Geo-Coded Field Studies in Mongolia Grasslands

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Abstract

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The purpose of these studies was to develop a model which enables to estimate grassland productivity using remote sensing technology. Productivity estimates were acquired from biomass measured at different times throughout the year. The measurement period ranged from a few weeks to several months, from which annual productivity could be obtained. Data from past research activities demonstrated that 1) there is a close relationship between grassland vegetation coverage and biomass which holds true for every (grassland) species, and 2) satellite remote sensing can be used to estimate the grassland vegetation coverage. The overall goal is to use AVHRR, MODIS, or GLI data to develop a productivity model. The specific objectives of the model are 1) to describe the relationship between the spectral response obtained by the satellite sensor and grassland coverage, 2) to describe the relationship between grassland coverage and biomass, and 3) to correlate the results of the remote sensing data models with those of a separate model that enables to estimate productivity without using remote sensing data. Scaling issues and atmospheric satellite data correction are inherent remote sensing problems which need to be addressed prior to data collection. Combining ground-collected information from a limited area (~ m^2) with low- or mid- resolution satellite observation data from a larger area (~km^2) is a problem that may be overcome by using geo-sampling procedures. Although atmospheric correction in the Mongolian data is simplified by Mongolia's high altitude, the correction may be dealt with simply by performing optical thickness and related measurements. The major difficulty involves normalization of the effect of the Bi-directional Reflectance Distribution Function (BRDF). The first step is to obtain BRDF parameters suitable for the description of the BRDF.

Purpose and introduction

The purpose of these studies was to develop a model which enables to estimate grassland productivity using remote sensing technology. Productivity estimates were acquired from biomass measured at different times throughout the year. The measurement period ranged from a few weeks to several months, from which annual productivity could be obtained. Data from past research activities demonstrated that 1) there is a close relationship between grassland vegetation coverage and biomass which holds true for every (grassland) species, and 2) satellite remote sensing can be used to estimate the grassland vegetation coverage. The overall goal is to use AVHRR, MODIS, or GLI data to develop a productivity model. The specific objectives of the model are 1) to describe the relationship between the spectral response obtained by the satellite sensor and grassland coverage, 2) to describe the relationship between the grassland coverage and biomass, and 3) to correlate the results of the remote sensing data models with those of a separate model that enables to estimate productivity without using remote sensing data.

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Data acquisition

A three-step plan for data acquisition over the test sites was developed:

1 The size of the test site which was 3 km x 3 km and 2 km x 2 km area aimed at non-destructive observations and the rest of the area at destructive (areas of clipped grass) observations. The size of this area was comparable to that acquired from satellite sensors.

2 The variation in scale should be addressed at multiple levels. Since ground level sensors can only measure small areas (~m^2), the average of many points is required. Additionally, the sensors should be raised off the ground for measurements at a higher altitude and over a larger scale.

3 The parameters for developing the biomass-coverage relationship and the BRDF effect should include a 3-D structure measurement of the grass canopy.

Observations

Field studies were divided into four data collection activities: biomass measurement, surface information via car, BRDF measurement, and measurements via helicopter. There were four teams for the four activities with each team working in parallel with a few exceptions. At times, data acquired from one team overlapped with those from the other teams, such that the data parameters were comprehensively incorporated into the productivity model. Each part was as follows:

1 Biomass measurement

The purpose of this measurement was to obtain a short-term time series for biomass change. Each week during the measurement period of approximately one month a sufficient number of clipped grass samples were taken, and the percentage of the coverage, spectral reflectance, soil moisture, 3-D structure of the grass, etc were recorded. The 3-D laser scanner scanned the target area and detected the distance from the target (Fig. 1). The scanner output consisted of a two-dimensional distance array which can retrieve a 3-D structure of the target. The information from the 3-D structure can be used for developing the biomass-coverage relationship and for estimating the BRDF effect.

2 Mobile measurement for grassland surface information using a specially equipped truck

The purpose of this observation was to obtain reflectances of the site surface and to estimate the relationship between reflectance and physical parameters of the vegetation on the satellite scale. We developed a new observation system, a multi-sensor system, consisting of a spectrometer, thermometer, GPS, GPS camera and digital still camera. By observing many points from this system, data in the reflectance, ground temperature and ground images (vegetation coverage) were obtained at each of the measurement points (Fig. 2).

3 BRDF measurement

The purpose of this measurement was to analyze the BRDF effect. In order to estimate the BRDF effect on the grassland surface, the magnitude of change of apparent reflectance was determined using the BRDF measuring device. These instruments can record the spectral reflectance for any sensor angle. For different sun elevation angles, it is possible to obtain the reflectance for more than 70 different angles.

While measuring BRDF, it is possible to obtain an image of the apparent vegetation coverage using a CCD camera. In addition, the scaling problem can be addressed by taking measurements at many points. This procedure is necessary to compensate for the sensor's field of view which was too small to represent the average characteristics of the test site. The truck is equipped with the instruments needed so that many points on the site can be easily reached and measured (Fig. 3).

4 Radio Control Helicopter (RC-Heli) measurement

The purpose of this measurement was to evaluate data on different scales and resolve scaling issues. RC-Heli lifts the spectrometer, CCD camera, and GPS system enabling observations from different heights and providing information in different scales (Fig. 4). The GPS system provides the height of RC-Heli. Every four seconds, spectral information is determined. If the variability of spectral reflectance is large, a sufficiently large number of samples is needed for the stabilization of the reflectance. When this objective is attained, the resolution of the measurement area becomes representative of the average reflectance of the target area.

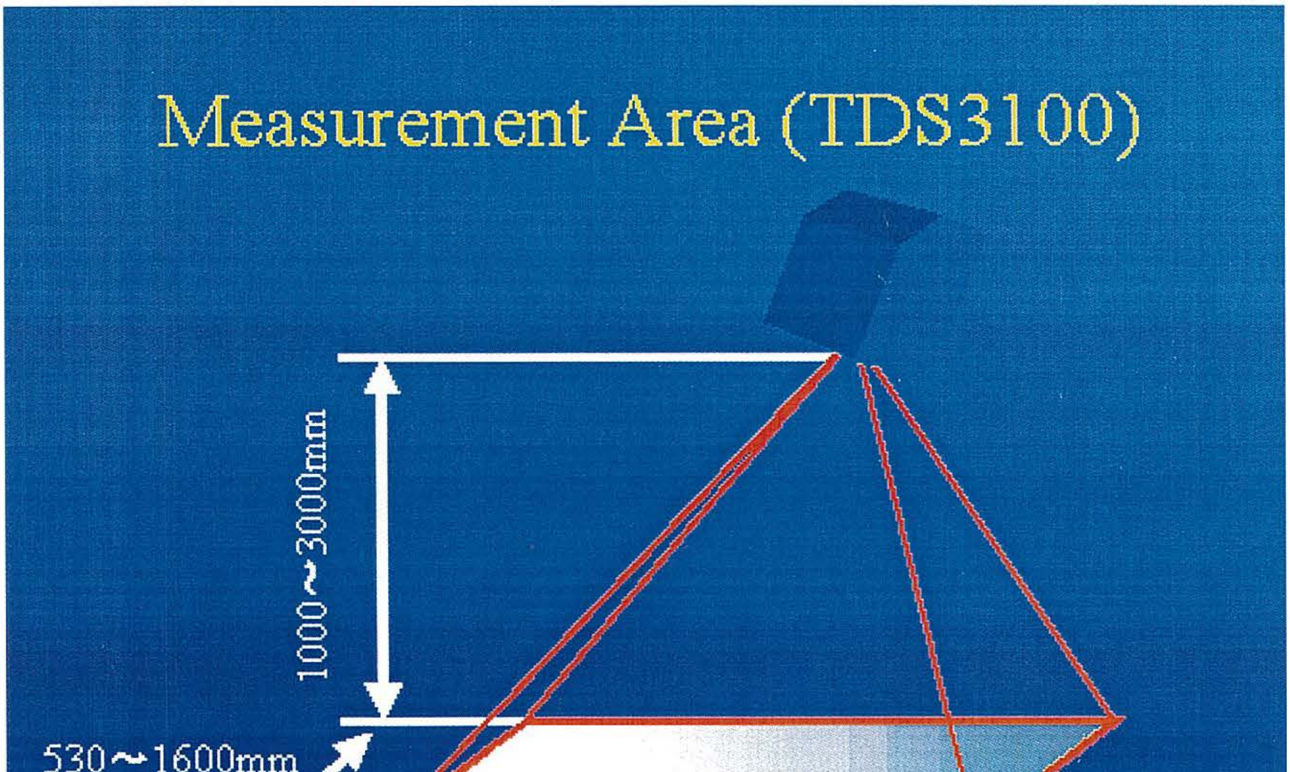

Fig 1 3D laser scanner

Fig 2 Mobile measurement system

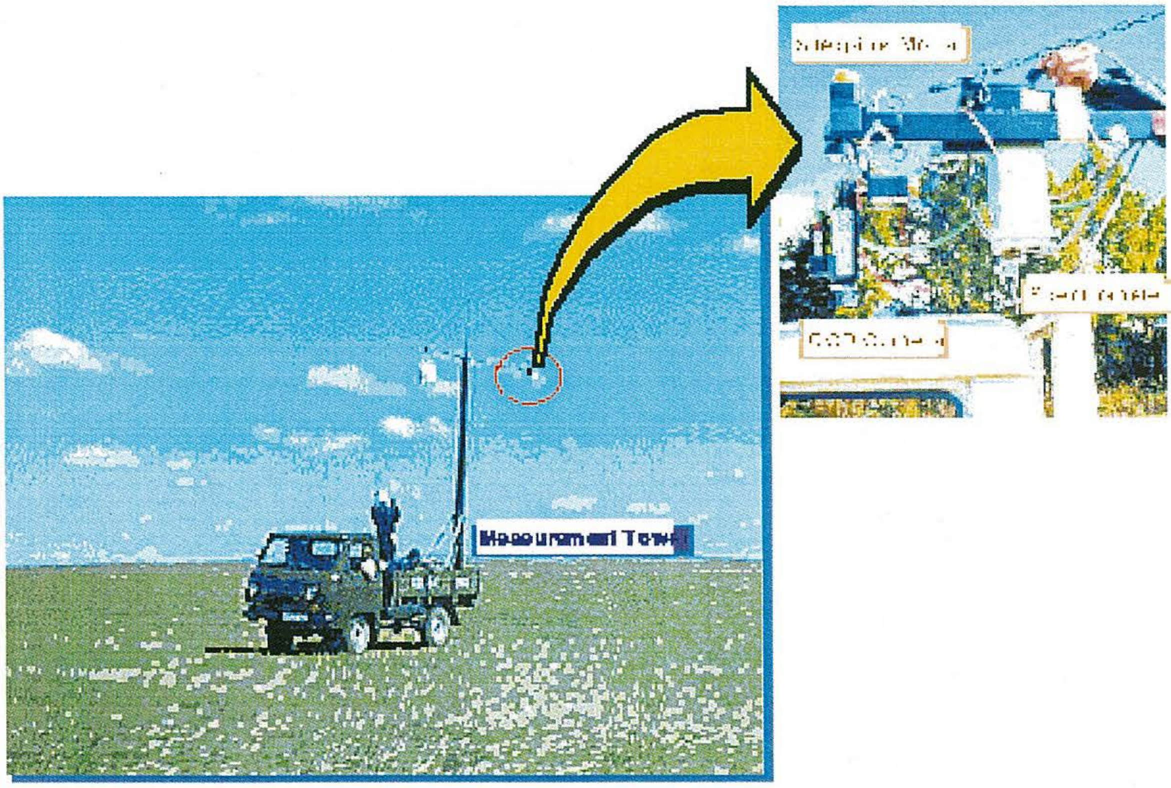

Fig 3 BRDF measurement system

Fig 4 Helicopter measurement system