Sustainable bioenergy from native prairies on abandoned agricultural lands

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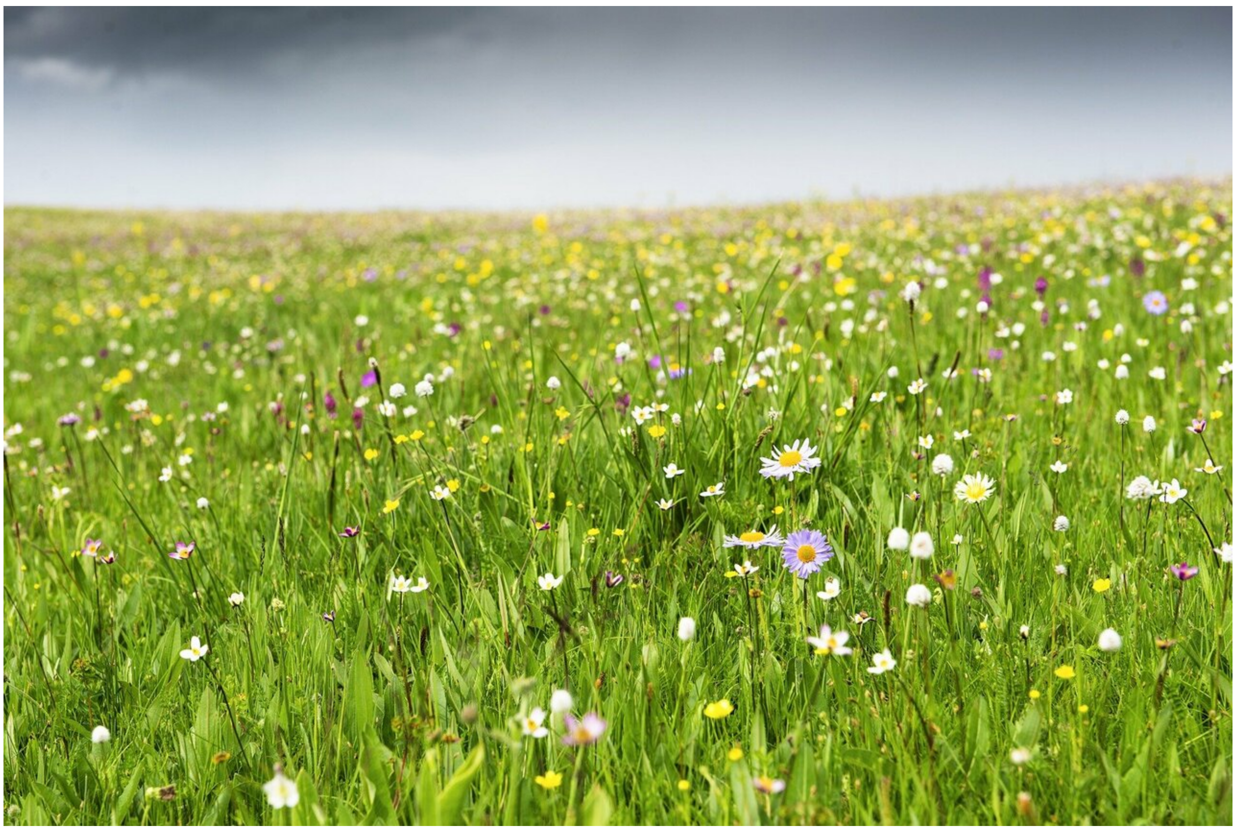

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In an ongoing effort to discover the ideal conditions to grow alternative biofuels that offer more environmental benefits, University of Minnesota scientists applied their research on native prairies in the

Upper Midwest to understand marginal lands—particularly abandoned and degraded agricultural fields.

"Native, perennial grasses and abandoned fields have been proposed as a way to increase the environmental benefits of biofuels. First generation biofuels, such as corn ethanol, require intensive use of nitrogen fertilizers and take land away from food production. We wanted to see if prairie grasses might prove to be a better crop," said lead researcher David Tilman, professor in the College of Biological Sciences (CBS) and director of the Cedar Creek Ecosystem Science Reserve.

Another potential benefit of perennial grasses is tied to their deep root systems. According to researchers, deeper root systems—as opposed to those seen in annual crops like corn—are able to store large amounts of carbon below ground that would otherwise be released into the atmosphere. However, because perennial grasses on marginal lands can have low yields due to less fertile soil, researchers examined ways to maximize growth of the grasses without negative effects on the environment.

In the 10-year study published in *Nature Sustainability*, researchers utilized 36 plots at an abandoned agricultural site in the Cedar Creek Ecosystem Science Reserve to plant 32 species of prairie and savanna plants that are native to Minnesota. In 2007, researchers divided the plots into several groups and assigned them a combination of two treatments: water addition (i.e., irrigated or non-irrigated) and nitrogen fertilization (i.e., 0 g/m^2, 7 g/m^2, 14 g/m^2).

Over the next decade, researchers found that:

- moderate treatments (irrigation and 7 g/m^2 of nitrogen) had the best biomass yields and soil carbon storage, while having negligible effects on the stability, diversity and nutrient loss to

groundwater;
- compared with the control (non-irrigated and no additional nitrogen), moderate treatments resulted in almost twice the yield and soil carbon storage and—if the plants were converted into bioenergy to displace fossil fuels—it would result in twice the greenhouse gas savings;
- compared with the moderate treatment, the more intensive treatment (irrigation and 14 g/m^2 of nitrogen) had 30 percent lower greenhouse gas savings, 10 times greater nitrate leaching and 120 percent greater loss in plant diversity.

"Our results indicate that different intensification levels have different environmental benefits and costs," said Yi Yang, the lead author of the study and now a postdoctoral researcher at the Department of Bioproducts and Biosystems Engineering at the University of Minnesota. "Our study suggests that optimizing multiple environmental benefits requires sustainable intensification practices appropriate for the soils, climate and plant species of a region."

Compared with corn ethanol, researchers found biomass yield from the best performing native prairie grasses was moderately lower (six tons per hectare versus the average corn yield of eight tons per hectare in the U.S.). However, researchers found that because of lower nitrogen use and larger amounts of soil carbon storage, the native prairies would result in higher overall greenhouse gas savings when converted to bioenergy.

"Growing high-diversity prairie grasses and all the related prairie flowers on abandoned agricultural lands and using them for bioenergy can restore the ecology for wildlife and ultimately improve Earth's climate by helping displace fossil fuels," said lead researcher and CBS faculty member Clarence Lehman.

Further studies in other regions with different soil characteristics and climates should be conducted to expand these findings.

More information: Yi Yang et al. Sustainable intensification of high-diversity biomass production for optimal biofuel benefits, *Nature Sustainability* (2018). DOI: 10.1038/s41893-018-0166-1

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