PRESS RELEASE

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Using fire to revive a fragmented prairie landscape

A new study reveals that the beneficial effects of fire on plant reproduction in North American prairies depend on the size of the plant population. Researchers found that summer flowering increases after spring fires regardless of the size of the prairie. In contrast, pollination and seed yield increased the most in small populations. Larger populations got a substantial boost, but the smallest population gained no benefits. Conservation scientists from the Negaunee Institute for Plant Conservation Science and Action at the Chicago Botanic Garden and the University of Minnesota investigated how fires stimulate flowering and pollination and how much the influence of fire depends on the population size. During the six-year study of *Echinacea angustifolia*, a prairie plant commonly known as the narrow-leaved purple coneflower, researchers tracked 6357 individuals across 35 populations ranging in size from 3 to nearly 4000 adult plants in western Minnesota. Before and after 22 experimental burns in these *Echinacea* populations, researchers measured flowering effort and outcomes to learn how fire influences different stages of plant reproduction and how much fire benefitted large and small populations. The paper will be published In Proceedings of the National Academy of Sciences on or after 18 Sept 2023 (https://www.pnas.org/doi/10.1073/pnas.2306967120/).

The narrow-leaved purple coneflower is native to the tallgrass prairie and plains west of the Mississippi River to the Rocky Mountains, ranging from Texas to Canada. Researchers use this plant as a model organism to study perennial plants in grasslands. Related species, including *Echinacea purpurea*, and ornamental cultivars are often grown in gardens. Echinacea plants are used in traditional medicine. The Echinacea Project has been funded by the National Science Foundation since 2000. Dr. Stuart Wagenius started the project as a graduate student at University of Minnesota. Many student, interns, and volunteer scientists contributed to this research over the years.

Visit https://echinaceaproject.org/habitat-fragmentation-decouples-fire-stimulated-flowering-from-plant-reproductive-fitness/ and follow @TeamEchinacea on X (twitter) for more information.

Background

Although a fire can kill some plants, many plants need fires to survive and flower. Entire habitats, like the tallgrass prairie, depend on fires, which historically burned across thousands of acres of grasslands in North America each year. Today fires are an important tool for managing prairies and conserving native plant diversity. It is well established that fire reduces shade, influences soil, and improves seed production in large preserves, but this research reveals how fires affects pollination in small, isolated prairie remnants—which are critically important for plants and pollinators. Fires consistently affect flowering, but pollination depends on the size of the population.

Quotes from Researchers

“Fire plays an important role in plant reproduction across historically fire-dependent habitats worldwide,” said Jared Beck, Ph.D., postdoctoral research scientist at the Negaunee Institute and lead researcher. “For example, fire stimulates flowering for thousands of plant species across historically fire-dependent habitats but few studies examine how fire influences seed production.”

“Seed production depends on both reproductive effort as well as pollination,” explained Amy Waananen, Ph.D., a recent graduate student and current postdoctoral research scientist at the University of Minnesota, and co-author of the study. “Bees are most likely to move pollen between plants that are nearby and flowering at the same time. In small populations, even after fire when more individuals are likely to flower, potential mates may still be few and far between.”

“Persistent reproductive failure can make small populations vulnerable to local extinction,” said Stuart Wagenius, Ph.D., senior scientist at the Negaunee Institute, and co-author. “Our previous work in large populations showed that fire synchronizes reproduction and improves seed production, which could help population persist or grow. This recent work from a range of population sizes suggests the beneficial effects of fire may not help the smallest plant populations at all but they can really boost small to medium-sized populations.”

“For decades, researchers and conservation practitioners working in fire-dependent habitats have focused on how fire influences the physical environment and creates conditions favorable for plant growth and seedling recruitment,” said Dr. Beck. “Our findings highlight how some plant responses to fire depend on population size, not just fire intensity or other related to the physical environment. This is important because many fire-dependent systems are experiencing ongoing habitat loss and fragmentation.”

“Tallgrass prairie historically covered millions of acres of central North America. Today tallgrass prairie is among the most threatened and least protected habitats in the world,” said Dr. Wagenius. “Most remnant prairies are small, isolated, and losing native plant species at an alarming rate.”

“Land managers rely on prescribed fire to maintain historically fire-dependent systems. Our research suggests that when populations become too small, we may reach a tipping point at which fire becomes ineffective,” said Dr. Waananen.

“On a more positive note,” Beck says, “we learned even small populations with just 30 adult plants benefit from fire. For us this is a call to action. We still have an opportunity to conserve the incredible plants inhabiting these remnants scattered across the landscape!”

“One of the most rewarding parts of this research has been working with private landowners and seeing their excitement, curiosity, and interest in conservation grow as the remnant patches spring to life after fire,” says Beck. “It is a good reminder that everyone can make a difference in their community and play an important role in conservation.”

Beck adds, “Multiple threats faced by plant populations can interact in nuanced and sometimes unexpected ways. The loss of fire coupled with ongoing habitat loss and fragmentation contribute to population declines, but conservation actions addressing one but not the other may fall short.”

Concise Summary of Key Findings/Observations

Fires consistently increase reproductive effort across populations, but the influence of fire on reproductive outcomes depends on population size. In large populations, fire increases mating opportunities, leading to better pollination and greater seed production. However, in small populations with fewer than 30 plants, fire does not consistently improve pollination or seed production. Medium-sized populations (40-100 individuals) saw the greatest increase in seed yield per plant.

Conclusions and/or Recommendations

Our findings have important implications for plant conservation in historically fire-dependent ecosystems worldwide. Many fire-dependent habitats are experiencing extensive habitat loss and fragmentation. Conservation practitioners rely on prescribed fire to maintain habitat structure and promote species diversity. This study reveals the beneficial effects of fire the beneficial effects of fire depend on the size of the plant population. Seed yield increased the most in small- medium populations. Larger populations got a substantial boost, but the smallest population gained no benefits. Habitat fragmentation compromises the reproductive benefits of synchronized flowering after fire. Prescribed fire is effective in small patches of prairie and other fire-dependent habitats but may become ineffective after populations shrink below 30 individuals making it important to act before populations become too small and isolated.

Future Research and Next Steps

This study raises two important questions that the Echinacea Project is currently working to address.

First, how general are the reproductive responses to fire that we observed in Echinacea? Hundreds of native plant species inhabit fragmented prairie remnants and many of these species flower vigorously after fire. Furthermore, thousands of plant species are known to flower after fire across fire-dependent habitats worldwide.

Second, how do these reproductive responses to fire influence population dynamics? Plants like Echinacea live for decades and reproduce multiple times during their life, so annual seed production may be less important to population growth than rates of survival. On the other hand, failure to produce seeds year after year will prevent populations from growing and could limit a population’s ability to adapt to a changing environment. We are working to understand how fire effects on different plant life stages contribute to population growth.

List of Funders

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