Abstract

Shirakami Mountains are located in northwestern part of Japan, and we have much snow, more than 1 m in depth, in winter. The Mountains include the last remaining virgin stand of beech (Fagus Crenata) forest, namely, the typical Japanese climax cool-temperate broadleaf deciduous forest. The area of the Mountains was listed in World Heritage Natural Resource by United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1993. In order to take effective measures to keep and manage this precious forest, it is important to know topography and vegetation in detail. The 3 km$^2$ study area was selected, and measured by airborne LIDAR (light detecting and ranging). The measurement data gave five-meter-grid digital elevation model (DEM) and vegetation height. According to the field survey, it is thought that the vegetation height more than 25 m reflects height of tall beech trees.

As a result, snow avalanche furrows were interpreted in detail on the contour map from the DEM. Furthermore, slope inclination was calculated using the DEM, and the relation between slope inclination and vegetation height more than 25 m were investigated. This study could not conclude the 25 m height vegetation is concentrated on the gentle slope such as 5-10 and 10-15 degrees.

1. INTRODUCTION

Shirakami Mountains, which are the largest virgin remnant of the cool-temperate beech forest, are located in the northeastern part of Japan (Figure 1). The forest of beech (Fagus Crenata), which is broadleaf deciduous tree, is virtually entirely undisturbed, and the area is a wilderness with no access trails or man-made facilities. The forest is significant in the traditional Japanese view of nature. Therefore, in 1993, United Nations Educational, Scientific, and Cultural Organization (UNESCO) registered the core zone 101.39 km$^2$ and the buffer zone 6,800 ha in the Mountains as World Heritage Natural Resource based on Convention Concerning the Protection of the World Cultural and Natural Heritage. To keep this precious forest, it is important to know topography and vegetation in detail. In this study, the area of 3 km$^2$ was selected, and topography and vegetation height were mapped using airborne LIDAR (light detecting and ranging).
2. STUDY AREA

Study area is southwestern part of Shirakami Mountains. The forest mainly consists of beech, but it is actually the mixture of beech, maple tree (*Acer pictum*), magnolia (*Magnolia obovata*), and so on. It includes Mt. Hutatsumori (1,086 m), which consists of late Miocene granite, but almost all of the study area consists of mudstone (Hayaguchigawa formation) deposited in middle Miocene (Ozawa et al., 1983). The elevation of the study area is between c.a. 700 m and c.a. 1,100 m, and gentle slope caused by the landslide are situated at the center of the study area. The beech forest mainly extends on the gentle slope (Photo 1, left), which consists of mudstone. A part of the gentle slope surface is thickly covered with granitic deposit, which is thought to be brought by snow avalanches in winter and the debris flows in summer. Steep slopes (Photo 1, right) of the Mt. Hutatsumori, which consists of granite, the beech forest is scarce, and instead of the forest, shrub (e.g. *Alnus pendula* matsumura) and grass (e.g. *Angelica ursina*) grow. Avalanche furrows (Sekiguchi and Sugiyama, 2003) and gullies incise the steep slope, and sediments were sent down to the gentle slope.
3. AIRBORNE LIDAR

To prepare topographic map, and to calculate vegetation height, airborne LIDAR data were measured in the study area. Airborne LIDAR is an active sensor that measures the distance from the sensor to the ground on which the laser beam is reflected (Figure 2). By a scanning mirror mounted in front of laser transmitter/receiver measures the distance on many points in cross-track direction and an area with some swath width is measured along with the forward movement of the aircraft. Sensor positions and attitudes as well as scanning angles of the mirror are measured onboard (Figure 2). The three dimensional positions of the ground targets are obtained by combining these data.

The airborne LIDAR data were measured in July 30 and October 31, 2004. Digital terrain model (DTM) was produced from the October 31 data when the leaves have fallen. The measurement accuracy of DTM is 0.15 m in elevation, but the accuracy tends to be reduced to 0.4-0.6 m when the measurement area is covered with vegetation (Sato et al., 2004). Five-meter-grid digital elevation model (DEM) was generated from the DTM, and tint map and contour map was prepared based on the DEM. Furthermore, slope inclination was calculated using nearest three by three DEMs. Digital surface model (DSM), which reflect top of the vegetation height, was generated from the July 30 data when the trees and vegetation grow thick.

![Airborne LIDAR](image)

Figure 2: Airborne LIDAR

4. RESULT AND DISCUSSION

4.1 Topographic map

The topographic map was produced as contour map and tint map. The tint map covering whole study area is shown in Figure 3 and contour map is shown in Figure 4. Figure 3 was produced by overlapping shading map, which gives us stereoscopic vision. It was found to be helpful to know landform approximately, because relief is visually
comprehensible (Sekiguchi et al., 2003). In Figure 3, the lower the elevation is, the bluer the color is, and the higher the elevation is, the redder the color is. The light is given from northwestern direction and shade is cast on the ground.

Figure 3: Elevation tint map superimposed on shading map. The black frame in the figure indicates the area of Figure 4.

Figure 4: Contour map
Figure 4 is the contour map of the steep slope on Mt. Hutatusmori. In the figure interpreted landform are described. Many avalanche furrows incise steep slope, and at the lower end of the furrows alluvial cones and snow avalanche deposit exist.

Figure 5 is the slope inclination map. The gentler the slope inclination is, the bluer the color is, and the steeper the slope inclination is, the redder the color is. The red-colored slope is not only on Mt. Hutatusmori but also around the four sides of the study area. The blue-colored slope is mainly located at the center of the study area.
Figure 6 shows slope inclination frequency at the interval of five degree on the five-meter-grid DEM, but total counts are given on the slope more than 40 degree. In the figure the total grid counts of the DEM was 135,321. The range from 0-5 degree to 35-40 degree in the figure are paid attention to, it was found that the steeper the slope inclination is, the more the grid counts is.

4.2 Vegetation height map

Figure 7 shows vegetation height map calculating of DSM-DTM. Tall trees cover slopes, the vegetation height reflects tall trees canopy height, but grasses only cover slopes, the vegetation height reflects grass height.

Comparing Figure 7 with Figure 5, vegetation height on the steep slope of Mt. Hutatsumori is low (0-5m) and it describe the actual field as shown in Photo 1, right. On and around the summit of Mt. Hutatsumori, where slope is gentle, vegetation height also low. This reflects alpine heath, according to interpretation of aerial photographs taken in July 30, 2004.

![Vegetation height map](image)

Legend

- 0–5m
- 5 - 15m
- 15 - 25m
- >25m

Figure 7: Vegetation height map based on DSM-DTM

Vegetation height more than 25m seems to be located at the gentle slope, and the relation between them was investigated. In Figure 7, the grid counts of vegetation height more than 25 m is 37,493. The frequency of 37,493 was investigated according to the slope inclination at the interval of five degree. The result is shown in Figure 8, and the range from 0-5 degree to 35-40 degree in the figure are paid attention to, it was found that the steeper the slope inclination is, the more the vegetation grid counts is, except 10-15 and 15-20 degrees. Grid counts of 10-15 and 15-20 degrees were approximately equal of 4097 and 4020. In Figure 8, it is not concluded that vegetation height more than 25 m is concentrated in the gentle slope such as 5-10 and 10-15 degrees. Figure 9, the distribution of the vegetation height more than 25 m mapped according to the slope inclination, is based on Figure 8. In the Figure 9,
vegetation height more than 25 m is located not only on the gentle slopes such as 10-15 degree but also steep slope such as 30-35 degree, along the gullies incising the gentle slopes and so on.

Figure 8: Relation between vegetation height (>25 m) and slope inclination

Figure 9: Relation between vegetation height (>25 m) and slope inclination

6. CONCLUSION

Topography and vegetation height in Shirakami Mountains were mapped. In mapping them, airborne LIDAR data were measured, and DTM and DSM were generated.
Tint map of elevation overlaid by shade map, which was produced from DTM, was helpful to understand approximate landform in the study area. Location of avalanche furrows and other landform features were mapped on the contour map.

Vegetation height was calculated using DSM-DTM, and it was found that the location where shrub and alpine heath grow is correspondent with the low vegetation height sites. The relation between vegetation height more than 25 m and slope inclination, but this study could not conclude the 25 m height vegetation is concentrated on the gentle slope such as 5-10 and 10-15 degrees.

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References


A biography of the presenting author