

## LANDSCAPE ECOLOGICAL MAPPING USING LIDAR DATA FOR BIODIVERSITY EVALUATION

M. Koarai <sup>a,\*</sup>, T. Nakano <sup>a</sup>, H.P. Sato <sup>a</sup>, T. Yoshida <sup>b</sup>, A. Yamashita <sup>b</sup>, R. Nagasawa <sup>c</sup>, Y. Hioki <sup>c</sup>

<sup>a</sup> Geo-Spatial Information Authority of Japan, 1 Kitasato, Tsukuba, Ibaraki 3050811, Japan  
- (koarai, t-nakano, hsato)@gsi.go.jp

<sup>b</sup> Rakuno Gakuen University, Ebetsu, Hokkaido, 0698501, Japan - (yoshi-ty, akio)@rakuno.ac.jp

<sup>c</sup> Tottori University, Koyama, Tottori, 6808553, Japan - (nagasawa, hioki)@muses.tottori-u.ac.jp

**KEY WORDS:** Air born laser survey (LIDAR), Landscape ecology, Three dimensional vegetation structure, Automated micro landform classification

### ABSTRACT:

The authors try to produce landscape ecological map for estimation of biodiversity using the airborne laser survey (LIDAR Survey) data. Study areas are Mt. Rausu of Shiretoko Peninsula, Hokkaido Island as an example of World Natural Heritage Area of Japan and Mt. Dougo of Chugoku Mountain area as an example of Satoyama Region. Basic legend of landscape ecological map consists of the combination of three dimensional vegetation structure classification using detailed DSM (Digital Surface Model) and micro landform classification using detailed DEM (Digital Elevation Model). By the LIDAR Survey in summer and autumn seasons, the authors got 0.5m grid DSM and DEM in summer and 1 or 2m grid DSM and DEM in autumn. LIDAR data is useful for detection of micro landform under forest area by using last pulse data in autumn season. Vegetation classification has been done using three dimensional vegetation structure detected by the difference between LIDAR data in two seasons. The legend of three dimensional vegetation structure maps consists of the combination of vegetation height, thickness of crown and difference in two seasons (deciduous single layer tree, deciduous multiple layer tree and evergreen tree). Landform classification has been done by two methods. One is automatic landform classification using 1 or 2m grid DEM, combining three categories, such as slope degree, convexity and roughness. Another is manual interpretation of 1m interval counter line produced from 1m grid DEM. The results of overlay analysis between vegetation classification and landform classification are as follows: At the Mt. Rausu, three dimensional vegetation structures are subject to site elevation rather than micro landform classification. At the Mt. Dougo, some early deciduous high thin crown trees (a kind of nut) are located in historical mining sites (Kanna-Nagashi) with following micro landform categories such as gentle slope, concave and rough texture. Now, the authors are considering new type legend of landscape ecological map of Shiretoko Peninsula and Chugoku Mountain in this research. In this paper, the authors introduce the utilization method of landscape ecological map for natural environment conservation planning.

### 1. INTRODUCTION

For biodiversity assessment, in addition to the distribution of species and the degree of deterioration of the natural environment, the topographic conditions of the assessment area must also be examined. Thus, the importance of a landscape ecological viewpoint that allows understanding of an ecosystem based on its topographic conditions is now recognized. Since Japan is a contracting state of the Convention on Biological Diversity, the acquisition of information on its biodiversity based on landscape ecology is essential. This study aims at understanding the detailed topographic information and the three dimensional structure of vegetation using airborne laser survey data (LIDAR data), and developing a technology to construct a dataset to be used for biodiversity assessment in Japan, based on the above understanding.

### 2. STUDY AREA

The authors have selected two study areas. One is Shiretoko Peninsula, Hokkaido Island as a wilderness area, and another is Chugoku Mountain, Tottori Prefecture as a Satoyama rural area (Figure 1).

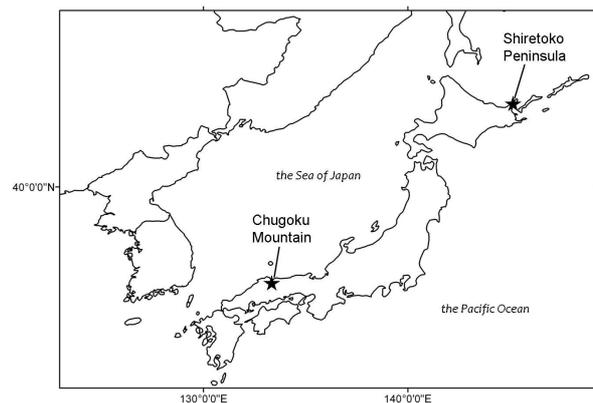


Figure 1. Location map of study areas

The Shiretoko Peninsula is the world natural heritage site, and a great portion of the peninsula is designated as Shiretoko National Park. The park has been subject to strict regulation as a nature preserve, and entering is prohibited in some area. The objective of the study is to understand biodiversity of this nature preserve, and to establish a landscape ecological map to

\* Corresponding author.

ensure protection of biodiversity by using high resolution LIDAR data.

The Chugoku Mountains is a typical region representing the environment of Satoyama rural areas. Research is under way to create a landscape ecological map to clarify the relationship between topography and vegetation at an iron sand mining (Kanna-Nagashi) site, and to investigate the effects of human interference activities on wildlife habitat.

### 3. LANDSCAPE ECOLOGICAL STUDY OF SHIRETOKO PENINSULA USING LIDAR DATA

The authors have been trying to produce landscape ecological maps for estimation of biodiversity using LIDAR data. The

targeted area is the south east foot of Mt. Rausu in Siretoko Peninsula, Hokkaido (Figure 2). Basic legend of landscape ecological map will consist of the combination of three dimensional vegetation structure classification using detailed DSM (Digital Surface Model) and micro landform classification using detailed DEM (Digital Elevation Model).

The authors obtained 0.5m grid DSM and DEM of four square kilometres on the south east foot of Mt. Rausu along a hiking trail in early September, 2008. And vegetation classification map with three dimensional vegetation structure was made by combining summer season (early September) 0.5m grid LIDAR data and archived autumn season 2m grid LIDAR data.

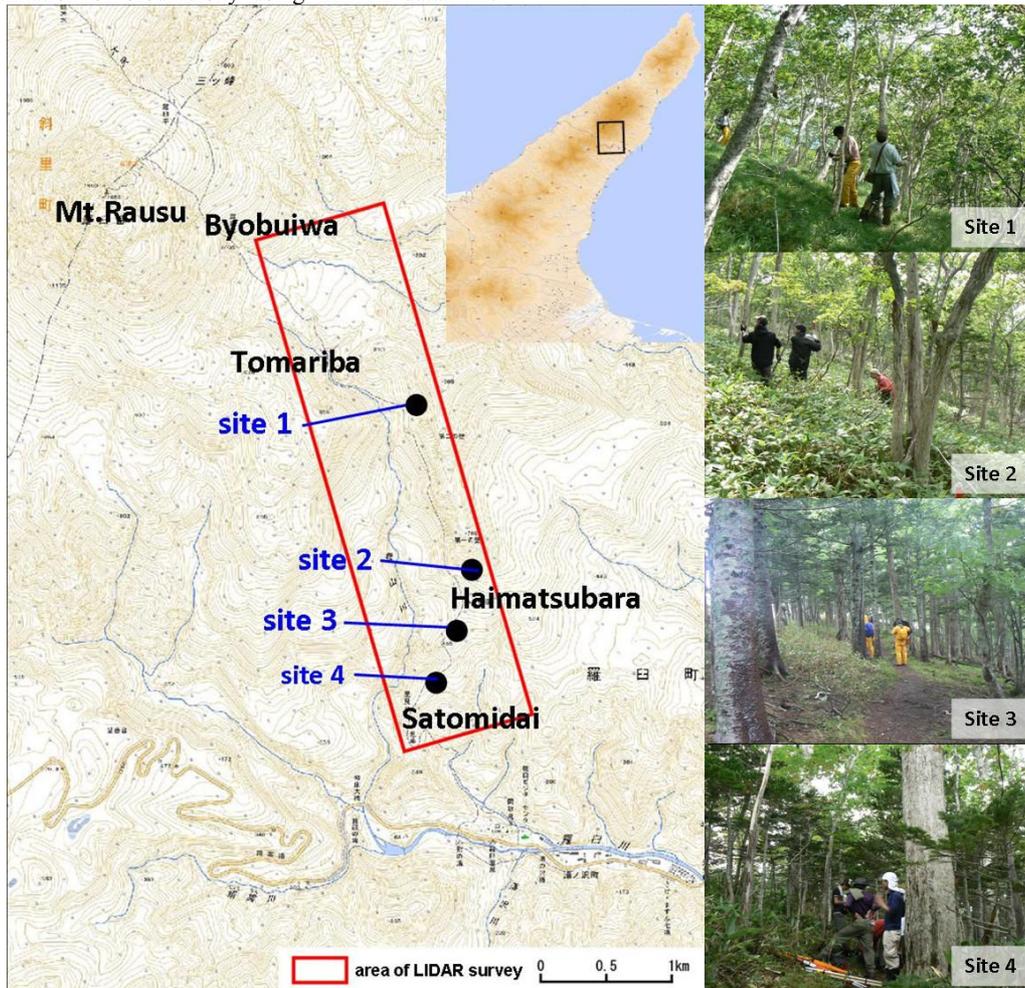


Figure 2. Area of LIDAR survey on south east foot of Mt. Rausu and photo of each ground truth site

Vegetation classification has been done using three dimensional vegetation structure detected by the difference between DSM data in two seasons. Algorithm of producing LIDAR vegetation map (three dimensional vegetation structure map) is as follows. The legend of LIDAR vegetation map consists of the combination of vegetation height, thickness of crown and difference in two seasons (deciduous single layer tree, deciduous multiple layer tree and evergreen tree).

Vegetation height of each grid is calculated by difference of DSM and DEM. Figure 3 shows histogram of vegetation height of representative colony, which is the result of overlay analysis between vegetation height by LIDAR and Actual Vegetation Map with 1/25,000 scale by the Ministry of Environment. As the result, vegetation height is classified into four categories

such as bare, grass and *Pinus pumila* (under 1.5m), low (over 1.5m and under 6m), middle (over 6m and under 10m) and high (over 10m). Thickness of crown of each grid is calculated by difference of max value and minimum value of DSM random point data except DEM. Thickness of crown of high tree is classified into two categories such as thin (under 10m) and thick (over 10m). The authors define that evergreen trees are those with difference between vegetation height on summer (Hs) and vegetation height on winter (Hw) under 3m and Hs over 7m, and other trees are deciduous tree. And deciduous tree, which Hw is over 5m is defined to deciduous multiple layer tree, because there is small evergreen tree under deciduous tree, other is deciduous single layer tree. Figure 4 shows the algorithm of vegetation classification of this study. Using this algorithm, it

is possible to classify vegetation with eleven categories. Figure 5 shows LIDAR vegetation map of south east foot of Mt. Rasue.

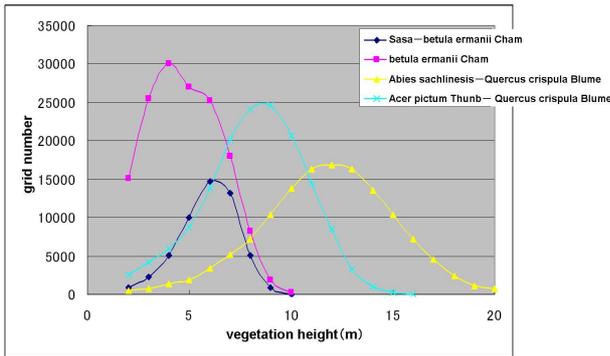


Figure 3. Diagram of height of each colony

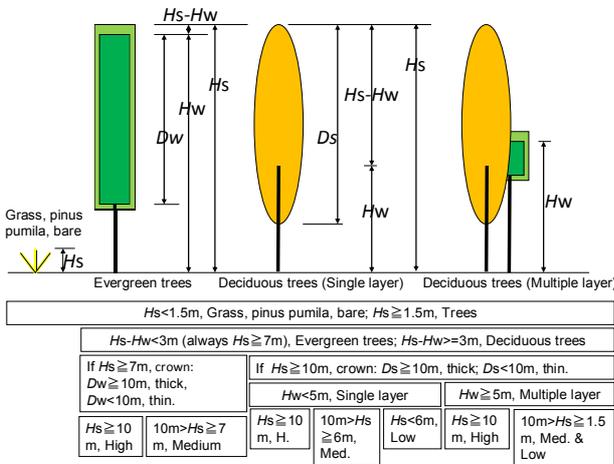


Figure 4. Algorithm of vegetation classification

Legend of vegetation classification by LIDER

class	tree height	crown thickness
bare, grass, pinus pumila		
deciduous (single)	low	
	middle	thin
		thick
deciduous (multiple)	middle	
	high	thin
		thick
evergreen	middle	
	high	thin

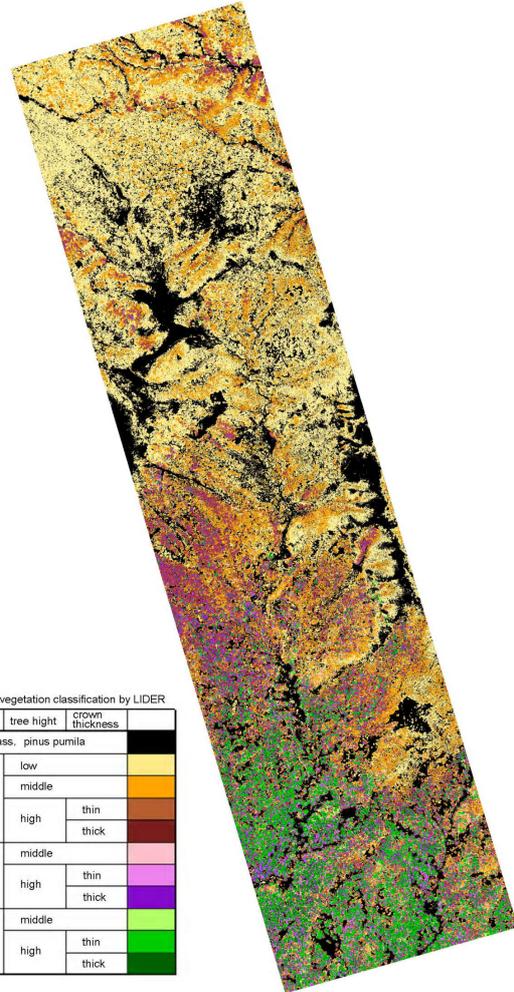


Figure 5. LIDAR vegetation map on the south east foot of Mt. Rausu

The results of comparison between LIDAR vegetation map and Actual Vegetation Map with 1/25,000 scale by the Ministry of Environment shows that LIDAR vegetation map is corresponding to Actual Vegetation Map. In this study, the authors carried out ground truth survey on four sites (Figure 2). Figure 6 shows the projected plan of the crowns on site4 with LIDAR vegetation classification. The results of comparison between LIDAR vegetation map and ground truth data shows that LIDAR vegetation map is not corresponding completely to ground truth data on Mt. Rausu, because of the size difference between crown size of tree and grid side of LIDAR vegetation map.

LIDAR data is useful for detection of micro landform under forest area by using last pulse data in autumn season. Automatic landform classification was done using 2m grid autumn season DEM, by combining three categories, such as slope degree (gentle, middle, steep), convexity (convex and concave) and roughness (rough, smooth) derived from the DEM. Figure 7 shows automated landform classification map with twelve category.

The results of overlay analysis of LIDAR vegetation map and automated landform classification map are shown in figure 8 and 9. Bare, grass and *Pinus pumila*, and deciduous single layer have high ratio of gentle slope compared with deciduous multiple layer and evergreen. There is gentle slope of pyroclastic flow deposits on high elevation area. With these reasons, the authors consider that three dimensional vegetation structures on Mt, Rausu are subject to site elevation rather than micro landform classification.

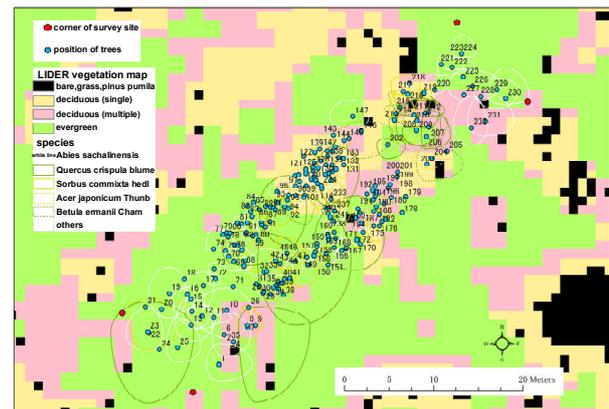


Figure 6. Comparison between LIDER vegetation map and ground truth data on site4 (projected plan of the crowns)

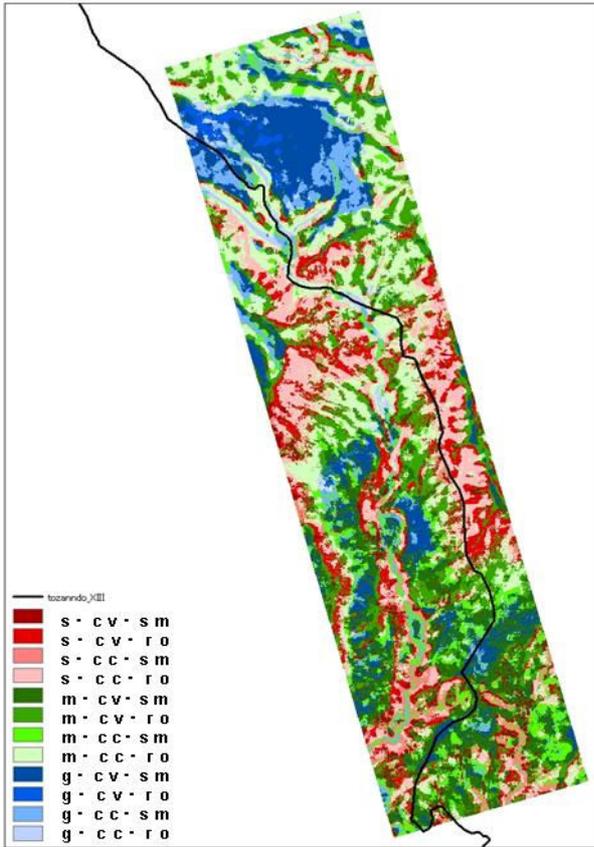


Figure 7. Automated landform classification of south east foot of Mt. Rausu using 2m DEM. (s: steep, m: middle, g: gentle, cv: convex, cc: concave, sm: smooth, ro: rough)

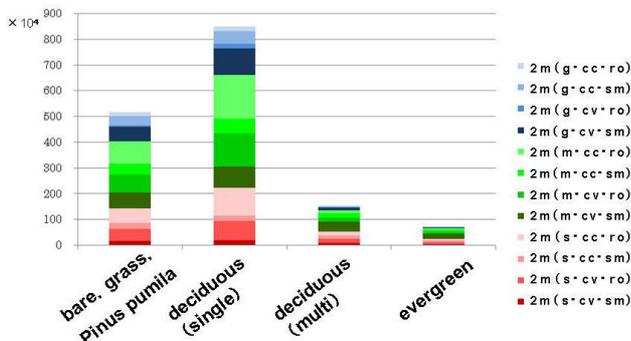


Figure 8. Results of overlay analysis between LIDAR vegetation classification and 2m DEM automated landform classification of Mt. Rausu.

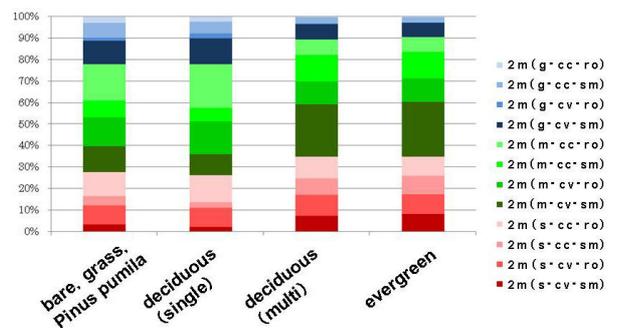


Figure 9. Ratio of 2m DEM automated landform classification on each LIDAR vegetation classification of Mt. Rausu.

#### 4. LANDSCAPE ECOLOGICAL STUDY OF CHUGOKU MOUNTAIN USING LIDAR DATA

The targeted areas of Chugoku Mountain are the north foot of Mt. Dougo and the south west foot of Mt. Hanami, Nichinan Town, Tottori Prefecture. The authors obtained 1m grid DSM and DEM of 25 km<sup>2</sup> on each targeted areas in November 2008, and obtained 0.5m grid DSM of 2 km<sup>2</sup> on the north foot of Mt. Dougo in August, 2009 (Figure 10).

Vegetation classification map with three dimensional vegetation structure was produced by the combination of summer season 0.5m grid LIDAR data and autumn season 1m grid LIDAR data. And topographic analysis and overlay analysis of geological data were done using autumn season 1m DEM.

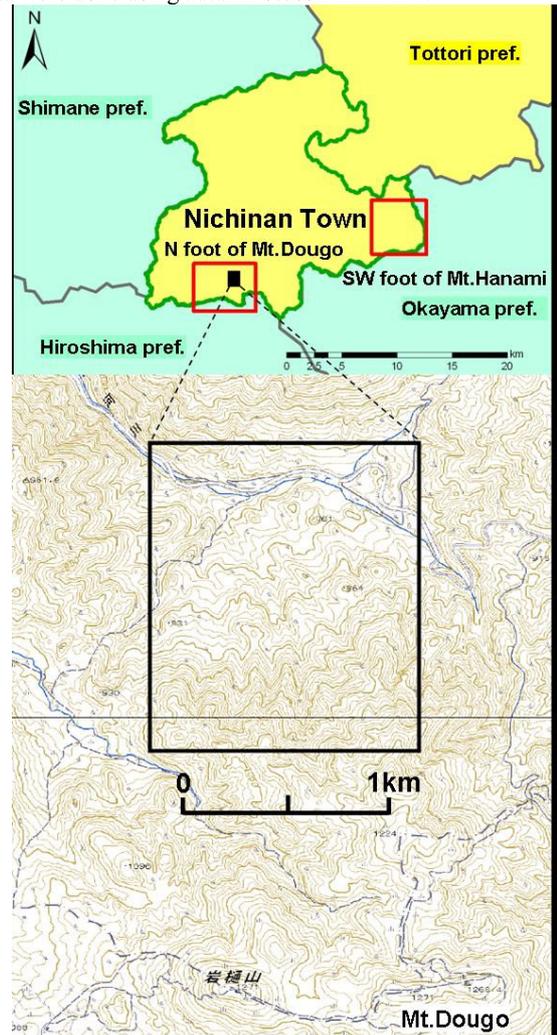


Figure 10. Study area of Chugoku Mountain

Figure 11 shows topographic counter map with 1m interval on the north foot of Mt. Dougo by LIDAR data and some pictures. It is possible to detect olden iron sand mining sites (Kanna-Nagashi) with concave gentle slope area in mountain area surrounded by artificially cutting steep slope, using the method of counter line interpretation. The authors interpret that area A and B are olden Kana-Nagashi sites, and area C and D are artificial cannels for mineral classification using specific gravity method on Kana-Nagashi site. In ground survey, *J. mandshurica* is dominated in concave gentle slope which interpreted as Kanna-Nagashi site.

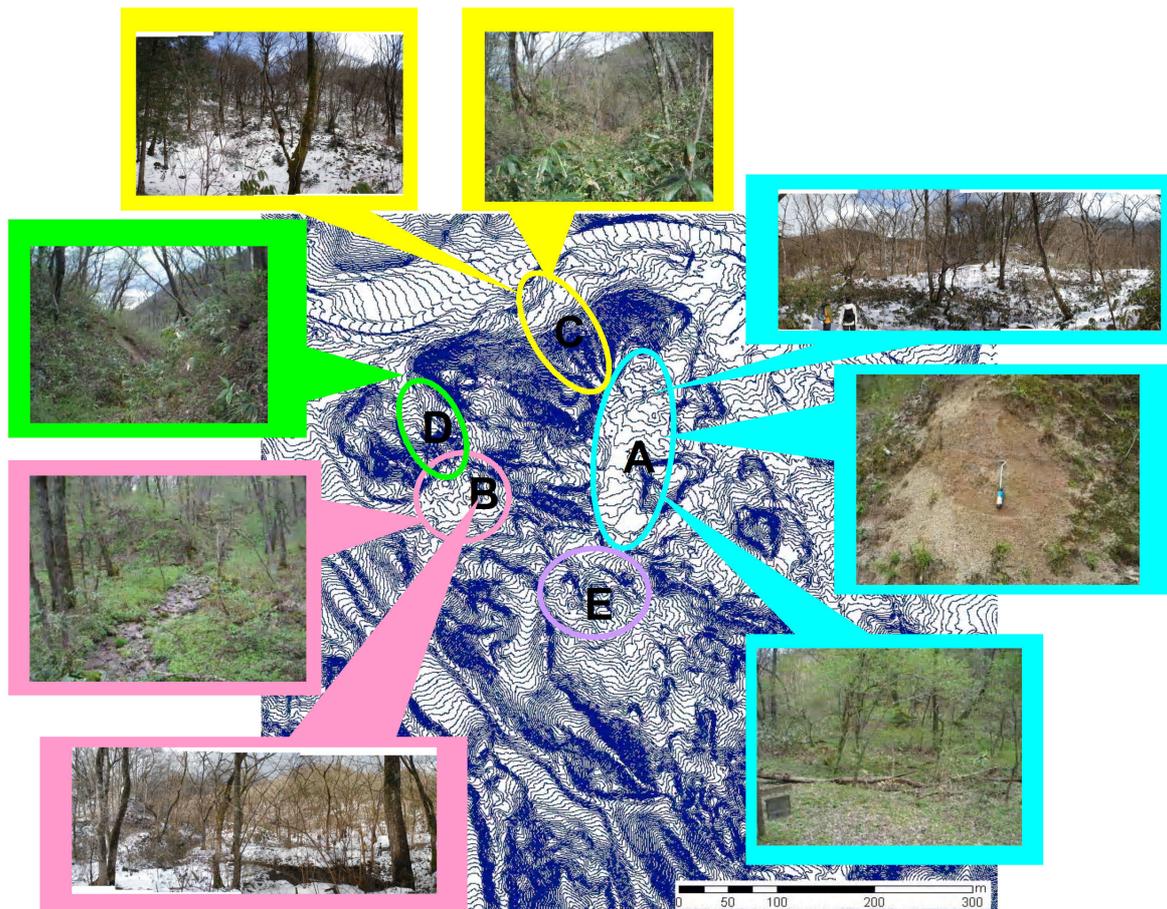


Figure 11. Topographic contour map with 1m interval of the north foot of Mt. Dougo by LIDAR data with pictures

Vegetation classification has been done using three dimensional vegetation structure detected by the difference between DSM data in two seasons. Algorithm of producing LIDAR vegetation map is as follows. The legend of LIDAR vegetation map consists of the combination of difference in two seasons (early deciduous tree, late deciduous tree and evergreen tree), vegetation height, thickness of crown and deference of forest structure (single layer or multiple layers).

The authors detect evergreen trees, roads by digital imagery interpretation. And they classified areas whose vegetation height on summer ( $H_s$ ) is less than 1.5m into bare or grass, and areas whose tree which  $H_s$  is over 1.5m into tree. Deciduous trees area classified into two categories such as early deciduous tree which the difference between  $H_s$  and vegetation height on winter ( $H_w$ ) is over 3m, and other trees are late deciduous trees. Vegetation height is classified into three categories such as low (under 5m), middle (over 5m and under 15m) and high (over 15m) for evergreen trees, and two categories such as low (under 10m) and high (over 10m) for deciduous trees. Thickness of crown of high tree is classified into two categories such as thin (under 10m) and thick (over 10m). Deciduous trees are divided into two categories such as single layer and multiple layers using histogram of DSM random point data in 2m grid.

Using this algorithm, it is possible to classify vegetation with twelve categories. Figure 12 shows LIDAR vegetation map of north foot of Mt. Dougo. In this LIDAR map, early deciduous thin crown trees mean *J. mandshurica*.

Automatic landform classification was done using 1m grid autumn season DEM, by combining three categories, such as

slope degree (gentle and steep), convexity (convex and concave) and roughness (rough and smooth) derived from the DEM. And overlay analysis between the results of topographic analysis and geological data was done. Figure 13 shows the result of overlay analysis between geological vector data and roughness analysed using 50m DEM published by GSI, and figure 14 shows the results of same analysis using 1m LIDAR DEM.

In figure 13, rough areas of 50m DEM are dominated by granodiorite, and smooth areas of 50m DEM are dominated by serpentinite, gabbro and paleozoic mudstone. In figure 14, rough areas of 1m DEM are dominated by flood plain and artificial cutting areas such as Kanna-Nagashi sites. In particular, the areas, which the values of roughness by 1m DEM is approximately 0.4, correspond to Kanna-Nagashi sites located along Mt. Dougo. It is expected the value of roughness indicate the existence of Kanna-Nagashi sites.

This study shows many forests consisting of *J. mandshurica* were distributed in areas with gentle slope, rough texture, and concavity, which were considered to be mainly created by Kanna-Nagashi. *J. mandshurica* is often observed as riverside vegetation and it inhabits places with abundant soil moisture. Since Kanna-Nagashi removes the soil from the mountain slopes, the slopes were flattened to become gentle slope with rough texture and concavity. Because of these unique topographic features, a riverside-like environment with abundant soil moisture was generated. *J. mandshurica* is characteristically distributed in a large area at present.

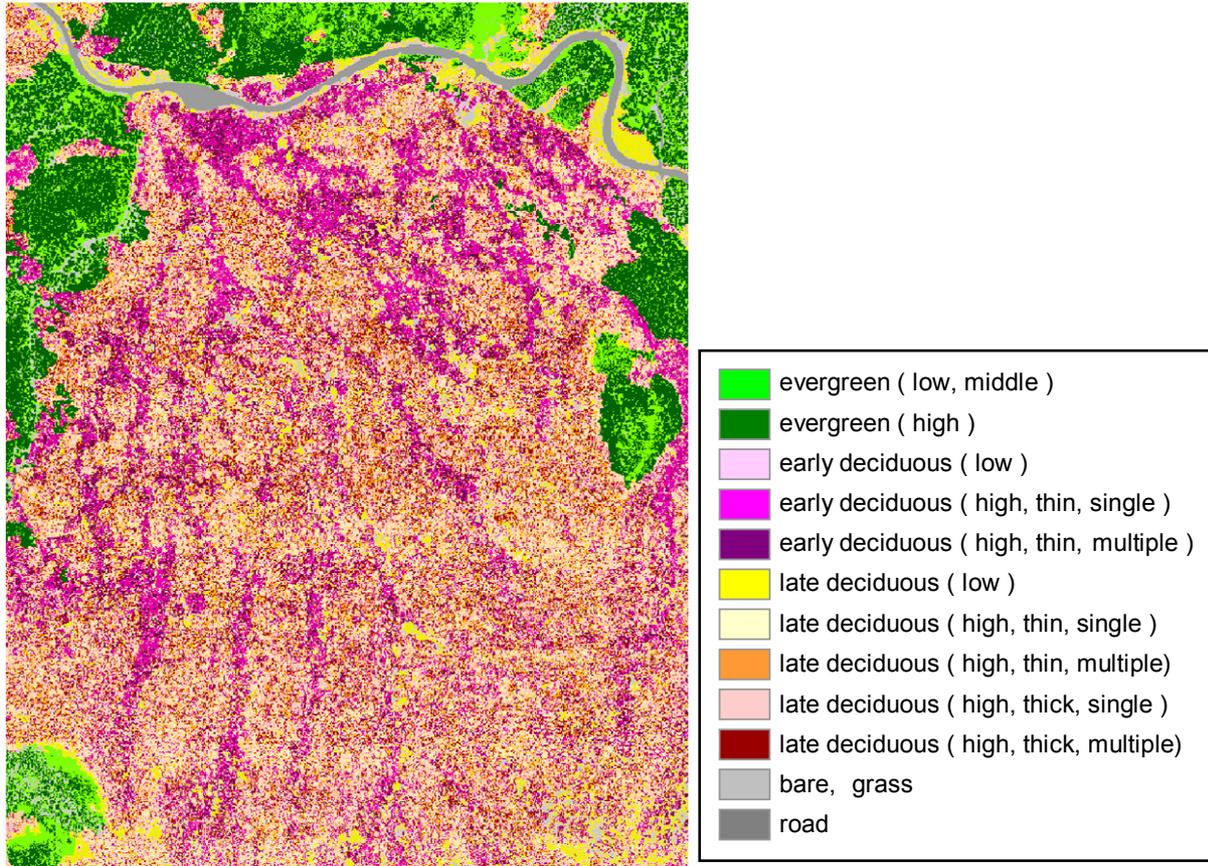


Figure 12. LIDAR vegetation map on the north foot of Mt. Dougo.

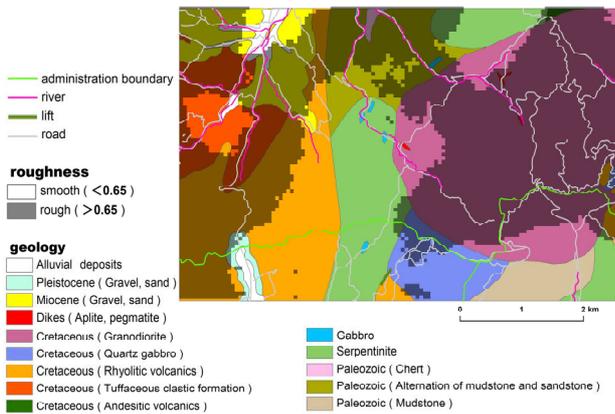


Figure 13. Overlay between geology and roughness using 50m DEM

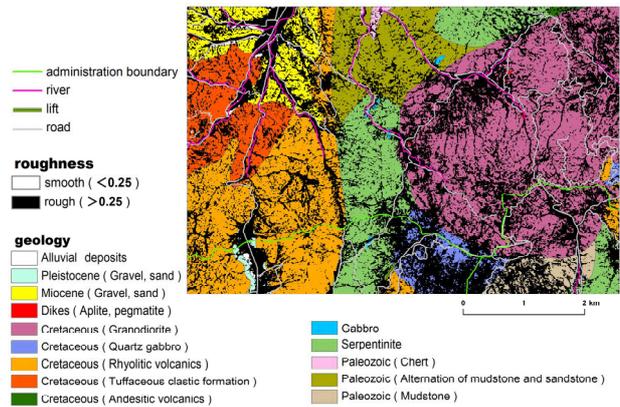


Figure 14. Overlay between geology and roughness using 1m DEM

### 5. CONCLUSIONS AND FUTURE PLAN

The authors plan to produce landscape ecological map combined with three dimensional vegetation structure and micro landform classification. Now, they are considering new type legend of landscape ecological map of Shiretoko Peninsula and Chugoku Mountain in this research, using the results of overlay analysis of LIDAR vegetation maps and automated landform classification maps, and plan to introduce

the utilization method of landscape ecological maps for natural environment conservation planning.

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