dense meadows of the *Blysmetum rufi*. At temporarily flooded Takys the *Salicornia europaea*-community is common. Other units on saline soils include the *Salsola passerinae-Kalidietum foliati, Glycyrrhizo-Achnatheretum splendentis*, and the *Nitraria sibiricae-Kalidietum gracilis*. Few *Populus diversifolia* trees are found (group 6), which sometimes form small forests in semi-deserts where water surplus is guaranteed.
Great Gobi B Strictly Protected Area
The vegetation of this area can be divided into groups which are quite similar to those described by Wesche et al. (in review) for the GGS NP. The moistest mountain sites (e.g. small valleys and ravines) in the south-western mountain range are partly covered by juniper vegetation, but mountain steppes with Festuca spp. are far more widespread and cover mountain slopes in all exposures.

Lower down, hills surrounding the main mountain ranges are widely colonized by Stipa gobica, which is the regional character species of the Stipa gobica-Anabasis brevifolia-community. On the flat upper pediments this species is absent, and a Stipa glareosa-Anabasis brevifolia-community covers wide areas, whereas the Stipa glareosa-Allium mongolicum-community is restricted to wet pediments covered by fine sands and a comparatively high water availability. Other communities growing on the pediments include Caragana leucophloea-Oxytropis aciphylla-steppes on coarse sand and Nanophyton erinaceum-steppes on finer flattened sands.

The semi-desert areas on the lower pediments are partly covered by a Reaumuria soongorica-community, but most areas on the lower pediments, including the outer regions of depressions, are colonized by a Haloxylon ammodendron-community. Where there is some water surplus such as in the central parts of depressions or on the wide fans deposited by rivers south of the Altay main thrust azonal vegetation is found. Large areas are grown with an Achnatherum spp.-community, whereas near open water the Blysmetum rufi is common. These saline meadows are often surrounded by the Nitaria sibirica-community. Occasionally, surroundings of Takyrs are inhabited by an Anabasis elatior-sub-community of the Haloxylon ammodendron-community. Populus diversifolia-forest are rare and were only encountered at one oasis.

Comparison of both community systems
Generally, the GGB SPA is drier than the GGS NP and a given plant community tends to occur at higher altitudes in the GGB SPA than in the GGS NP. Specialized high altitude communities such as Kobresia-mats, however, seem to be absent in the GGB SPA.

Overall, high mountain communities of both areas are comparable regarding their distribution, ecology, and species composition. However, the GGS NP has a higher number of montane communities. This is probably due to the higher proportion of mountain ranges within the GGS NP, but may also be due to a sampling effect, as only a limited number of relevés could be collected in the mountains of the GGB SPA, which lie at the international boundary. There, armed guards granted access only for some few hours during each collecting trip whereas days or even weeks were spent sampling in the mountains of the GGS NP.

The hilly regions of both protected areas share many similarities, among them the presence of the Stipa gobica-communities. The absence of these on the upper pediments in the GGB SPA indicates an overall higher dryness of this area. The same is true for communities with Anabasis brevifolia. While this species is restricted to the lower pediments in the GGS NP, communities containing A. brevifolia in the GGB SPA start at the lower hillsides and upper pediments reaching downwards to the oases. Its absence from the upper pediments in the GGS SPA, is related to the presence of one of the most dominant factors in the GGB SPA, i.e. coarse sand. Generally, the distribution of sand influences the vegetation patterns of wide areas in the GGB SPA, where extensive sands are grown with the Caragana leucophloea-community and with the Stipa glareosa-Allium polyrrhizum-community, while in the GGS NP sands only influences the distribution of the Psammochloa villosa-community and the Caragana bungei-community.

The lower pediments in both parks, i.e. the driest regions, carry very similar semi-desert scrub communities; the dominant species Haloxylon ammodendron and Reaumuria soongorica are equally widespread in both parks. This indicates that the driest parts within both areas are quite comparable with respect to their ecology and species composition. Apparently, in the drier areas the average rainfall seems to be relatively similar in the GGB SPA and the GGS NP.

In the GGB SPA, occasionally flooded rivers are more common since they originate in the
Altay main thrust. This pattern is an important factor determining the distribution of the *Haloxylon ammodendron*-community as saxaul seemingly depends on the presence of at least some water in the upper layers of the soil; this groundwater is available on the extensive fans deposited by the rivers.

**Vegetation maps**

**Gobi Gurvan Saykhan**

For the GGS NP 17 communities are included in the final map. The overall accuracy is above 93% based on an independent check with training areas not used in the supervised classification. Separate mapping of units which are rather similar in terms of their phytosociological status proved difficult. However, this is not surprising as some communities are differentiated from each other only by some percent of cover of characteristic species and such small differences are hardly detected by remote sensing. Checks of the spectral signatures using scattergrams confirmed that some communities have identical spectral signatures with respect to channels 3 and 4, but are distinct in channels 5 and 7. This indicates that some communities are strongly linked to edaphic and geomorphological patterns, which can also be used for classification.

Furthermore, several communities are always small in extent and therefore mainly part of mixed pixels. Nevertheless it usually is possible to classify them since these plots generally show exceptionally dense vegetation.

**Great Gobi B Strictly Protected Area**

Covering only one third of the area of the GGS NP, the GGB SPA features only 12 communities which were spatially extensive enough to map them at the given scale. Nonetheless, three salt-adapted, albeit spatially unimportant communities are additionally included in the final classification as these were frequently sampled and rather distinct with respect to their habitat preferences. Again, overall accuracy is above 95%, as assessed with an independent check using 'fast plots' taken en route. This is due to the limited number of communities and their even stronger association with geomorphologic patterns.

Sand is more common in the GGB SPA than in the GGS NP. It is an important feature determining the distribution of at least two communities and influencing other communities as well. Only the southern part of the reserve contains high mountain vegetation. All other hills or lower mountains are primarily covered by *Stipa gobica-Anabasis brevifolia*-steppes. Thus, these areas were frequently sampled and classification is very reliable.

The semi-desert areas are widely dominated by *Haloxylon ammodendron*-stands. Intermediate semi-desert communities are also mostly classified into this group, since saxaul is one of the most obvious plants of the region and has distinct habitat preferences. Thus, assigning intermediate pixels to other communities would be less reliable, since these communities are more complex in their composition. Therefore, it should be kept in mind, that areas with even just one percent covered by saxaul are usually classified as the *Haloxylon ammodendron*-community (see Abeyta & Franklin, 1998, for a description of the problem).

**Discussion**

Although both regions differ in their floristic composition they share most of the dominant plants, the majority of which are Central Asian elements. In both reserves high mountain regions are dominated by juniper stands and mountain steppes with *Festuca* spp. Due to the absence of very high mountain regions in the GGB SPA, moist mountain steppes as they are common in the GGS NP are absent in the Dzungarian Gobi. Similarly, *Stipa gobica*-communities are widespread on pediments in the GGS NP but are restricted to hilly terrain and lower mountain
sides with somewhat higher water availability in the GGB SPA. The relatively high drought-tolerance of this vegetation type in the GGB SPA is underlined by the almost constant presence of *Anabasis brevifolia*. In the GGS NP *A. brevifolia* is mainly found at the lower pediments, where it mediates between dry steppe and semi-desert communities.

Sand, which plays only a minor role in the semi-deserts of the GGS NP is an important determinant even at the higher hilly regions in the GGB SPA. This explains why in the northern part of the GGB SPA *Nanophyton erinaceum* and especially the *Caragana leucophloea*-community cover wide areas. Thus, higher pediments are edaphically dry and are often grown with semi-desert-communities in the GGB SPA. All this indicates that the average rainfall is lower than in the GGS NP.

A unifying feature in both areas is the occurrence of the *Haloxylon ammodendron*-community. It is linked to fans and rivers within the semi-deserts but is often absent where such water surplus is lacking. Thus it seems to depend highly on water availability, and indicates the presence of groundwater and/or rare events of surface water flow.

Plant communities of saline habitats are much more widespread in the GGB SPA than in the GGS NP. The large fans and rivers draining away from the Altay main thrust are often covered with dense vegetation linked to a high groundwater table. The most abundant units are the *Blysmetum rufi* at rivers and oases, and *Achnatherum* spp. vegetation on fans or at the outer belt of oases. Where they become drier, wide riverbeds and fans are also quite often covered by dense and high *Haloxylon ammodendron*-stands. Although much rarer, similar patterns are also observed in the GGS NP.

Overall, both reserves show similar patterns in plant communities dominating the semi-deserts. Two possible explanations exist for this: Either, this is an indicator that the (semi-) desert communities tolerate a higher variability of precipitation, or that despite the precipitation gradients observed for other communities the lower elevations gain an almost equal rainfall. However, with respect to the limited data available at present this question can not be decided.

**Implications for nature conservation and resource management**

In the GGS NP, mountains are a characteristic feature. The park incorporates at least six major ranges covering more than 30% of its area. In the GGB SPA on the other hand, such habitats are only found at the southern border and account for less than 5% of the area. Precipitation generally increases with altitude, so the overall lower elevations in the GGB SPA explain why this park is generally drier than the GGS NP. This effect is apparently even more pronounced for the vegetation of the upper pediments, which appear to be much drier than in the GGS NP. This finding is further supported by the distribution of wells in both reserves: While in the GGS NP dozens if not hundreds of wells are found especially but not exclusively around the mountain ranges, only few wells exist in the GGB SPA. In contrast, open water bodies are restricted to a few oases in the GGS NP (Chimedregzen, 2000), whereas at least three rivers originating in the Altay main thrust control the flow regime in the GGB. Thus, open water was found at eight sites in the GGB SPA. However, sites were mainly situated in relatively dry surroundings, offering only moderately dense grazing pastures.

This explains why – at least during summer – herdsmen and livestock are nearly absent in the GGB SPA, whereas in the GGS NP people utilize all sites (Bedunah & Schmidt, 2000) save the driest semi-desert areas that are only occasionally grazed by camels. Judging from the vegetation maps these semi-desert areas are key habitats for the protection of Khulans (*Equus hemionus*), Gazelles (*Gazella subgutturosa* and *Procapra gutturosa*), and other species restricted to semi-desert environments (Reading et al., 1999). The mountain habitats also host many species that are in the focus of nature conservation as well, such as Argali (*Ovis ammon*), Ibex (*Capra sibirica*), Snow-leopard (*Uncia uncia*) and others. Their habitats cannot only be clearly defined on the vegetation map, but can easily be mapped from a digital elevation model as well.
Thus, the usage of a GIS including vegetation maps and topographic information allows the identification of key regions for protection. Candidates include rare plant communities such as *Festuca* spp.-steppes, or extrazonal woodland on steep slopes.

**Conclusions**

The Great Gobi A SPA and the two small Gobi national parks are scheduled for mapping within the next two years. Since a digital elevation model (Bolstad & Stowe, 1994) became recently available as an open source ([ftp://edcgs9.cr.usgs.gov/pub/data/srtm/](ftp://edcgs9.cr.usgs.gov/pub/data/srtm/)), these classifications will be based on initially stratified data sets (Hinton, 1999). The data described above will be classified again to achieve overall consistency of the entire data set.

The two maps produced so far are already used for habitat assessment (GGB SPA), and resource management (GGS NP). Within the next two years all protected areas in the southern Gobi will be mapped. Since this sums up to an area of approximately 90,000 square kilometers, sound and comprehensive background data will become available for the design of large-scale protection schemes for rare mammals of the deserts with their exceedingly large home ranges.

With the help of multi-temporal data such as MODIS (see Kawamura et al., 2003, Zhang et al., 2002) and NOAA-AVHRR (see an application for northern Mongolia in Burkart et al., 2000) a further approach will be made to get an idea on the phenology of the region (or cover change, see Munkhtuya et al., 2002; Leprieur et al., 2000). Climatic data processed on a coarse scale will be compared to multi-temporal data derived from remote sensing, which will then be used to elucidate the interplay of interannual changes in precipitation and the relative productivity of the vegetation (Goodchild, 1994) within mountain steppes, pediment steppes, and desert steppes. Possibly, above-ground biomass can be identified with the help of the LANDSAT data as well (Anderson et al., 1993), but this will require a calibration.

By combining all data from these works and other available data a complex (partly even multi-temporal) GIS can be created that is expected to facilitate nature conservation (Bridgewater, 1993; Gunin et al., 1999; Walsh et al., 1994) within the national parks as well as the resource management (M{"u}ller & Bold, 1996).

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