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Functional trait-based approaches to disentangle the complex mechanisms underlying plant diversity organization

Abstract

"How the plant communities are assembled." This has been the central theme of community ecology for more than a century and is essential to understand biodiversity. The interactions of a variety of ecological and non-ecological processes contribute to multi-plant species assemblages (community) at the local scale. To understand the enigma of biodiversity, disentangling the factors shaping the local scale plant assemblages (community) is essential. In chapter 1, I have discussed how functional traits help explain existing diversity patterns (environment, space, and time) generated through mutually correlating processes (abiotic, biotic, disturbance, dispersal, and stochastic).

Even though the processes are the same, the importance is highly variable among regions. In chapter 2, I have tried to assess how herbivory (disturbance) and nutrient cycling affect plant diversity in extremely nutrient-limited high-Arctic wetlands. Here, wetland sites, where geese have been almost absent for at least 50 years (Pond Inlet), were compared to nearby sites, where geese are abundant but have been excluded experimentally by cages and where the ground has been experimentally fertilized for over 16 years (Bylot Island). From the community composition and weighted mean functional trait values, I could disentangle the direct disturbance and indirect fertilization effects. Long-term goose disappearance likely alters the competitive relationships between three dominant plant species. Taken together, the direct effects of goose herbivory on vegetation are more profound than their indirect effects, through an alternation of nutrient cycling in nutrient-limited Arctic wetlands.

Spatial factors are also important for plant distribution and diversity patterns. Even if the given environmental conditions are suitable for

certain species, they cannot establish in place when they cannot disperse. In chapter 3, by using dispersal related functional traits, I have tried to detect how dispersal processes influence plant community structure. The study site, patchy tundra vegetation, is suitable for testing the importance of dispersal processes. Here, I researched 433 vegetation patches (separate from each other) in a patchy tundra vegetation in northern Canada at three spatial scales (150 m, 2 km, and 10 km). The results showed that dispersal abilities were related to existing plant patterns. This could be because harsh arctic environmental conditions strictly sort the species, and its importance becomes much higher.

The third study site is the Shiretoko National Park cool-temperate forest. This site has a high abundance of deer. Contrary to high arctic areas, these temperate forests are characterized by substantial water, nutrients, and growing seasons. In Chapter 4, I assessed the effects of over- and no-grazing on the mechanisms of plant community assembly. By comparing the control with exclosure plots, vegetation coverage was found to be considerably lower, while species richness and diversity were higher in the plot with herbivory. Functional traits associated with competitive ability (leaf area and chlorophyll content) were significantly higher in the exclosure plot. The results emphasized that, although over-abundance of deer is of concern, without-deer had negative effects on plant diversity through competitive dominance.

Temporal factors are also important for plant distribution and diversity patterns. Temporal dynamics of a community are usually related to disturbance processes. However, they are not well synthesized since the effect of disturbance is depends on the types of disturbance, the strength and length. In chapter 5, by focusing on the different two types of disturbance “press” and “pulse”, I addressed how these types of the different affects the community dynamics. Here, I used six years of understory vegetation dynamics data under press (deer herbivory) and pulse (rodent outbreak herbivory) at the Shiretoko. The results showed that deer and rodent herbivory had opposite effects on plant community dynamics. The effects of press disturbance on existing community patterns (i.e., community weighted mean) were considerably higher. By assessing the temporal dynamics at plot scale (IWM, DWM), we could detect the opposite effects of existing patterns generated by stable conditions (no and press disturbance).

Ecologists are eagerly seeking general theories, but these do not necessarily solve every ecological issue. A lot of unique systems in nature and complex ecological systems remain unknown. To understand the diversity

formation and maintenance mechanisms in focal systems, we need to carefully gather information to deal with each ecological issue. In chapter 6, I outlined some of the results presented in former chapters, and discussed how functional traits contribute to disentangle the focal community assembly processes in three existing diversity generating patterns. In addition, I propose the use of functional traits in future studies.