Biodiversity and ecosystem functioning: Understanding the importance of restoring and preserving diversity at multiple levels

PURPOSE

Much ecological research over the past decade has focused on how biodiversity contributes to ecosystem functioning, community structure, and community stability. The overwhelming majority of these experiments found that the loss of biodiversity negatively influences ecosystem function. Despite important applied implications, very few of these studies have been conducted in a restoration context. The Great Lakes sand dunes are an ecologically important system in need of restoration due to years of human disturbance and development. We propose to explore how different levels of biodiversity may interact to influence ecosystem processes in a restored vegetative community at Sleeping Bear Dunes National Lakeshore. Specifically, we will simultaneously manipulate both species diversity and genetic diversity within a dune dominant grass species, American beachgrass (Ammophila breviligulata), to answer the following questions: (i) Does increasing the number of species planted in a restored ecosystem improve ecosystem function and community stability? (ii) Does increasing the number of genotypes of a dominant restoration species improve ecosystem function and community stability? (iii) Do species diversity and genetic diversity interact synergistically to improve ecosystem function and community stability? By employing a novel approach to examine factors that affect community diversity and ecosystem processes, our research holds promise not only for advancing general theory in restoration ecology by improving understanding of how communities function, but also for providing new and tangible recommendations for land managers for successful dune restoration.

FIELD METHODS

This spring, we will plant the remainder of the restoration. Then, the following data will be collected during the growing season, and for the next two seasons:

Ecosystem response variables – Our restoration goal is to recreate levels of primary productivity, sand stabilization, and biogeochemical processes found in natural dunes in order to produce optimum habitat for native animal and plant species. Four times yearly, We will survey above-ground productivity and plant composition as well as key biogeochemical processes – nitrogen and phosphorus availability and carbon storage. We will also monitor sand accumulation (to assess the development of dune stabilization) and determine plant community stability by comparing the similarity of the realized communities to the initial planted composition and by estimating species turnover rates for each pair of censuses. To assess the effectiveness of our treatments, we will compare these responses to the same variables measured in nearby reference (undisturbed) natural dune communities.

One mechanism by which diverse communities may outperform less diverse communities is the more efficient use of limiting resources. To test for this potential mechanism, we will monitor the use of soil nutrients and water in all plots. Samples of soil will be collected to test nitrogen, carbon, potassium, and phosphorous levels. To compare water usage in monocultures versus diversity treatments, we will use stable isotope analysis of 18O. The percent of 18O in water differs at different depths in the soil; thus, values of 18O taken from soil cores can be compared to 18O values in water from the xylem tissue of the plants to determine where the plants are deriving most of their water.

Community response variables – In addition to re-establishing key ecosystem services, restorations should, over time, promote levels of biodiversity that match natural communities. To test for the effectiveness of the biodiversity treatments, we will survey above- and below-ground biodiversity during the growing season, including microbes (mycorrhizal fungi, N-fixing bacteria) and insects (3 times yearly), and we will constantly survey the plots for the return of rare and endemic species. Soil microbes are important, yet often overlooked, drivers of ecosystem processes. They can function as decomposers, nutrient cyclers, and as plant mutualists and pathogens. Understanding how they respond to differences in biodiversity treatments will provide key insights for restoring ecosystems. These data will allow examinations of how richness, abundance, evenness, and composition of the associated community differ among diversity treatments. Plant composition will be monitored over a three year period to examine the successional trajectory of the treatments. We will pair these results with surveys performed in reference natural dunes systems to analyze the effectiveness of the diversity treatments for restoration.