7.13 Case Study: Biodiversity and stability of natural grasslands

There are many reasons to conserve biodiversity ranging from a moral obligation to protect the Earth's resources to more pragmatic and utilitarian reasons that serve humans. The issue of preserving biodiversity has usually been framed in the context of saving individual species, especially threatened or endangered species, before they become extinct. Another view of saving biodiversity is to save or restore communities that provide essential ecosystem services for humans.

One crucial question is whether more complex communities perform better than simple communities. This question has two important parts; what do we mean by "simple" and "complex" and what do we use as a basis to judge what is "better"? For our purposes the complexity of a food web will be related to the number of species and the connectivity. The complexity of these systems will increase with the more ways that the species can interact. More complex systems will also have an intermediate level of connectivity, every species will be connected to several other species. Better performance does not mean simply more efficient production. In natural communities, better performance is related to the ability of the entire community to survive disturbances. A "better" community structure would bounce back from small disturbances very quickly and would have to be very severely disturbed not to recover. The degree of the stress that a community can withstand and still recover is the resilience.

Researchers have taken several approaches to address the relationship between species richness and the productivity of community. One approach is to construct artificial communities in well-controlled experimental chambers and another approach is to compare natural communities that have different species richness. Each approach has its benefits and drawbacks.

In a study conducted in artificial and highly controlled chambers, communities with nine, fifteen and thirty-one species were compared. All three communities consisted of decomposers, primary producers, primary and secondary consumers. The results were that the productivity (measured as total plant biomass increase over time) was higher with more diversity. The most diverse community had almost twice as much production as the species-poor community. The species-poor community was also more variable, indicating that it was not as stable as the more diverse communities.

Another study conducted in the field demonstrated that species-rich plots of grassland were more resistant to drought events than species-poor plots. These species-plots were both more resistance to drought and they recovered more rapidly after drought stress. More diversity seemed to help the communities use the resources more effectively and thus increase both productivity and resilience.

We have to be cautious when interpreting these studies and attempting to extrapolate from controlled and small-scale experiments to the ecosystem level. There are many methodological and statistical problems that could weaken the impact of these findings. These studies, however, are an important demonstration of the value of diverse communities. The more complex networks in diverse communities are able to utilize the

available resources in flexible ways that can lead to their ability to resist stress in the first place and recover more swiftly afterwards.

A more complete story

Please see these references for a more complete description of this problem.

Chapin et al. (1998). Ecosystem consequences of changing biodiversity. Bioscience ???:45 - ??/ (January)

Tilman, David & John A. Downing. 1994. Biodiversity and stability in grasslands. Nature 367: 363-365. (27 Jan)

Tilman, David, Peter B. Reich, & Johannes M. H. Knops (2006) Biodiversity and ecosystem stability in a decade-long grassland experiment. Nature 441:629-632 (June 1)

Tilman, David, David Wedin & Johannes Knops. 1996. Productivity and sustainability influenced by biodiversity in grassland ecosystems. Nature 379:718-720. (22 Feb)

Or you can search for "drought", "biodiversity", and "grasslands" to find other references.

Salient features

The focus of this case study makes it ideal to examine some of the points from a network perspective. The proposed reasons for increased stability of the diverse grassland include compensatory interactions between species. The weak positive and negative influences that these species have on each other can be described as linkages (rather than flows and stocks that we would have to use with our simple system viewer). Another feature is that they are looking for resilience and stability under conditions of disturbance or perturbations by the weather (i.e. drought).

to be added: a list and simple description of the species-species interactions and microhabitat-species interactions that were observed.