学 位 論 文 内 容 の 要 旨

博士（環境科学）　　　　　氏　名　Végh Lea

学 位 論 文 題 名

Evaluating the impacts of disturbance scale, management history, and stochastic effects on succession by remote sensing and field surveys

（リモートセンシングおよび野外調査による撹乱規模、管理履歴、確率事象が遷移に与える影響の評価）

Human and natural activities lead to continuous change of plant communities, called succession, which is the focus of interest after disturbances. If the vegetation cover and any legacy effect are completely removed from an area, for example by a volcanic eruption or mining activities, the process of vegetation development is called primary succession. Primary succession often takes decades, but active management practices, like plantations, hasten the development of vegetation cover. The long-term effects of management practices are unclear, due to the uncertainty surrounding successional processes, and because stochastic effects cause divergent trajectories.

The aim of this research was to detect long-term trajectories after primary succession, and examine the effects of scale, management history, and stochastic effects after volcanic eruptions. For this purpose, three eruptions sites of Mount Usu, an active volcano in northern Japan, were studied by combining remote sensing and field surveys. The three eruptions sites studied were Yosomi (1910 eruption), the summit (1977-78), and Konpira (2000). The first two chapters used remote sensing to observe landscape scale processes and to address the shortcomings of traditional field survey methods. However, remote sensing is unable to detect the community species composition and abiotic factors, which are the focus of previous research on Mount Usu. Therefore, to examine species composition and environmental factors, and to maintain comparability with previous studies, Chapter 3 and 4 are based on traditional field surveys.

Chapter 1 focused on vegetation patch dynamics at the summit and at Konpira, and used remote sensing to quantify patch development by developing a novel approach, called imagery chronosequence. The scale of eruptions was larger at the summit than at Konpira, and the large disturbance and harsh environment slowed patch development at the summit, where the patches remained sparsely vegetated, especially in steep slopes. At the smaller Konpira site patch growth was quick and not restricted by slope steepness, and in contrast to the summit, almost the whole area became revegetated by the end of the study.

In Chapter 2, plant community diversities were evaluated by using remotely-sensed (spectral) diversities, examining the effect of image resolution and spectral plot size on the spectral diversities. Two different field layer diversities, canopy and total diversities at the Yosomi and summit, were estimated by the spectral indicators, testing multiple combinations of field indices and spectral diversities. Spectral indicators developed from the low resolution image (approximately 3 m) and from the same spectral plot size as the field plot (narrow extent) correlated strongly with field indices, especially if calculated from the first principal component axis. The canopy and total diversities were evaluated similarly, with evenness and true diversity indices being estimated best.

Chapter 3 compared forest types either developed by succession or from plantations at Yosomi and the summit. Species composition, plant richness, and diversity were measured by field surveys during 2015–2019. The canopy was more diverse, but the herb layer was less diverse at Yosomi than at the summit. Richness and diversity were higher in natural forests than in plantations, but variance was lower. The species composition remained distinct in the plantations, often preventing the immigration of native species, indicating that management history had larger impact than stochastic effects on successional trajectories.

Species diversity is affected by abiotic factors, such as soil nutrients, temperature, and light competition. The impact of abiotic factors on forest development was examined in Chapter 4 via analysing soil nutrients, seedbank, temperature and light intensity of the forests. The soil conditions did not vary greatly among the sampling locations, apart from a plantation where *Alnus* spp. were established. *Alnus* spp. are good nitrogen-fixers, and the plantation had increased levels of soil nitrogen compared to the other forests. Plantations had also higher seed density, diversity, and percentage similarity at the summit than natural forests. Temperature did not differ between the forest types, but the summit forests had higher light intensity. Thus, nitrogen-fixing species and light conditions separated forests and had a larger effect than soil chemistry and temperature on vegetation composition and succession.

In conclusion, the imagery chronosequence and spectral diversities evaluated successional developments well on large scales and in various forests across Mount Usu. The remote sensing was complemented by field surveys, which established the diversity relationships of canopy and herb layers and also detected edaphic and light conditions. Active management strategies, such as the plantation of woody species, had larger impact than stochastic processes, and often resulted in decreased diversity compared to naturally recovered forests. However, if plantations would be carried out following a mosaicked spatial pattern instead of planting continuous areas, they may enhance patch dynamics and promote recovery after large scale disturbances. As successional processes are comparable between distant geographic locations, the combination of remote and field observations can examine vegetation and patch dynamics after various disturbances on landscape scale, focusing field surveys on areas where successional developments deviate from expectations.