ANALYSIS OF TIME SERIES SATELLITE IMAGES FOR PASTURE AREA IN KAWATABI FIELD SCIENCE CENTER, OSAKI CITY, JAPAN

Muxiye[1] and Chinatsu YONEZAWA[1*].

[1] Graduate School of Agricultural Science, Tohoku University,
468-1 Aramaki Aza Aoba, Aoba-ku, Sendai, Miyagi, 980-8572, Japan,
muxiye.r6@dc.tohoku.ac.jp, chinatsu.yonezawa.e7@tohoku.ac.jp

Abstract:

Grassland ecosystems cover 31 to 43 percent of the Earth's land surface. Grazing is one of the most essential grassland usages. "Underuse", such as grassland abandonment, and "overuse", such as overgrazing, contribute to grassland degradation. Grazing intensity and history influence vegetation diversity, productivity, and carbon storage in grassland ecosystems. The Great East Japan Earthquake of 2011/3/11 triggered a tsunami that caused the Fukushima Daiichi nuclear disaster. The spread of radioactive materials polluted many areas of eastern Japan. Consequently, grazing has been suspended in some pastures in Iwate, Miyagi, Fukushima, Tochigi, and Gunma prefectures of Japan. However, few studies have focused on pasture changes in areas affected by the Great East Japan Earthquake. It is critical for future planning to clarify spatial and temporal changes in unused pasture areas. This study analyzed multitemporal optical satellite data to investigate the effects of the absence of cattle grazing on pastures.

The study area was the pasture located at the Kawatabi Field Science Center of Tohoku University in Osaki City, Miyagi Prefecture, Japan. We compared two test sites. One site was Rokkaku pasture, in which grazing has been suspended since the aforementioned nuclear disaster. The other site was Daishaku pasture, which has been continuously grazed following the nuclear disaster for experimental studies.

We collected high-resolution satellite data from QuickBird (multispectral resolution 2.4 m) on 2012/7/19, Worldview-2 (multispectral resolution 1.8 m) on 2017/5/20 and 2018/5/26, and SPOT 6 /7 (multispectral resolution 8 m) on 2014/9/26, 2015/10/1, 2018/9/26, and 2019/5/25. All images were ortho-geometrically and radiometrically corrected. We generated pan-sharpened image that combined a high-resolution panchromatic image with a low-resolution multispectral image for interpretation. Vegetation was grouped into three categories (pasture, broad-leaved trees, and needle-leaved trees) using the maximum likelihood method. The overall accuracy and Kappa coefficient of the classification maps were greater than 0.87 and 0.75, respectively. To investigate temporal changes, we compared the pasture areas extracted from the land cover classification maps of the two test sites.

The area analyzed from the high-resolution satellite imagery of the Rokkaku pasture that has refrained from grazing since 2011 was 66.0 ha on 2012/7/19, 64.0 ha on 2014/9/26, 60.0 ha on 2015/10/1, 52.2 ha on 2017/5/2020, 49.0 ha on 2018/5/26, 50.0 ha on 2018/9/26, and 53.8 ha on 2019/5/25. From 2012 to 2019, the area of the Rokkaku pasture decreased from 66.0 ha to 53.8 ha, a decrease of approximately 18%. Previous data from 2007/7/24 reordered the area of Rokkaku

pastures at 66.1 ha and the area of Daishaku pastures at 2.9 ha. By comparing the areas in 2007 and 2012, it was reasonable to assume that there was no significant change in pasture before the earthquake. On the other hand, the area of continuously grazed pasture was 2.9 ha on 2012/7/19, 3.1 ha on 2014/9/26, 3.1 ha on 2015/10/1, 2.9 ha on 2017/5/2020, 2.8 ha on 2018/5/26, 3.1 ha on 2018/9/26, and 3.3 ha on 2019/5/25, indicating no significant change.

Optical remote sensing is strongly affected by cloudy conditions, making it difficult to simultaneously acquire data from the same location because of the limited number of usable images. We observed differences in the timing of observations in multitemporal high-resolution satellite imagery in 2017, 2018, and 2019 imagery in May; 2012 imagery in July; and 2014, 2015, and 2018 imagery in September. Vegetation changes seasonally, which may affect the outcome of the area change. In addition, the resolution of the multitemporal high-resolution satellite images also varied. The results show that the area of unused pasture has decreased since the voluntary grazing suspension in 2011, with a change to forest, mainly of broad-leaved trees. The change from grassland to forest likely occurred as tree-dispersed species grew and were no longer influenced by cattle foraging behavior and grassland management once grazing ceased. Trees were invasive not only within pastures and forest boundaries, but also within pastures alone. This was because the dispersal of tree species was partitioned into gravity dispersal, animal dispersal, and wind dispersal, which varied by species. The latter is thought to have dispersed tree seeds to the non-grazing pasture. The annual rate of change from 2012/7/19 to 2014/9/26 was slower than the annual rate of change from 2014/9/26 to 2019/5/25. The annual growth rates of the shrub and adult species can be attributed to the time required for the dispersed seeds to reach the seedling stage. This is essential for grassland management.

Time series analysis of high-resolution optical satellite imagery over multiple time periods revealed that the pasture area has significantly decreased since 2011, when grazing was restricted. Remote sensing technology is useful for the management of grassland maintenance.

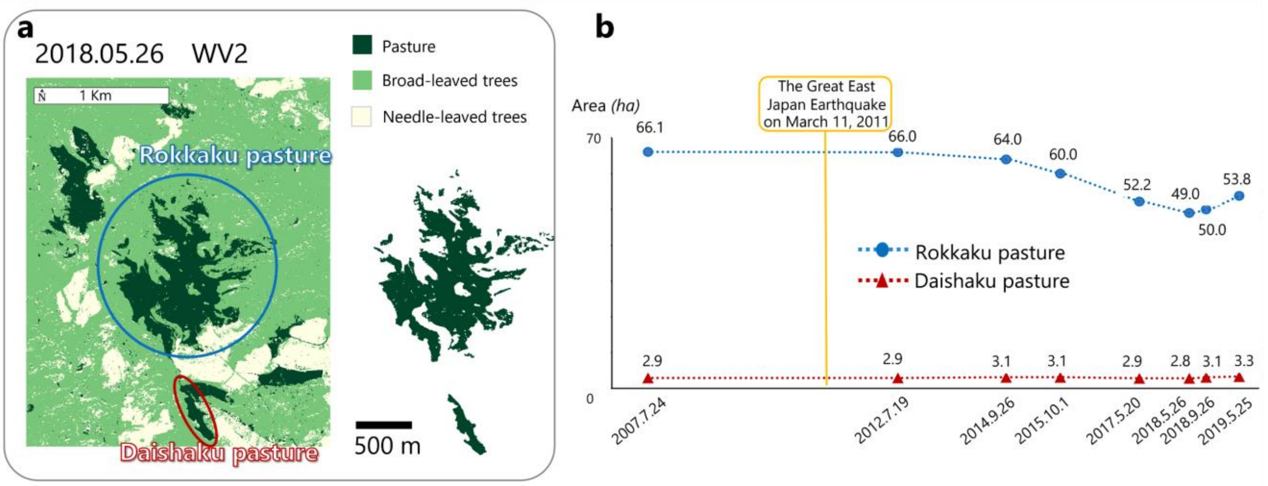

Figure 1. (a) The land cover classification map and extracted pasture. (b) Temporal variation in pasture area. Horizontal axis is the observation time for high resolution satellite images. Vertical axis is the area in hectares. The blue line is Rokkaku pasture and the red line is Daishaku pasture.

Keywords: Pasture Area, Optical Satellite Imagery, Time Series Analysis