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Application of Airborne Remote Sensing to Biomass Estimation - A case study on Field Science Center, Tohoku University -

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Abstract

Remote sensing is one of the techniques to sample a large area at once. It is expected for biomass estimation in regional area. An approach to estimate biomass on Field Science Center, Tohoku University (FSC) using aerial remote sensing data is presented. FSC is an experimental study site to consider production and consumption in the compost science program. Hyperspectral remote sensing data were obtained in 2007. LiDAR (Light detection and ranging) measurements were performed in 2008. Hyperspectral sensor is a kind of optical sensor, and land cover classification method using spectral information was applied. LiDAR technology provides vertical information of high accuracy and fine spatial resolutions for the earth surface target.

Land cover map in 2007 is generated from aerial hyperspectral image. Land cover change from 1960's to 2007 is extracted. The most of the land cover change is recognized in the north region of the target area. Total 265 ha of grassland area transformed to broadleaf forest from 1960's to 2007.

Digital Canopy Height Model (DCHM) was calculated by subtracting the Digital Terrain Model (DTM) from the Digital Surface Model (DSM) generated from LiDAR data. The footprint interval of laser beams from observed data is larger for single tree mapping. Therefore, possibility of forest canopy density estimation by the acquired data is examined. Standard deviation of canopy height on each plot is affected by thinning rates except for one heavily thinning plot.

Evaluation of types and amounts of local resources is necessary for their utilization. For the assessment of larger areas such as a municipality, satellite remote sensing data would be valuable.

Introduction

Remote sensing technology has been widespread for mapping and monitoring land cover. Remote sensing means research of objects from afar without actually touching them by using sensors (Legg, 1992). Acquired data provide us basic information for biomass estimation on the target area (Lu, 2006). Image of large earth's surface area is obtained at once using airborne and spaceborne remote sensing technique.

Optical remote sensing sensor image contains spectral information of the targets. Land cover type can be uniquely identified by the optical remote sensing data. Fine spectral resolution image is obtained using hyper-spectral sensor, and it is expected to estimate precise land coverage, as mineral type and vegetation species.

LiDAR (Light detection and ranging) technology provides vertical information of high accuracy and fine spatial resolution for the earth surface target. Forest attributes such as canopy height can be directly retrieved from LiDAR data. Direct retrieval of canopy height provides opportunities to model aboveground biomass (AG biomass) and canopy volume (Lim et al., 2003). The use of small footprint airborne LiDAR systems is one of the main fields of research in the last decade (Koch, 2010).

We have been attempting to estimate biomass on Field Science Center, Tohoku University (FSC) using various remotely sensing data (Namiwa, 2009, Yabe, 2012, Yabe et al., 2013, Yonezwa et al., 2013). FSC is an experimental study site to consider production and consumption in the compost science program. We report result of land cover change estimation from 1960's to 2007 using aerial hyper remote sensing data. An attempt of LiDAR measurements on FSC is also reported.

Test Site

FSC is located in the hilly and mountainous area on the west side of Miyagi prefecture in Japan. Total area is about 2,200 ha. It has been used for experimental farm, grassland and forestry of the faculty of agriculture, Tohoku University since 1947. It was used for war-horse training center until the end of world war II. Digital field science center system using GIS and remote sensing data has been developed since 2004 (Saito et al., 2009). There are records for crop, forest and livestock production by the university since the 1950s. The vegetation in the 1960s was recorded on 1:10,000 map. This map is estimated to be drawn in 1968 or 1969 (Nishiwaki, 1998). Change in the land use of this site until 1995 was summarized by Nishiwaki (1998).

Airborne Remote Sensing

Hyper-spectral imaging data

Aerial hyper-spectral imaging data were taken in the test site on 24 July, 11 August, 20 September, 21 September and 25 November in 2007. Observation sensor was Airborne Imaging Spectroradiometer for Applications (AISA) Eagle and Hawk owned by PASCO Co.. AISA Eagle operated across the VIS/NIR portion of the spectrum (400-1,000 nm), resolving spectral differences as 2.9 nm with 1.5 m spatial resolution. AISA Hawk obtained image of 8.5 nm spectral resolution in the spectral range of 1,000-2,400nm with 3 m spatial resolution. The observation swath width was 900 m and all of Kitayama area around FSC was covered by plural paths oriented by the approximate north-south direction. The observation was performed by the collaboration with Japan Space Systems.

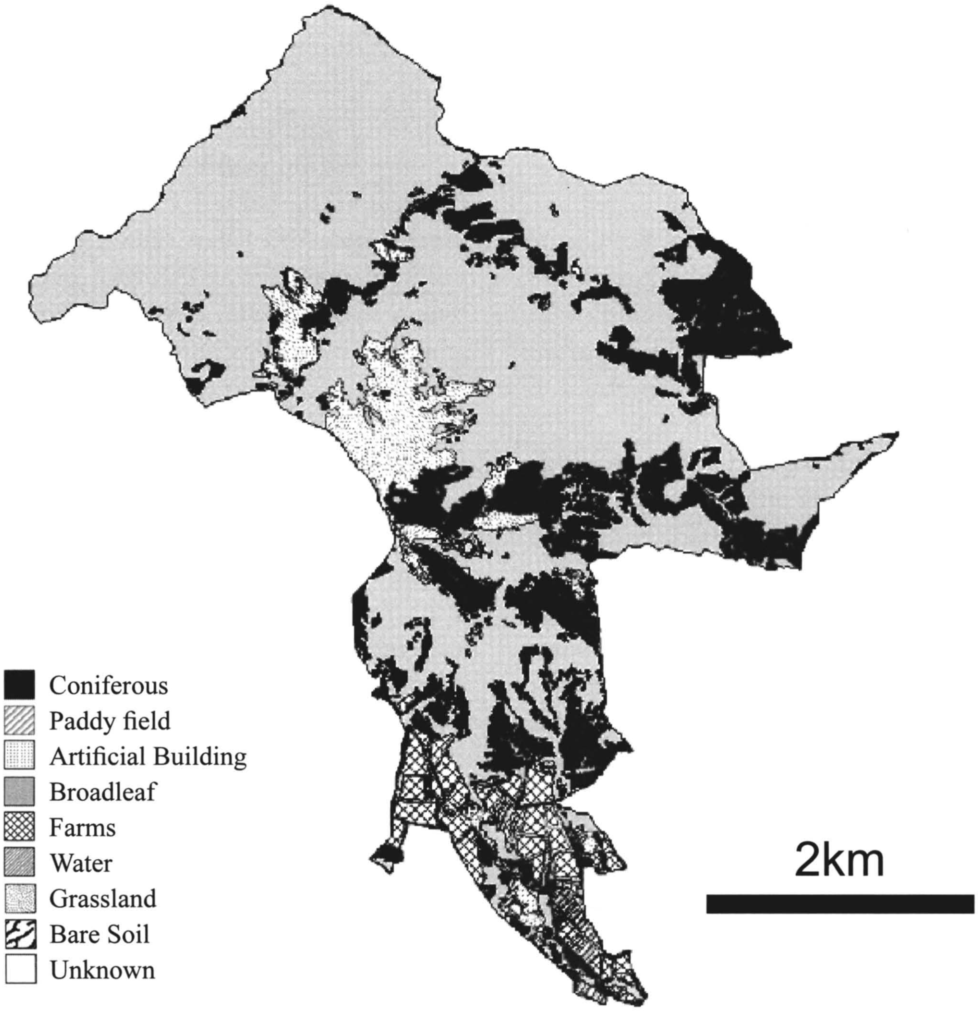


Figure 1. Land cover map in 2007 generated from aerial remote sensing data (Namiwa. 2009).

LiDAR data

The LiDAR dataset was acquired on 13, 14 and 26 November and 3 December 2008 by Ecosystem Adaptability Global COE, Tohoku University. All of Kitayama area around FSC was observed in the 14 flight courses, and one course was approximately northwest-southeast direction and other 13 flight courses were approximately north-south direction. In north-south direction measurements, footprint interval of laser beams was 2 m and swath width was ca. 900 m. The footprint interval of laser beams was 0.5 m in the measurement of the northwest-southeast flight course.

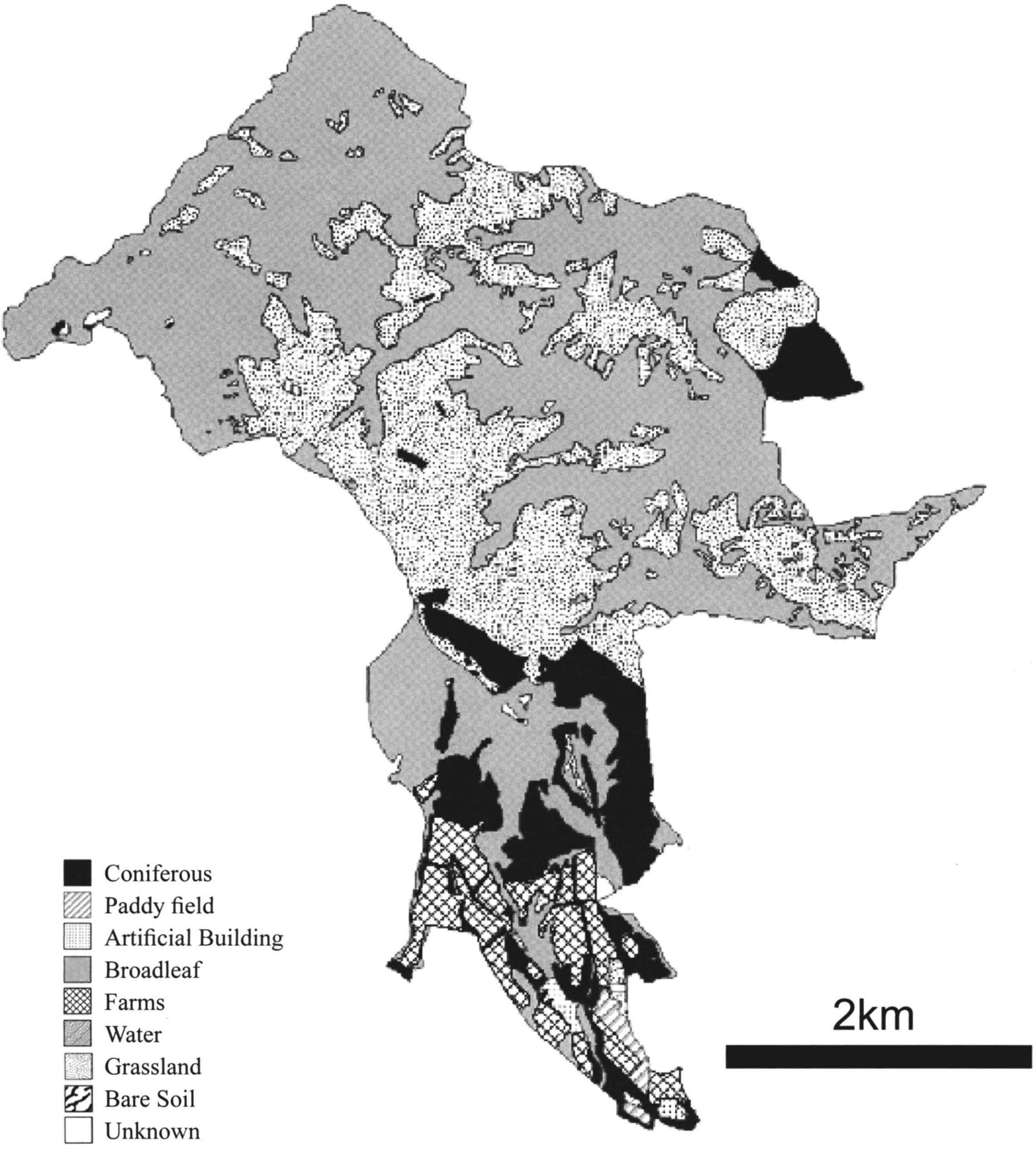


Figure 2. Land cover map in the 1960s (Namiwa. 2009).

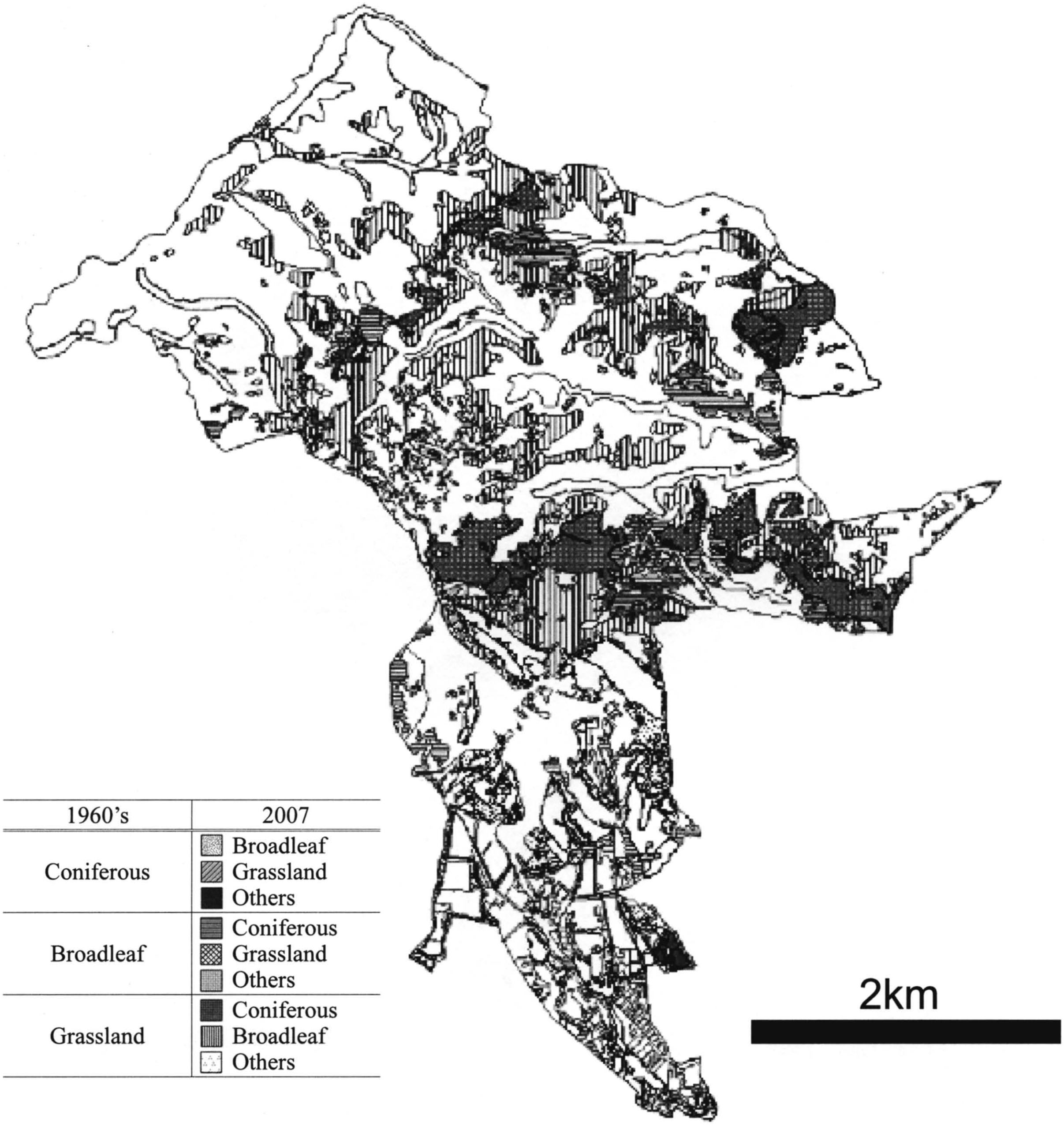
Results and Discussions

2007 land cover

Land cover map in 2007 was generated from aerial hyper-spectral image and shown in Figure 1 (Namiwa, 2009). Most of the target area was covered by coniferous and broadleaf forests.

Land cover change from the 1960's to 2007

Land cover map in the 1960s is shown in Figure 2. This map is based on a paper vegetation map generated in the 1960s that was scanned and digitized by Namiwa (2009). It is obvious that the large grassland area was expanded in the north region of the target area.



1960's	2007
Coniferous	░ Broadleaf ▨ Grassland ■ Others
Broadleaf	▤ Coniferous ▩ Grassland ▒ Others
Grassland	▦ Coniferous ▥ Broadleaf ☐ Others

Figure 3. Land cover change from the 1960s to 2007 (Namiwa. 2009).

Figure 3 shows vegetation change from the 1960s to 2007. The landcover transformation is extracted and the transformed area is 32% of the total area. The largest change in landcover class is from grassland to broadleaf forest and it occupies 49 % of the transformed area. The change from grassland to coniferous forest, broadleaf forest to coniferous forest, and coniferous forest to broadleaf forest is 23%, 14 %, and 7 %, respectively.

DCHM and attempt for biomass estimation

Digital Surface Model (DSM) and Digital Terrain Model (DTM) were extracted from obtained LiDAR data. Digital Canopy Height Model (DCHM) was obtained by subtracting the DSM from the DTM.

To estimate AG-Biomass, it is necessary to estimate forest canopy height and density. It is pointed out that 3 hits per m^2 of the pulse density in the plots are necessary for the extraction of single tree information from DCHM (Nawamura et al. 2007). The footprint interval of laser beams in the observed data is larger for single tree mapping. Therefore, possibility of forest canopy density estimation by the acquired data is examined (Yonezawa et al., 2012). DCHM in the experimentally thinning plots in FSC were analyzed (figure 4). This plot includes heavy thinning plots, weak thinning plots and no thinning plots. Standard deviation of canopy height in each plot is affected by thinning rates except for one heavily thinning plot. Relative frequency of 0 m is larger than 1 m in the heavily and lightly thinning area except for one heavily thinning plot of which standard deviation is less than the lightly thinning areas.

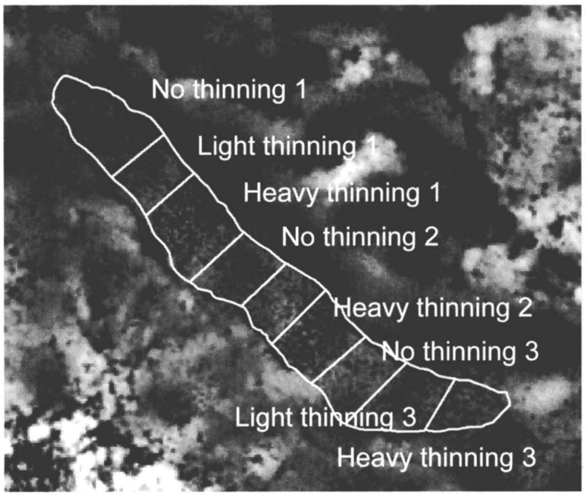


Figure 4. DCHM for experimentally thinned plots (Yonezawa et al., 2012).

Conclusion

An experimental study of biomass assessment using airborne remote sensing in a hilly and mountainous study site is presented. Land cover classification is one of the analysis methods by multispectral optical remote sensing data and the analysis result provides fundamental information for biomass estimation. Land cover change analysis is useful to evaluate transformation of local resources. Airborne LiDAR is powerful a tool to estimate AG-biomass if we do not have to think about measurement cost. The measurement data of FSC in 2008 has a large footprint interval of laser beams. Moreover, it is necessary to find effective method for biomass estimation to use this data.

Evaluation of types and amounts of local resources is necessary for their utilization. For the assessment of larger areas such as a municipality, satellite remote sensing data would be valuable.

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