# Vegetation monitoring using different scale of remote sensing data

Junko Kunitomo, Yukihiro Morimoto

Department of Regional Environmental Science, Osaka Prefecture University, 1-1 Gakuen-cho Sakai, Osaka 599-8531, Japan

**Abstract**—This work sets out to simulate landscape model of Mu Us Desert in Inner Mongolia Autonomous Region of China at different spatial resolution using remote sensing images and distinguished landscape heterogeneity among different spatial resolutions. Landscape models were created from classification image of SPOT satellite data with 20m resolution and NOAA data with 1 km resolution. This study created landscape models of different scales by resampling the SPOT classified image using majority rule. The pixel resolution was increased from the finest scale of 20m by 20m up to 1000m by 1000m that was the coarsest spatial resolution. The Shannon diversity index was used to compare landscape models between different scales.

At the finer scale the verify small patches such as deciduous forest, shrub and reedswamp with high vegetation coverage set on matrices with low vegetation cover (moving sand dune and sparse grassland) were verified. Broadening of scale resulted to the loss of small patches and at 1000m resolution, matrix classes were dominant. At 1km resolution of NOAA data, the matrix classes which greatly related to the topography of Mu Us Desert were detected. Diversity index decreased during scale broadening and the difference between SPOT 1km scale model and AVHRR data was not significant.

The results showed that SPOT 20m model is good for the use of ecotone oriented revegetation planning, and NOAA 1km model is good for the seasonal and annual monitoring of each landscape unit, and revegetation planning at the regional level.

**Keywords**: vegetation monitoring, landscape model, remote sensing, Mu Us Desert.

## 1 Introduction

Landscape structure within the Mu Us Desert, a semi-arid region of northeastern China, is the basic focus of this study concerning land-use planning for sustainable vegetation restoration. Vegetation biomass in semi arid areas is constrained because of limited water resources, and over revegetation should avoided for sustainability.

Therefore we need to identify suitable locations and adequate size for revegetation. For this purpose, it is necessary to recognize landscape structure from different landscape models. Landscape structure could be perceived at different scales, because they describe individual land covers components or processes across a landscape (Quattrochi, 1990). The concepts of heterogeneity and homogeneity are scale-dependent (O'Neil, 1988). The question that we must consider here is scale or grain size, for example pixel resolution.

In this paper, we would like to examine landscape models that spatial pattern vary through changing scales by application of remote sensing. We compared images obtained broadening of scale in SPOT satellite data with the NOAA AVHRR satellite data using landscape quantitative indices. Finest scale is a 20m pixel resolution that is offered from SPOT and coarsest data is 1km pixel resolution that is a result of resampling by broadening function using majority rule for SPOT and NOAA original resolution. We would like to focus attention on clear meaning of landscape models at different resolution and utilization of different sensors for the same geographic area within the Mu Us Desert.

## 2 Materials and methods

### 2.1 Site description

The Mu Us Desert, 40000 $km^2$ in extent is situated in the southern part of the Ordos Plain surrounded the Yellow River in the Inner Mongolia Autonomous Region of China. The elevation of Ordos Plain is 1000—1500m in gently sloping from northwest to southeast. Desertification in this area advanced due to adverse weather conditions, soil infertility, and salt accumulation and over pasturage. It is certain that the most major cause of desertification is human interference, excessive cultivation and over-grazing.

Regional topography is characterized by following five elements: hill, moving sand dune, semi-fixed sand dune, fixed sand dune and lowland. The height of sand dune ranges between 5—30m and moves to southeast during winter because of northwest wind due to Siberian high atmospheric pressure. The groundwater level is high at lowland and water resources are abundant. Human activity that is mainly stock farming has had a great impact on fixed sand dune and lowland areas.

The climate is semi arid in character with annual rainfall of 362 mm and annual temperature of 6.4℃ at Uxin Ju that is positioned at northeast Mu Us Desert. Most of the annual precipitation is received in June to August, and yearly annual rainfall varies between 140—170 mm(Kamithika, 1986).

## 2.2 Data

Data from SPOT satellite on 22 June 1997 and 24 December 1995 (path 266 row 272) were used for landscape modeling. A supervised classification procedure with help from ground truthing data was implemented using ERDAS software (ERDAS, 1991). We were able to recognize areas of evergreen forest and shrub, which has a higher response at infrared band than the other area from winter image. The resulting image and the plant species within each category are shown in Fig.1 and Table 1.

**Table 1 Plant species within each cover type**

| Cover type | Species |
|---|---|
| Evergreen forest | *Sabina vulgaris*, *Pinus sylvestris* var, *mongolica*, *Pinus tabulaeformis* |
| Deciduous forest | *Salix matsudana*, *Salix psammophila*, *Populs* sp. |
| Shrub | *Artemisia ordosica*, *Hedysarum mongolicum*, *Caragana microphylla* |
| Reedswamp | *Typha latigolia*, *Phragmites communis*, *Calamagrostis epigeios* |
| Meadow | *Agrostis* sp. *Stipa* sp. *Puccienellia* sp. *Carex* sp. *Halerpestes* sp. *Potentilla* sp. |
| Sparce grasses | *Cynanchum komarovii*, *Chenopodium dasyphylla* |
| Semi fixed sand dune | *Psammochloa villosa*, *Agriophyllum squarrosum*, *Altemisia ordosica* |

We used the global land 1 km resolution AVHRR data by NOAA satellite, which was downloaded from internet by the Earth Resources Observation Systems (EROS) Data Center. NOAA data sets consisted of 10-day composite between June 21—30, 1993 and January 1—10, 1993. We selected range 40°N 107°E to 38°N 110°E, including the whole of Mu Us Desert. Supervised classification was conducted in the same way for SPOT image(Fig.2).

Resampling process was conducted on the classified image of SPOT through a broadening function using majority rule. The smallest pixel size (grain size) was 20m by 20m and was broadened by 20m increment up to 1000m(20, 40, 60, ..., 1000m). Out of this 50 data sets were produced as landscape models.

## 2.3 Land cover pattern analysis

It has been demonstrated in various researches that spatial pattern and heterogeneity of landscape changes with scale and can be quantified by ecological indices (Obeysekera, 1997; Cain, 1997). In this study we quantified changes of land cover pattern of different scales using the diversity index.

The diversity index essentially analyzes the relative number of type, size, shapes of patches present in mosaic and it is useful for measuring landscape heterogeneity and spatial pattern. In this case, we used the Shannon index (O'Neil, 1988) as follows:

$$H = -\sum Pk \ln Pk,$$

where $Pk$ is proportion of area in cover type $k$. Diversity indices were calculated to compare for examination of function of scale increasing.

# 3 Results

At 20m resolution of the SPOT image, we can recognize that there are some matrices with less vegetation coverage, for sample moving sand dune and sparse grassland, occupied about 60% of the entire area(Fig.2a). Some cover types with high vegetation coverage, for example deciduous forest, shrub and reedswamp, are set on the larger matrix (moving sand dune and sparse grass). The NOAA classified image (Fig.2) shows coarser and fewer categories than SPOT classified image. It implies that each category distinguished from NOAA comprised some categories of SPOT.

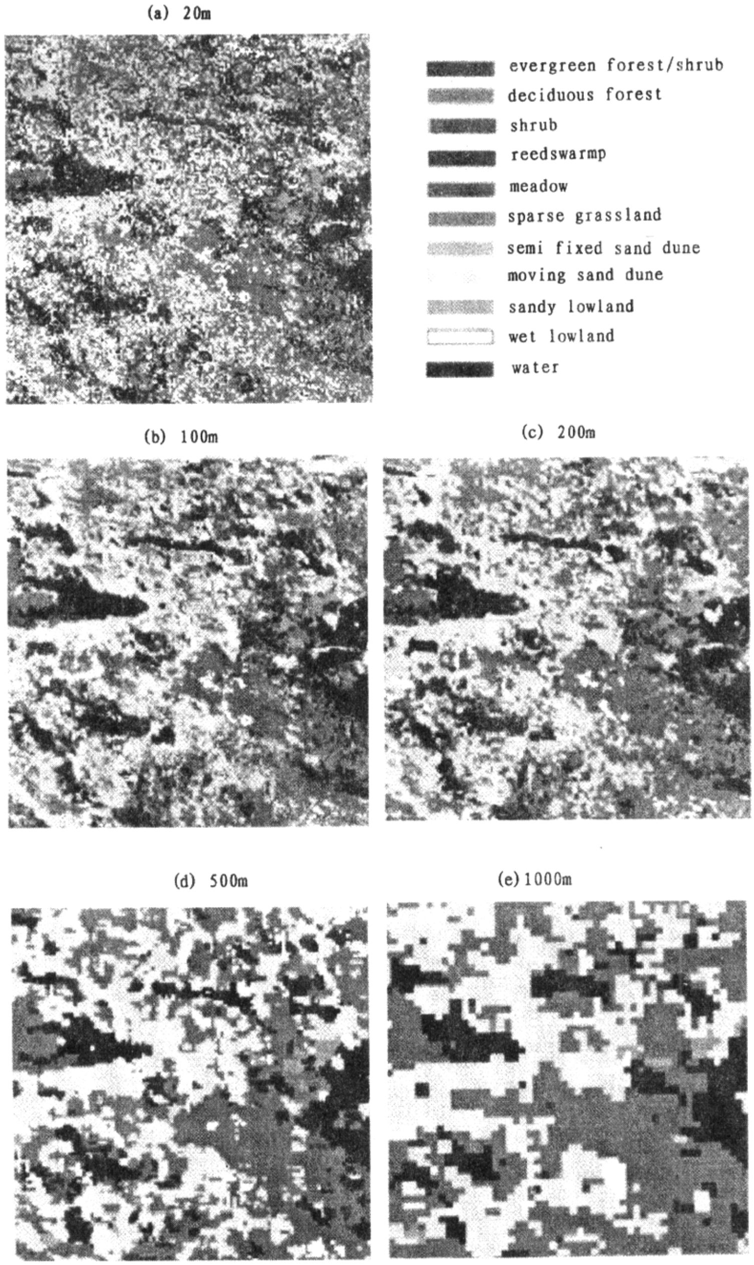


Fig.1 A series of broadning spatial resolution of SPOT classified image

A series of broadening pixel resolution of SPOT classified image is shown in Fig.1. These models illustrate that the mosaic of landscape consists of heterogeneous patches and matrices.

Fig.3 shows the area ratio of each cover type by topographical type from the result of broadening scale. Fraction of each cover type changed in the process of scaling up, and two changing trends are recognized. Matrices such as moving sand dune, sparse grassland, semi fixed sand dune and meadow were stable during scaling up, while small portion cover types were

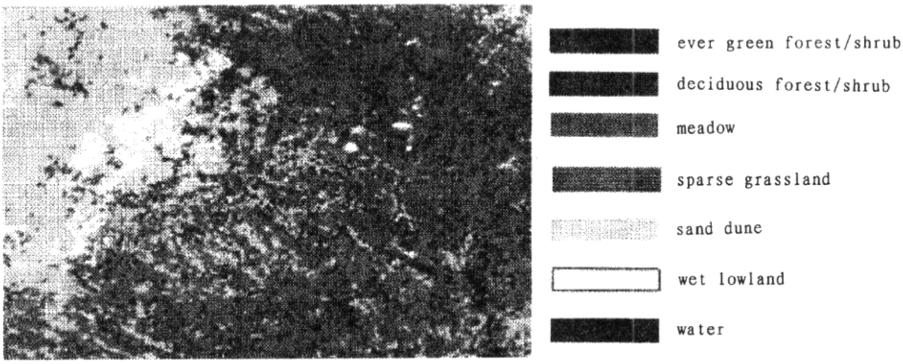


Fig.2 Land cover map of the whole Mu Us Desert, derived from AVHRR data

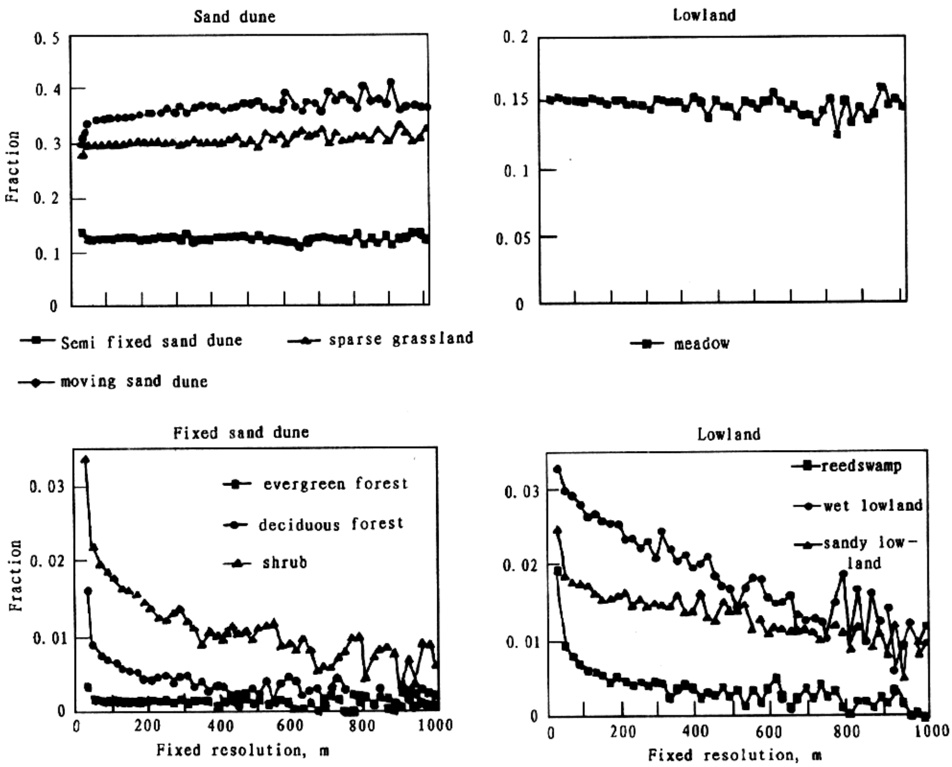


Fig.3 Fraction of cover types as a result of broadening scale

gradually lost, and almost disappeared beyond 800m resolution. At 1000m resolution, shapes of larger matrices (moving sand dune, sparse grassland, semi fixed sand dune and meadow) were recognized(Fig.1 and 3). These matrices, which include small but high vegetation cover patches inside, were considered to have a relationship to the topography of the Mu Us Desert.

The diversity index decreased by 20% as the result of broadening scale 20m scale to 1km scale, due to loss of some finer patches(Fig.4). The difference of diversity index between SPOT

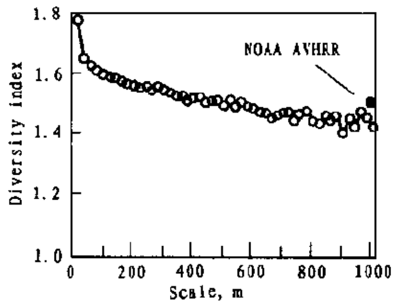


Fig. 4 Variation of diversity index as a result of broadening scale

1km scale model and AVHRR data was not significant. It follows from this that in the mater of category of cover type, 1km scale of SPOT is similar to AVHRR data, implying that matrix classes were dominant in each image.

## 4 Discussion

Through scaling of remote sensing data the heterogeneity and hierarchy of the Mu Us Desert landscape could be detected. 11 cover types were identified using SPOT data at 20m spatial resolution. We considered that these categories corresponded to vegetation communities observable in the field. As a result of broadening scale, small sized cover types (deciduous forest, shrub and reedswamp) were absorbed into the larger matrix. At 1000m resolution, matrix cover types (moving sand dine, sparse grassland, semi fixed sand dune and meadow) were dominant. While 1 km resolution of AVHRR data, 7 cover types were observed and it was possible to recognize matrix classes such as sand dune and sparse grassland that were related to topographical complexes. We can describe them as landscape types of the Mu Us Desert. Kobayashi (Kobayashi, 1990) has described the Mu Us Desert by four landscape types: hill, moving sand dune, fixed sand dune and wet lowlant by observations. We could get a similar result from satellite data, however, semi fixed sand dune and sparse grassland could be detected as large matrices in stead of fixed sand dune. This may have a relationship to the current status of desertification.

From these changing heterogeneity at different scales, we would like to focus attention on revegetation planning. It would be possible to utilize the SPOT data for the ecotone oriented planning of revegetation in determining the size and location of planting area. In the Mu Us Desert, the most important consideration for revegetation is sand dune stabilization. For this purpose, salix psammophila and Salix matsudana are planted around the moving sand dune. And for conservation of reedswamps and meadows, Salix matsudana have been planted in the edge of lowlands. However, over revegetation could lead to over usage of the limited water resource. Therefore using ecological indices such as LAI and biomass (Kunitomo, 1998) we can design the appropriate size and location of revegetation sites for the purpose of adequate water utilization.

Regarding coarse resolution data, we could recognize landscape units as matrix types from SPOT 1 km scale model and NOAA data. From this result, we can find vegetation coverage of matrices which is useful for planning revegetation methods of wide areas in the Mu Us Desert, e.g. aircraft seeding. *Artemisia ordosica* and *Hedysrum squarossum* are used as seeding plants and are dominant in semi fixed sand dune and fixed sand dune areas. In addition, the high temporal resolution offered by NOAA makes it possible detect seasonal and annual changes useful for monitoring of the revegetated areas.

**Acknowledgements**——The author grateful to Prof. Wang and Dr. Chen of Inner Mongolia Forestry College and Prof. Yoshikawa of Okayama Univ. for helping us during conducting groundtruth.

## References

Cain D H, Ritters K, Orvis K, 1997. Landscape Ecology, 12:199—212

Kamichika M, Yamamoto, T, 1986. Natural environment on the Mu Us Desert in the Inner Mongolia Autonomous Region of China——A few characteristics of meteorology and soil factor-Bulletin of Sand Dune Research Institute. Tottori University. 25—35

Kobayashi T, 1990. Journal of Japanese Society of Revegetation Technology, 15(4):43—57

Kunitomo J, Morimoto Y, 1998. Journal of the Japanese Institute of Landscape Architecture, 61(5):577—580

Obeysekera J, Rutchey K, 1997. Landscape Ecology, 12(1):7—8

O'Nell R V, J R Krummel, R H Gardner, G Sugihara *et al*., 1988. Landscape Ecology, 1:153—162

Quattrochi D A, Pelletier R E, 1990. Quantitative methods in landscape ecology(Eds. by Tuner M G, Gardner R H). Berlin: Springer-Verlag. 51—76