Harnessing PRAIRIE PLANT POTENTIAL for Human Needs A Plant Ecologist's Perspective

Interview with Dr. Jake Jungers

I first met Jake Jungers in 2010, when he was a graduate student and attended an MPF board meeting with MPF Technical Advisor Rudi Roeslein. At the time, Jungers was studying with Dr. Clarence Lehman, a leader in prairie ecosystem research (see the fall/winter 2011 issue of the *Missouri Prairie Journal* for Lehman interview).

Today, Jungers is a postdoctoral research associate in the Department of Agronomy and Plant Genetics at the University of Minnesota, pursuing his own research projects. In the interview below, Jungers discusses the many fascinating aspects of his work.

—Carol Davit, *editor*

What does a plant ecology postdoctoral researcher do?

I get to design experiments, write grants to fund new experiments, conduct research, analyze data, and write research papers. I also have the opportunity to do a little undergraduate teaching and graduate student mentoring. My position lets me interact with fellow academics, industry representatives, state and federal land managers, farmers, non-profits, and policymakers.

How did you get interested in prairie?

Three days after finishing my undergraduate degree at the University of Wisconsin–Oshkosh, I loaded all of my belongings into my car to start a new job in Minnesota. I was hired as a field technician at the Cedar Creek Ecosystem Science Reserve, which is both a research station of the University of Minnesota and a designated "long-term ecological research" site funded by the U.S. National Science Foundation. Before starting this job, I didn't know that Cedar Creek was the site where Raymond Lindeman conducted his seminal research on ecosystem ecology in the 1950s, and I didn't know much about prairies. Within the first few months of working at Cedar Creek, I was exposed to—and then quickly became fascinated by—the power of large-scale manipulation experiments and prairie ecosystems. My passion for ecological research and prairies really developed together. From then on I have spent months of my summers for 6+ years on my hands and knees sorting through blades of grass and other vegetation during peak mosquito season and summer temperatures. It was during this time that I started to value the prairie for its vast diversity of plants and animals—and the wind for its ability to mediate the harsh conditions brought on by bugs and heat!

Please discuss your graduate work, as a plant ecologist.

As a graduate student, I measured how much energy could be produced using biomass harvested from grasslands managed for other conservation purposes. Specifically, I measured the bioenergy potential of grasslands in Waterfowl Production Areas managed by the U.S. Fish and Wildlife Service, in the Conservation Reserve Program, and grasslands managed by Minnesota called Wildlife Management Areas. I wanted to see if certain plant species or plant traits were associated with bioenergy potential. Then, I looked to see if annual biomass harvest changed the abundance of plant species within these grasslands, and if so, determined whether the change would result in more or less bioenergy. My advisors and I found that if we harvested half of the land in conservation grassland programs in the southeastern corner of Minnesota annually, there would be enough biomass to fuel a production-sized cellulosic ethanol plant for the entire year. We also learned that harvesting the same areas for up to three years in a row did not affect plant species diversity during that time period.

What kind of research are you doing regarding effects of management activities on belowground carbon storage, root biomass changes, and soil microbial changes?

Roots are the key to how prairies can help fix the problem of too much carbon dioxide in the atmosphere. Roots support a prairie plant's perennial nature so that aboveground biomass can be harvested for hay or bioenergy, or grazed. Roots also serve as the mechanism for carbon storage. Plant roots grow and some portion dies each year, and in the early years of a prairie's existence, they usually grow more than they die.

TERESA MIDDLETON

Dr. Jake Jungers in a field of intermediate wheatgrass, a perennial crop that is the subject of one of his research projects.

Root biomass is somewhere between 40 and 50 percent carbon, which the plant removed from the atmosphere during photosynthesis to create root and other plant tissue. When roots die, some of that carbon is returned to the atmosphere when it is decomposed, but some is converted into other substances that become part of the soil and can persist for decades. So roots can be both a short- and long-term mechanism for carbon sequestration. My colleagues and I are working to measure how much carbon is actually stored in these two different pools (live root biomass and soil organic matter), and if we can control it by altering which species are in the prairie, by fertilizing it with nitrogen, or if these pools change when we mow or burn the prairie.

We are very interested in how microbial communities beneath prairies respond to management activities like biomass harvest or fertilization, and what the outcomes might be in response to those changes. We are studying original, unplowed prairies to understand how properties of certain plants (e.g., root structure, chemical composition, phenology) affect the microbial community in those systems. The information we get from prairies can be used to inform management practices related to cover crops. For example, we know that some microbes can degrade weed seeds within a soil seedbank, and that some cover crop species might better support or enhance those soil microbes. We would like to develop a "cocktail" of cover crops that can be planted during alternate years in between corn and soybeans to support microbes that degrade weed seeds and thus reduce weed pressure on the cash crops. If this would work, we may not have to be so reliant on chemical herbicides.

You work in the University of Minnesota Department of Agronomy and Plant Genetics, but you are a plant ecologist. Why it is important to have a plant ecologist's perspective added to the agronomists' perspectives when working on plant selections?

As a plant ecologist working in prairies, I've spent a lot of time trying to figure out why certain species can be neighbors in a community in some areas and not in others. I've learned that there are many factors that determine which species can coexist in a community, including factors related to climate, soils, and traits related to the species in the community. For decades, agricultural researchers have sought to improve resource use efficiency by diversifying cropping systems in time, space, or both. For example, diversifying crops in time might include adding a cover crop to a corn/soybean rotation that grows in late fall and early spring. This allows a farmer to harvest biomass from land that is usually bare, which improves the efficiency of the land resource. However, we need to identify cover crops that have the traits to grow during those difficult periods of time, and in a variety of soil and climate conditions all across the Upper Midwest and beyond. Likewise, intercropping (i.e., growing more than one species in a field) is another way to diversify agriculture to increase yield and resource use efficiency. The challenge in intercropping is to identify two or more species that produce the harvestable products society needs when grown together without limiting the productivity of the others. The principles of plant ecology that provide us insight as to why certain species can coexist in a natural environment can also guide us to develop more efficient agricultural systems for food, fuel, and fiber production. This is what I am excited about.

Your work involves breeding perennial crops from both native and non-native plant species. Why is this important ecologically, and for human needs?

One way to develop a perennial crop is to domesticate a wild plant. Breeders work to fix certain traits that make a wild plant useful as a crop, such as large seeds to be harvested for grain.

CLAIRE FLAVIN

A field of intermediate wheatgrass emerging just weeks after a September planting.

According to Jungers, the principles of plant ecology provide insight as to why certain species can coexist in a natural environment and can also guide us to develop more efficient agricultural systems for food, fuel, and fiber production. Says Jungers, "This is what I am excited about."

However, developing a perennial grain crop is no easy task. The individual plants that breeders select possess a delicate balance of traits that would make those individuals poor competitors in nature. Breeders look for individuals of a species that work against the fundamental strategies of plant evolution. Annual plants have only one year to pass on their genetic material and reproduce in the form of seeds. It makes sense for annuals to produce as much seed as possible or large seeds that are likely to germinate. Both of these are good traits for grain production. However, perennial plants can invest their resources into roots, which allow them the opportunity to reproduce over many years. This means that it might not be so essential to invest valuable resources into seeds every year. Some perennial plants can invest resources into other reproductive tissues like rhizomes or tillers. With this reproduction strategy, perennial plants don't need to produce large amounts of large seed, which would result in low grain yields.

The challenge is to develop a plant that produces enough roots to be perennial and enough seed to be a profitable grain crop. Large root systems in perennial plants hold soil to prevent erosion, store carbon that would otherwise be emitted into the atmosphere, capture more nutrient fertilizers to minimize pollution, and allow the plant to overwinter to eliminate to need to reseed every year. These outcomes benefit both the environment and the farmers' wallet. The task of breeders is to balance the plant's allocation of energy so that it produces enough seed to make marketable grains and enough roots to provide the aforementioned ecosystem services.

What about drought tolerance of prairie plants and other potential perennial crop plants, as this pertains to agriculture?

Perennial plants can use their roots to access water deeper in the soil column compared with annual plants, which is one way that perennials are more drought tolerant than annuals. Some perennials, especially those that have been targeted for potential grain production, begin growing earlier in the spring compared with annuals. This means that perennials have access to water earlier than annuals, giving them one more advantage to be drought tolerant. Prairies have species with many different root architectures, some have shallow, fibrous root networks while other have long taproots that can reach water nearly two meters deep. As a community, a prairie can remain productive under extreme water conditions, whether it is too much or too little rain, because a prairie has species that are particularly resilient to such conditions and can thus continue to grow when other species may be negatively impacted.