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Editorial

Harvested perennial grasslands: Ecological models for farming's perennial future

Humanity's unprecedented global demand for farm products poses one of the greatest threats to global biodiversity and ecosystem function. This demand will almost certainly increase as the human population continues to expand over the next several decades. Annual crops supply much of that demand and occupy roughly 85% of global croplands (Monfreda et al., 2008). Staple grain crops, such as wheat, rice, and maize, alone provide more than 70% of human food calories and occupy 69% of global cropland. During the last half of the 20th century, farmers, overall, kept pace with or exceeded global food demands by expanding production onto previously unexploited landscapes and by utilizing new crop varieties, agricultural technologies, and management practices. Now, however, much of the global lands best suited for annual crop production are already in use. More marginal lands, which are at greater risk of degradation under annual crop production, are increasingly being exploited. Climate change, resource scarcity, and continued land degradation, which forces farmers onto even more marginal lands, exacerbates the problem of developing sustainable agricultural systems in the 21st century.

A key objective of most agricultural production is the harvest and removal of relatively large amounts of concentrated nutrients, particularly nitrogen, from landscapes. The ability of annual crops to meet this objective in the future on more marginal landscapes, in less favorable climates, and with fewer inputs without degrading important ecosystem services is increasingly in doubt. Perennial crops offer many opportunities to eliminate or greatly reduce the problems of annual crops (Jordan et al., 2007). Herbaceous perennials, many of which are closely related to the most widely used annual crops, have the added advantage of rapid regrowth following harvest and the ability to be harvested each year. Historically, though, herbaceous perennial crops offered less valuable farm products than their annual counterparts and have been primarily used to feed animals.

Until recently making the transition from extensive reliance on annual crops to perennial crops for a wide range of basic agricultural products was impractical or technically impossible. Achieving this transition is now more feasible because of advances in plant breeding, and innovations in post-harvest processing. Plant breeders have greater potential to develop perennial crops that produce a wider range of valuable products, such as grains (Glover et al., 2007). There is also growing potential to use a wider range of plants to produce non-traditional bio-products including fuels, solvents, and durable and bio-degradable materials (Regauskas et al., 2006; Nash, 2007). The long-term impacts of achieving a perennial revolution in agriculture, one capable of sustaining the large harvests provided by our annual crops each year, are not well understood due to the dominance of annual crops.

Four reports of studies of harvested perennial grassland systems appearing in this issue illustrate the potential for sustaining high yields over long time periods with fewer inputs and negative environmental impacts. Glover et al. (2010) report on the findings of a team of soil scientists, microbiologists, plant and insect ecologists, agronomists, and water quality experts that has been studying the productive and environmental potential of harvested perennial grasslands at multiple temporal and spatial scales. A key finding was that the unfertilized grasslands, annually harvested for roughly 75 years, yield similar amounts of nitrogen per hectare in annual harvests of biomass as adjacent high-input wheat fields yield in grain. The grasslands, despite being harvested each year, supported a range of ecosystem functions at higher levels than the annual croplands.

Culman et al. (2010), providing more detailed information on belowground characteristics, found that the harvested perennial grasslands included in the Glover et al. study support higher levels of soil fertility and structure and more complex biological communities than annual crops produced for similar periods of time on adjacent farm fields. To determine whether these differences were artifacts of less than ideal farming practices, such as mold-board plowing and poor fertility management, used for annual crop production during the initial years of management, replicated plots of the harvested grasslands were converted to annual crop production using appropriate fertilizer and no-tillage practices. From that study, DuPont et al. (2010) report that the conversion of the harvested grasslands to no-till annual crop production resulted in reduced root biomass, decreased active soil carbon stocks, and impacted the soil biological communities.

Plant species diversity can also play a role in maintaining productivity and ecosystem health. To address that issue, DeHaan et al. (2010) determined that the level of plant species diversity found in natural grasslands might not be necessary to maintain high productivity. Over the 11-year period of the study, average yields of perennial legume and perennial warm-season grass bicultures were similar to those of the 16-species plots. By selecting plant species or cultivars with key characteristics, farmers might be able to achieve many of the advantages and services of higher diversity natural ecosystems using lower diversity agricultural production systems. This could make the development of sustainable systems much more feasible by avoiding some of the management problems associated with higher diversity systems.

These unfertilized, harvested grasslands do not represent the full potential of perennial cropping systems but likely represent their lowest potential. And while these studies were located in the mid-western states of the USA, other studies of harvested grasslands in the UK and Russia support the conclusion that perennial grasslands can provide sustained yields over long

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periods of time without experiencing reductions in soil fertility (Jenkinson et al., 1994; Jenkinson et al., 2004; Mikhailova et al., 2000; Mikhailova and Post, 2006). Through plant breeding and improved fertility management these studies indicate that perennial cropping systems could greatly outperform annual systems in terms of production and environmental performance.

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Jerry D. Glover*
The Land Institute, 2440 E. Water Well Road, Salina, KS 67401, USA

*Tel.: +1 785 823 5376; fax: +1 785 823 8728
E-mail address: glover@landinstitute.org

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