Lattice modeling for the dynamics and biodiversity of plant communities

（課程博士・様式７）（Doctoral qualification by coursework, Form 7）

学 位 論 文 要 旨

Abstract of Doctoral Thesis

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Abstract：

The present richness of ecological diversity in the world has always baffled scientists. This is because of the fact that a lot of ecological models in literature point to the existence of a single or a few superior species also known as competitive exclusion principle. Adapting these models so that the present diversity is taken into consideration would be almost impossible and very hard to achieve. Moreover, most of these models includes complicated equations which only consider a few species.

Here, we build simple models in attempts to explain the rich diversity of species of phytoplankton in limnological waters and terrestrial plants present in the world today. We present very simple competition models based on the lattice Lotka-Volterra system that includes several parameters that can be seen in the real world.

The first phenomenon that we considered is the vast number of phytoplankton species in fresh bodies of water even though limited nutrients for proliferation is scarce. This phenomenon is also known as the paradox of the plankton which apparently contradicts the competitive exclusion principle. This phenomenon is in conjunction to the paradox of enrichment proposed by Michael Rosenzweig in 1971. This refers to the occurrence where abundance in food availability is detrimental to the diversity and destabilizes the population dynamics between predator and prey, not just in freshwater ecosystems, but also in other biological communities. This can be seen as eutrophication reported in aquatic ecosystems, e.g., water pollution and red tides. We here propose the paradox of enrichment by induced competitive interactions using

multiple contact process, a lattice Lotka-Volterra model. Simulation results demonstrate how eutrophication invokes more competitions in a competitive ecosystem resulting in the loss of phytoplankton diversity in ecological time. The paradox is enhanced under local interactions, indicating that the limited dispersal of phytoplankton reduces interspecific competition greatly. Thus, the paradox of enrichment appears when eutrophication destroys an ecosystem either by elevated interspecific competition within a trophic level and/or destabilization by trophic interactions. Unless eutrophication due to human activities is ceased, the world's aquatic ecosystems will be at risk.

The other model is the verification of David Tilman's hypothesis that the present abundance in biodiversity can be attributed to the minute differences in suitable microhabitat. This can be clearly observed in terrestrial plant communities like forests and even grasslands. Unlike the homogenous characteristic of freshwater ecosystems, terrestrial communities is so heterogeneous that even neighboring soil plots differ greatly in terms of nutrients and mineral compositions. Here, we verify this hypothesis by including this minute differences in microhabitat in the lattice Lotka-Volterra competition model. By applying the site variations in species-specific settlement rates of a seedling, we achieved the coexistence of more than 10 species. This result indicates that competition between many species is avoided by the spatial variations in species-specific minute microhabitats. We also achieved more than 15 species by adding the variations in species-specific mortality rates. Our results demonstrate that coexistence of many species becomes possible by the minute differences in microhabitats. This mechanism should be applicable to many terrestrial plant communities, such as temporal forests and grassland communities.

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