How do we describe biodiversity? It's multidimensional!

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Overview

The goal of this South Dakota State University (SDSU) Extension publication is to describe and discuss dimensions of biodiversity that, in combination, are vital to the function of ecosystems.

At the most general level, biodiversity is defined as the variety among living organisms or having many different kinds or species of organisms (i.e., plants, animals, insects, etc). Biodiversity provides a variety of benefits, or "ecosystem services," such as soil health[1, 2], soil carbon storage[2], forage production[3, 4], and water storage and purification[5]. Biodiversity has also been linked to ecosystem stability in the face of environmental change and enhanced resilience, or the ability to "bounce back" following disturbance[6, 7]. Promoting biodiversity has become a focus for many research and policy initiatives (e.g., the United Nations Decade on Biodiversity and the Society for Range Management)[8, 9] that are important in implementing these well-documented benefits into management of our restoration and conservation efforts.

The above definition of biodiversity – many kinds of species – is specifically species richness. However, biodiversity can be defined in other ways including genetic variation within a population of a single species (genetic diversity), diversity of evolutionary relatedness (phylogenetic diversity), and diversity of functional traits (functional diversity). You can think of biodiversity having multiple dimensions like you would with any 3-D shape. For example, the volume of a triangle better describes its complexity than a single dimension. In a similar fashion, the complexity of biodiversity is better described using multiple dimensions. In spite of these nuances, "biodiversity" has become something of a buzzword in many scientific papers and popular media articles, but clarity on a definition for biodiversity and how it is measured is lacking[10].

Species Richness

Species richness is the most frequently used and well known biodiversity metric[11]. Species richness is a count of the number of species within a community and is the easiest way to measure and conceptualize species diversity[12]. It was likely the first definition of biodiversity[13]. Higher species richness has been shown to increase carbon storage[2] and increase multiple ecological functions simultaneously such as carbon, nitrogen, and phosphorus cycling[14]. However, species richness isn't quite the same as species diversity since it doesn't include how evenly the numbers of each species are spread within each community[11]. The most commonly used measures of species diversity use both species richness and some measure of the abundance of each species in proportion to the others in the community[15, 16] (Figure 1). They account for the difference between being common and being rare.

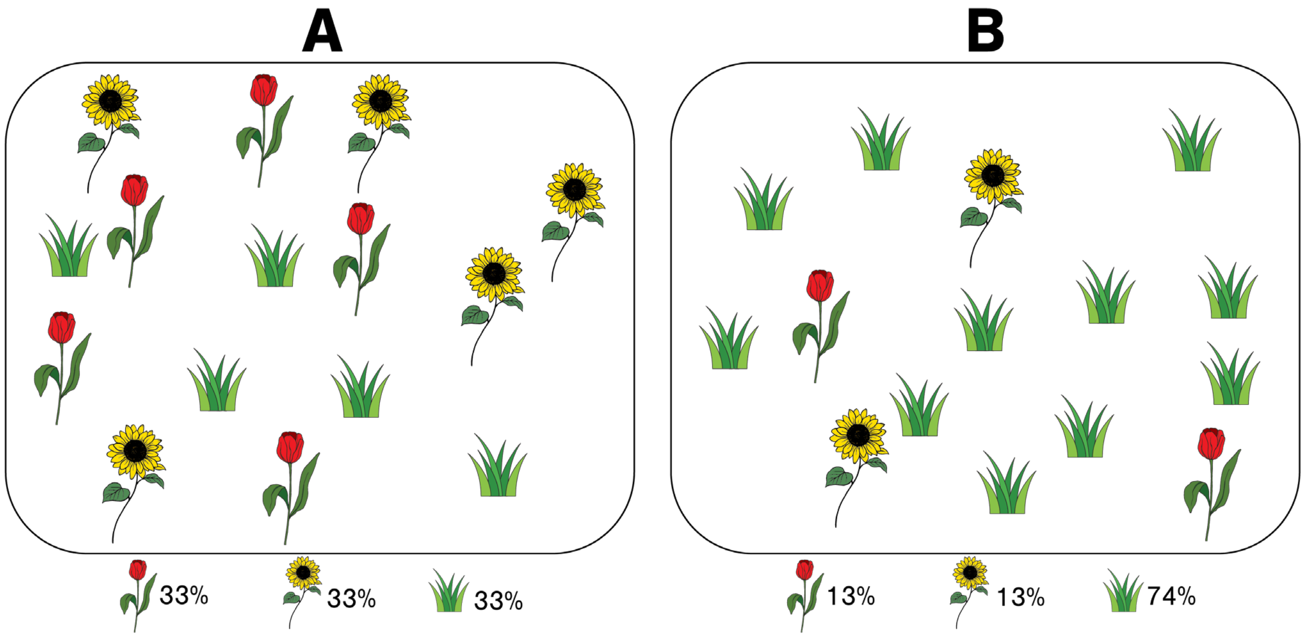

Figure 1. An example of two different plant communities – Community A and Community B. Both have the same number of species (3) and individuals (15), but there are different levels of evenness with Community A having more species evenness – there are 5 plants each of the red flower, yellow flower, and grass; Community B has less species evenness – there are only 2 plants each of red flower and yellow flower, and 11 grasses.

Genetic Diversity

Genetic diversity is a metric that incorporates variation in genetics within and among individuals of a population. When there is low genetic diversity, the individuals within a population will have very similar genetic makeup, which leads to inbreeding and decreases the potential to adapt to changing environments. Increasing genetic diversity is generally positive and leads to more robust plant populations. There is a caveat, however, which is that when you are dealing with a locally adapted species, genes from other places can decrease plant performance[17]. Local adaptation may play an important role in seed-based restoration. It is recommended to source seeds from multiple locations per species while also ensuring that where the seeds are sourced from are an environment that mirrors that of the planned restoration area[18]. Having multiple sources of seed increases the probability that ensures that seeds will have a lot of genetic diversity, and sourcing seed from locations with similar environmental conditions to your restoration area increases the probability that seeds will be adapted to your site, leading to increased seeding success.

Phylogenetic Diversity

Phylogenetic diversity is another dimension of biodiversity that adds to the complexity of the biodiversity "triangle." It is a measure that captures how related species in a community are to each other[19]. For example, if you have a community of plant species that are closely related to each other (e.g., all members of the grass family), this will lead to low phylogenetic diversity. On the other hand, if you have a community of species from several distantly related families, then the phylogenetic diversity is greater. Higher phylogenetic diversity has been correlated with increased biomass productivity[3] and increased soil fertility[20]. Phylogenetic diversity is often a better predictor of ecosystem performance than species richness[21] and may reflect lots of functional traits. For example, variability in function is important in providing a variety of resources, such as floral resources for pollinators and food sources for animals[22]. This concept is like a car making factory – each part of the car has a different function; as a whole, all those parts work together to move the car.

Conclusion

Each of these components of biodiversity are one dimensional and consequently, represent a part of total biodiversity. When they are combined, they approximate a more holistic depiction of the amount of biodiversity available (Figure 2). Considering multiple dimensions of biodiversity can improve outcomes of management and restoration practices. Deciphering how these various biodiversity metrics affect ecosystem services for stakeholders by estimating their impacts— both individually and when combined— is a research focus of the Native Plant Initiative (NPI) at South Dakota State University. The overall goal of the NPI is to develop tools for optimizing biodiversity across the Northern Great Plains, including expanded native seed resources, seed mix optimization techniques, and developing educational materials. If you have questions or feedback for the NPI, please contact Lora Perkins, Ph.D., lora.perkins@sdstate.edu.

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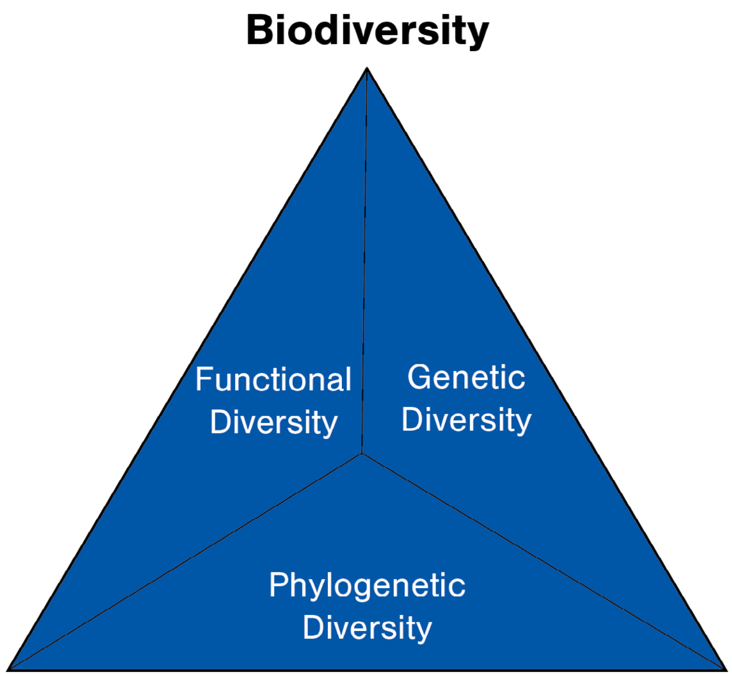

Figure 2. An example of how three components of biodiversity – functional, genetic, and phylogenetic diversity – fit together to comprise a more holistic understanding of the biodiversity in ecosystems.

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