How do nutrients change flowering in prairies?

Lori Biederman  
*Iowa State University, lbied@iastate.edu*

Brent Mortensen

Philip Fay

Nicole Hagenah

Johannes Knops

*See next page for additional authors*

Follow this and additional works at: [https://lib.dr.iastate.edu/eeob_ag_pubs](https://lib.dr.iastate.edu/eeob_ag_pubs)

Part of the Agriculture Commons, Plant Sciences Commons, and the Terrestrial and Aquatic Ecology Commons

The complete bibliographic information for this item can be found at [https://lib.dr.iastate.edu/eeob_ag_pubs/313](https://lib.dr.iastate.edu/eeob_ag_pubs/313). For information on how to cite this item, please visit [http://lib.dr.iastate.edu/howtocite.html](http://lib.dr.iastate.edu/howtocite.html).
How do nutrients change flowering in prairies?

Abstract
Farmers today apply more synthetic fertilizers to farm fields than ever before – but not all of these nutrients are used by crops: some fertilizer escapes through the air, soil, or water. Nitrogen, phosphorous, and potassium flow off farm fields when it rains, billow into the air when fields are plowed, and drift with the wind to other areas. Extra nutrients are also released to the air when people burn fossil fuels. We wanted to find out: what happens when these extra nutrients land on wild prairie ecosystems? How do its wild plants respond? Do they all just grow better? Or could there be any negative side effects? To answer these questions, we systematically added nutrients to experimental patches of prairie. We found that these added nutrients (specifically nitrogen) made early-season plants thrive while reducing the amount of late-season plants, but only in some prairie types. This change could have serious implications for the way prairie ecosystems function.

Disciplines
Agriculture | Ecology and Evolutionary Biology | Plant Sciences | Terrestrial and Aquatic Ecology

Comments

Creative Commons License
This work is licensed under a Creative Commons Attribution 4.0 License.

Authors
Lori Biederman, Brent Mortensen, Philip Fay, Nicole Hagenah, Johannes Knops, Kimberly La Pierre, Ramesh Laungani, Eric Lind, Rebecca McCulley, Sally Power, Eric Seabloom, and Pedro Tognetti

This article is available at Iowa State University Digital Repository: https://lib.dr.iastate.edu/eeob_ag_pubs/313
How do nutrients change flowering in prairies?

Authors:
Lori Biederman, Brent Mortensen, Philip Fay, Nicole Hagenah, Johannes Knops, Kimberly La Pierre, Ramesh Laungani, Eric Lind, Rebecca McCulley, Sally Power, Eric Seabloom and Pedro Tognetti

Abstract

Farmers today apply more synthetic fertilizers to farm fields than ever before – but not all of these nutrients are used by crops: some fertilizer escapes through the air, soil, or water. Nitrogen, phosphorous, and potassium flow off farm fields when it rains, billow into the air when fields are plowed, and drift with the wind to other areas. Extra nutrients are also released to the air when people burn fossil fuels. We wanted to find out: what happens when these extra nutrients land on wild prairie ecosystems? How do its wild plants respond? Do they all just grow better? Or could there be any negative side effects? To answer these questions, we systematically added nutrients to experimental patches of prairie. We found that these added nutrients (specifically nitrogen) made early-season plants thrive while reducing the amount of late-season plants, but only in some prairie types. This change could have serious implications for the way prairie ecosystems function.

Introduction

All living things use nutrients to grow. Nitrogen is one of the most important ones. In fact, the majority of the air we breathe (about 80%) is nitrogen gas. But neither animals nor plants can use it directly from the air. Instead, we (and other animals) have to get nitrogen from our food, and plants get it from the soil.

Human activities have caused major changes to the nitrogen cycle. Many farmers today use synthetic fertilizers on their fields to make their crops grow bigger and faster. These are made by chemically converting nitrogen gas to forms of nitrogen that plants can use. However, not all fertilizer is used just by the crops “to which it was applied. Some of this fertilizer floats through the air, gets into the soil, or flows into water. This has unintended consequences for different ecosystems, like causing overgrowth of algae in water (which can lead to fish dying), or polluting the drinking water for humans.

In addition, burning fossil fuels – whether as gasoline in cars or as coal in power plants – releases excess nitrogen. These particles of nitrogen drift through the air or get caught in raindrops, falling to the earth and also acting as unintentional fertilizers.

We centered our research on prairies, which are open grasslands in the Midwestern United States (Fig. 1). Prairies consist mainly of grasses, but other small plants also grow there. Biodiversity (the number of different species) can be quite high. Most of the plants in prairies can survive on very few nutrients.

We wanted to find out:

- What happens when these extra nutrients land on wild prairies?
- Specifically, how do additional nutrients affect when prairies flower?
Methods

For this study we used data from 11 sites in the Midwestern United States. These sites included three different types of prairies: short-, mixed-, and tall-grass prairies. (The amount of rain determines which type of grass grows in the prairie: the more rain, the taller the grass). We determined which months in the growing season (May through October) each plant normally flowered by consulting local floras. We also noted whether each plant species we found in our plots was native to the region or originated in another part of the world (known as exotic species). Back at our computers, we did statistical analyses on the data we had collected to see how added nutrients affected when the plants in the prairie produced flowers.

<table>
<thead>
<tr>
<th>Control</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>NP</th>
<th>NK</th>
<th>PK</th>
<th>NPK</th>
</tr>
</thead>
</table>

Figure 2: Experimental setup of our prairie study plots. The control plot was left untouched, but we added different combinations of the following nutrients to our study plots: N = Nitrogen, P = Phosphorus, K = Potassium.

Results

In one of the prairie types, the tall-grass prairie, we found that adding more nitrogen caused plants that flower in the spring (May and June) to flourish (Fig. 4). This allowed them to cover a greater area than usual. Moreover, nitrogen also decreased the relative cover of plants that flower in September and October. This pattern happened mainly because the plants that flowered early in the season (mainly exotic grasses) grew enthusiastically with all the excess nutrients and invaded the plots, leaving little room for the late-season grasses (some of them native species) to grow.

Why don’t you go out and observe, and try to notice all the biodiversity around you? There are so many different species of plants and animals! With a little practice you can learn to recognize some of them. Learning what’s around you will help you to connect with nature, which is the most important step for protecting it.
We think that the tall-grass prairie ecosystems are particularly vulnerable to nutrient additions because they don’t normally have many plant species that flower in the spring. It may be that adding nitrogen creates a window of opportunity for exotic species to invade, allowing them to take advantage of less competition from native plants. Mixed- and short-grass prairies have many native plant species that flower during the spring, which might make them more resistant to invasion from exotic species even when nutrients are added, because these early-season native plants can use the fertilizers and also crowd out the exotic species.

The shifts in flowering we find in tall-grass prairie plant communities with added nitrogen could have serious ecological effects: animals and insects that rely on late-season prairie plants for food would find less of it and will have a harder making it through the winter. More early-season growth might cause plants to use up more water stored in the soil, leaving them vulnerable if rains don’t come later. Shifting when plants flower and die may also affect the timing and intensity of fires.

Discussion

The shifts in flowering we find in tall-grass prairie plant communities with added nitrogen could have serious ecological effects: animals and insects that rely on late-season prairie plants for food would find less of it and will have a harder making it through the winter. More early-season growth might cause plants to use up more water stored in the soil, leaving them vulnerable if rains don’t come later. Shifting when plants flower and die may also affect the timing and intensity of fires.

Conclusion

Though synthetic fertilizers can help crops grow bigger and faster, the nutrients in these fertilizers can escape into the air, soil, and water, where they can have undesirable effects in many different ecosystems. To prevent this, we can support organic farmers who don’t use synthetic fertilizers on their fields by buying their organic produce whenever possible. At home, we can use less fertilizer in our gardens. Finally, we can observe and document how nutrient addition changes ecosystems – the more we understand about the unintended consequences of nutrients on different ecosystems, the more we will be able to mobilize support to prevent negative side effects of nutrient overdose in the first place.
Glossary of Key Terms

**Abundance** – the number of members of a species in a given area.

**Biodiversity** – the variety of organisms that live in any given ecosystem. We say that there is high biodiversity when there are lots of different types of plants and animals in an ecosystem.

**Early-season plants** – plants in the prairie that flower in the beginning of the growing season, in our case in May and June.

**Ecological niche** – the resources, conditions, and interactions a species experiences in an environment.

**Ecosystem** – a community of interacting plants and animals and their physical environment.

**Exotic species** – a species of plant or animal in a particular place that has been brought by humans from its place of origin, sometimes on purpose, sometimes by accident.

**Fertilizer** – a substance applied to plants that makes them grow bigger and faster; fertilizers generally contain all or some of the following elements: nitrogen, phosphorous, and potassium, sometimes in various proportions.

**Flora** – an encyclopedia or list of the plants in a particular region.

**Late-season plants** – plants in the prairie that flower in the end of the growing season, (September and October in the Northern Hemisphere).

**Native species** – species that naturally occur in a particular ecosystem and that are not brought in by human activity.

**Nitrogen (N)** – an element found in the atmosphere, in minerals, and in all living things. Nitrogen is essential for life because it is an important part of proteins.

**Nitrogen cycle** – the series of processes by which nitrogen moves between in the air, soil, water and living things its different forms.

**Nutrient** – a tiny part of food that organisms use to eat and grow. Nitrogen is a very important nutrient for plants.

**Organic farmers** – farmers who do not use synthetic fertilizers or pesticides on their fields, but rather use more natural fertilizers from manure, crop rotations, and biological pest control.

**Particles** – a very small piece of something.

**Phosphorus (P)** – an element found in rocks, bones, teeth, and all living cells. Phosphorus is necessary for life.

**Plant community** – a group of plants living together within an ecosystem.

**Plot** – a small parcel of land, in this case that is observed in an experimental context.

**Potassium (K)** – a nutrient that is often found in fertilizer.

**Prairie** – an open area of native grassland in the Midwestern United States. Prairies are categorized as short-grass, tall-grass, or mixed-grass prairies based on the types of plant communities that are found there. These are usually determined by the amount of rain that falls in the area.

**Relative cover** – the proportion of ground a particular plant species covers in a plot of land, compared to the other plant species present.

**Scientific control** – one of the tested groups in a scientific experiment, which is NOT exposed to any experimental treatment but is tested under the same conditions as all other groups. This helps the scientists confirm that the experimental treatment actually makes a difference. Every good experiment must have a control group if it wants to reach valid results.

**Statistical analysis** – a mathematical analysis of scientific data within a study to test whether its results are significant.

**Synthetic fertilizer** – a human-made fertilizer, which is often made by chemically converting nitrogen gas to forms of nitrogen that plants can use.
Check your understanding

1. How have human activities affected the nitrogen cycle?

2. Why do nutrients in fertilizers applied to farm fields end up in other places, like prairies?

3. What effect did excess nitrogen have on flowering plants in tall-grass prairies?

4. How might nutrient-induced changes to flowering plants in the prairie affect the wider ecosystem?

References

http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0178440

Environmental Protection Agency. The Problem: Nutrient Pollution.
https://www.epa.gov/nutrientpollution/problem

The Nutrient Network
http://www.nutnet.org/home