A 50-Year Farm Bill

proposed by

The Land Institute
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Introduction

Long-term food security is our issue. We begin with the knowledge that essentially all of nature's ecosystems feature perennial plants growing in species mixtures and that they build soil. Agriculture reversed that process nearly everywhere by substituting annual monocultures. As a result, ecosystem services—including soil fertility—have been degraded. Most land available for new production is of marginal quality that declines quickly. The resulting biodiversity loss gets deserved attention, soil erosion less.

Acknowledgment of coalitions

To address diminishing agricultural potential with a new vision, The Land Institute sponsored ten meetings coast-to-coast with farmers and representatives of sustainable agriculture organizations. This loose coalition can help to build a broader constituency.

Organic and local food organizations, including some represented in our coalition, provide vision, education and models of greater sustainability. With those constituencies, we share common principles and the goals of returning the world's grain-producing landscapes to perennial plants in the rotation for grain production.

Green Lands Blue Waters is an Upper Midwest coalition advocating the need to perennialize the landscape of the Mississippi Basin out of concern for soil erosion and the leaching of nitrogen, which is responsible for one of the largest dead zones of the world. GLBW partners include the University of Illinois, Iowa State University, including the Leopold Center for Sustainable Agriculture, Louisiana State University, the University of Minnesota, North Dakota State University and the University of Wisconsin, and the Audubon Society, the Illinois Stewardship Alliance, the Institute for Agriculture and Trade Policy, The Land Institute, The Land Stewardship Project, the Minnesota/Iowa Farmers Union, The Nature Conservancy, Trout Unlimited, Practical Farmers of Iowa, and the Rural Advantage and Agricultural Watershed Institute.

What is required?

Promote systemic change

A 50-Year Farm Bill is a proposal for gradual systemic change in agriculture. Perhaps what has been missing is an available vision with scientific feasibility. Implementation will depend on endorsement by the Secretary of Agriculture, the President, Congress, nonprofit organizations, corporations, and citizens.

Plan

Enclosed are charts which illustrate changes over ten 5-year farm bill periods. Each 5-year bill, in addition to its existing programs for subsidies, food programs, etc., moves incrementally toward the 50-year goal of stopping the deficit spending of ecological capital necessary for food production. Thus, the 50-year Farm Bill becomes an instrument for increasing sustainability and food security.

In the short run, we can achieve a significant measure of success through farm policy that encourages farmers to increase the use of perennial grasses and legumes in crop rotations. But that will not be enough. Options for farmers will take a major leap when perennial grains are available. Their input costs will decline as the landscape benefits. USDA and other researchers will need policy to sustain funding. Breeding perenniality into a broad spectrum of our current grain crops will take time. Even so, prototypes have thrived for several years in Kansas. As their yields increase, they will replace their annual relatives—one in as few as 10 years.

Our project would employ the ecosystem as the standard. Once that standard is adopted, an array of technologies can become useful tools. Technology would follow, rather than lead the vision.

Cost

USDA funding

We do not seek USDA funding for The Land Institute, or The Leopold Center, or any particular organization. The Land Institute will offer to the project free germplasm and more than 30 years of experience with perennials. Its staff in this decade has greatly enhanced the diversity of crops and speed of change. We have hybrid prototypes of perennial wheat, sorghum, sunflower and other crops (see Attachment II). We are giving people small samples of flour from a perennial wheat relative we have named Kernza™. Biochemical analysis shows it to be superior to annual wheat in nutrition. People like it. We expect it to be farmer-ready in a decade.

During three decades, we have collaborated with several land grant universities and other institutions. We include them as assets. **Because the change needed is systemic, we believe that USDA should take the lead.** The Obama administration's devotion to change makes our proposal now seem possible.

We propose that, over an eight-year period, federal funding would sponsor 80 plant breeders and geneticists who will develop perennial grain, legume, and oilseed crops, and 30 agricultural and ecological scientists who will develop the necessary agronomic systems. They will work on six or eight major crop species at diverse locations. Budgeting $400,000 per scientist-year for salaries and research costs would add less than $50 million annually. This is eight percent of the amount that the public and private sectors have been spending on plant breeding research alone, according to a late-1990s survey.

Reversing ecological damage

Our vision is predicated on the need to end the ecological damage to agricultural land associated with grain production—damages such as soil erosion, poisoning by pesticides, and biodiversity loss. The most cost-effective way to do so and stay fed is to perennialize the landscape.

The transition of agriculture from an extractive to a renewable economy in the foreseeable future can now be realistically imagined. Our proposal is ambitious but it is necessary and it is possible. We have little doubt that we can make the agricultural transition faster than the adjustments imposed upon us by climate change and the end of the fossil fuel era. If we can keep ourselves fed, we have a chance to solve the other problems.

Conclusions

Perennialization of the 70 percent of cropland now growing grains has potential to extend the productive life of our soils from the current tens or hundreds of years to thousands or tens of thousands. New perennial crops, like their wild relatives, seem certain to be more resilient to climate change. Without a doubt, they will increase sequestration of carbon. They will reduce the land runoff that is creating coastal dead zones and affecting fisheries, as well as saving and maintaining the quality of scarce surface and ground water. U.S. food security will improve.

Social stability and ecological sustainability resulting from secure food supplies will buy time as we are forced to confront the intersecting issues of climate, population, water and biodiversity.

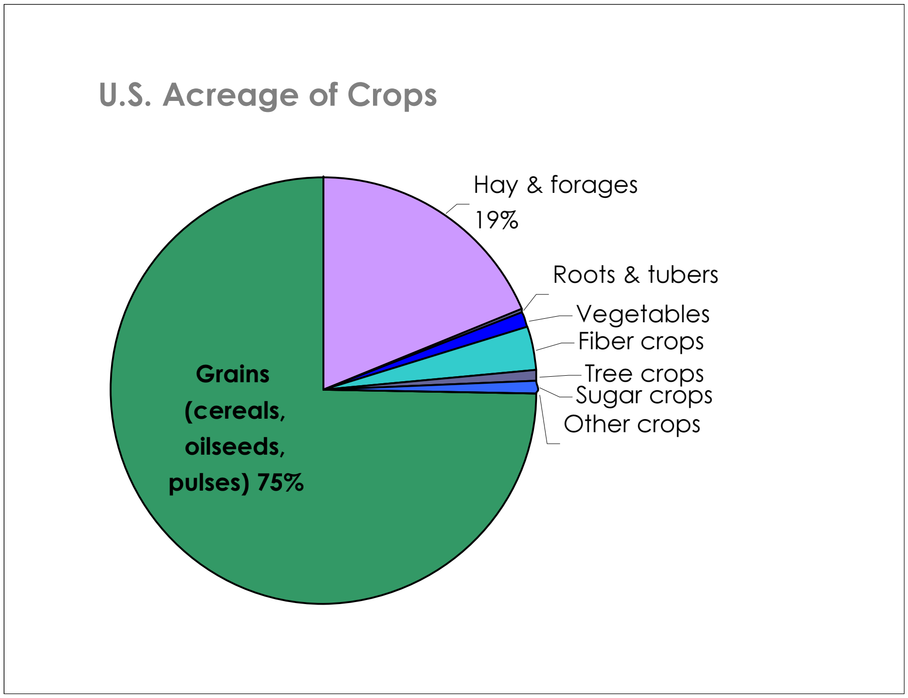
Five-year farm bills address:

- Exports
- Commodities
- Subsidies
- Some soil conservation measures
- Food programs

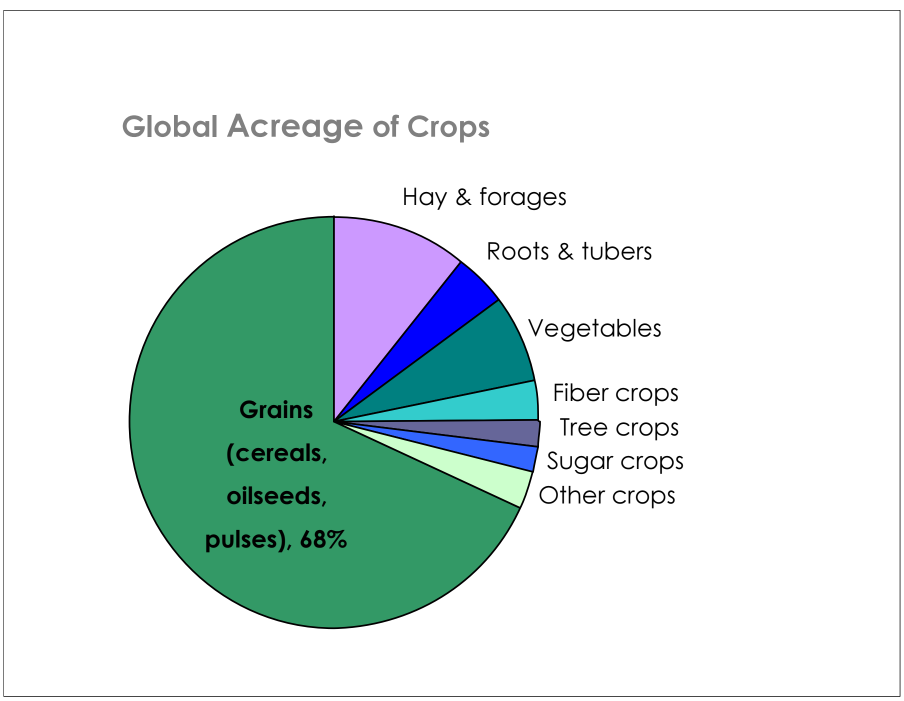
A 50-Year Farm Bill would be a program using 5-year farm bills as mileposts, adding larger, more sustainable end goals to existing programs:

- Protect soil from erosion
- Cut fossil fuel dependence to zero
- Sequester carbon
- Reduce toxics in soil and water
- Manage nitrogen carefully
- Reduce dead zones
- Cut wasteful water use
- Preserve or rebuild farm communities

U.S. and global crops



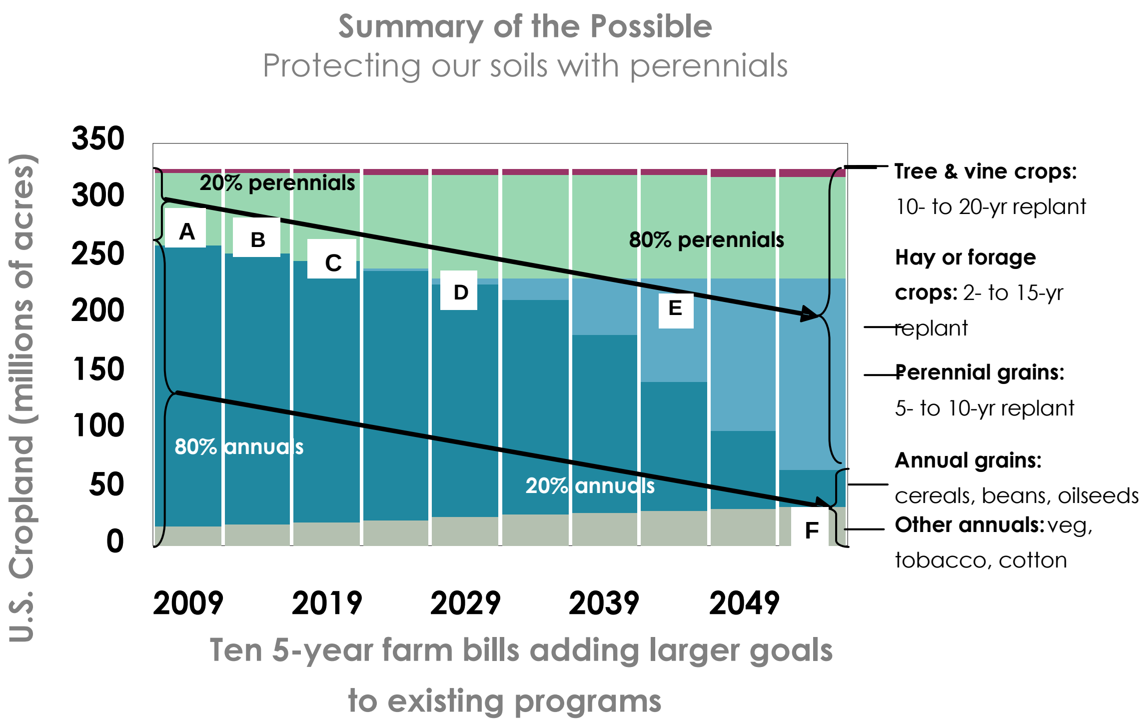
Although we start with our own country's soils and food supply, negative results of our present agriculture—soil erosion, chemical contamination, fossil fuel dependency for food production, and dead zones—are global problems, so this 50-year farm bill ultimately is for the world.



Protecting our soil with perennials: national acreage goals

Half a century of concerted investment in research, education and incentives to conserve soil with deep-rooted, long-lived perennial crops could increase the protected acreage from 20 to 80 percent.

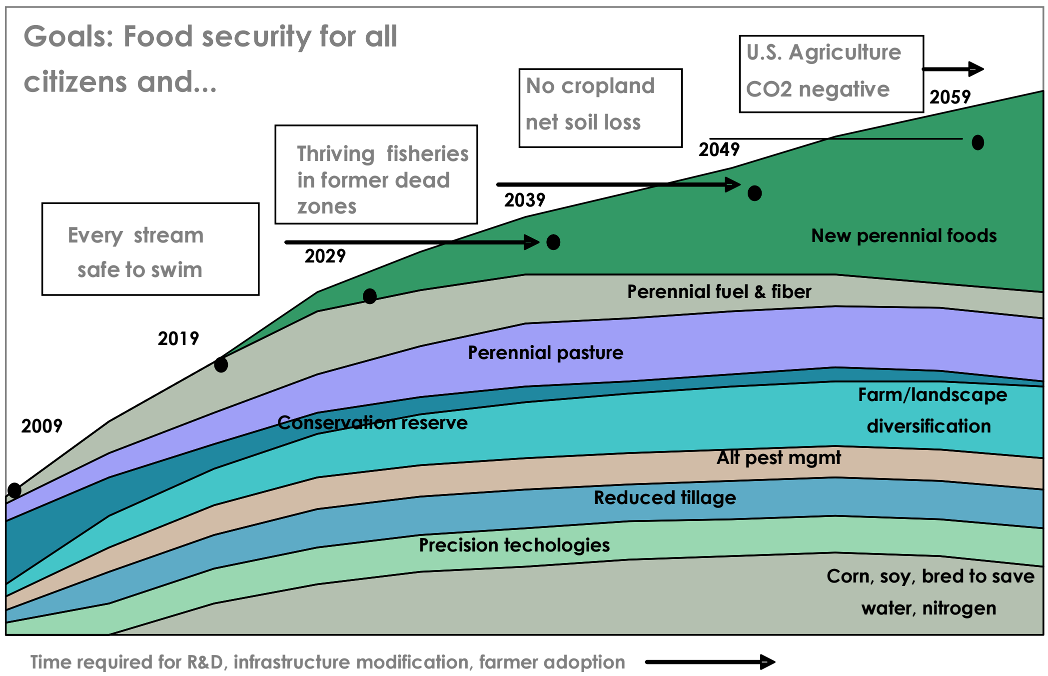
Pastures and perennial forage crops area already available either in permanent stands or in rotations. We propose incentives which would maintain the present perennial acreage and increase perennials in rotations. When perennial grains become available, they will require no financial subsidy, since they would represent a compelling alternative.



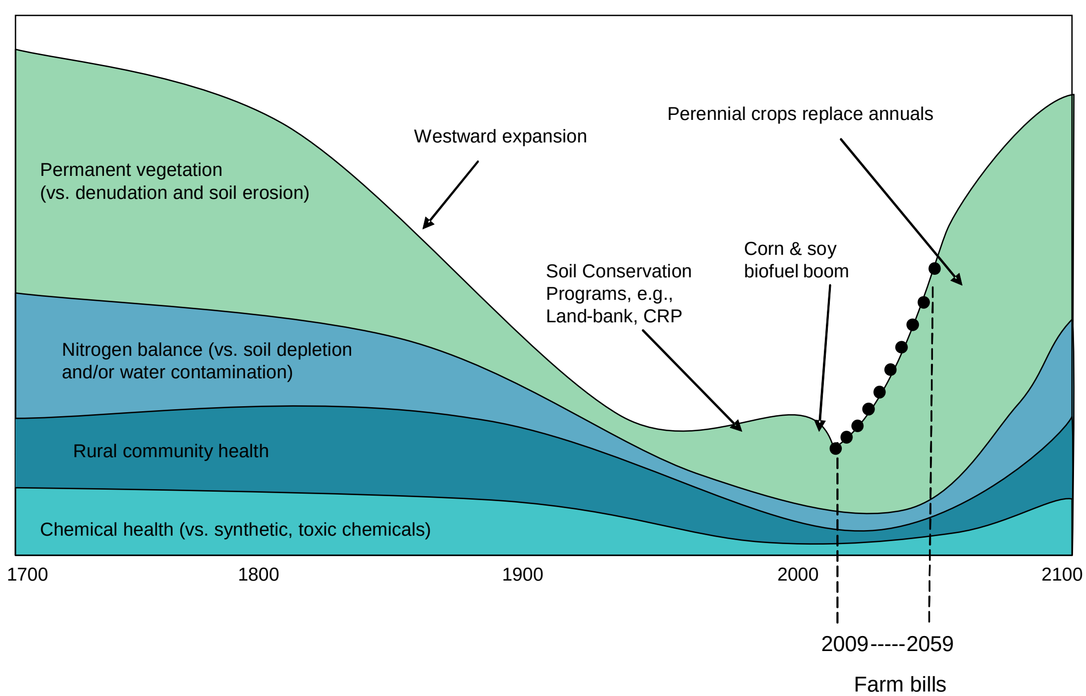
The chart above projects what is possible if we assume that the following are achieved in the 5-year periods shown above.

- A, 2009 Hay or grazing operations will continue as they exist. Preparations for subsidy changes begin.
- B, 2014 Subsidies become incentive to substitute perennial grass in rotations for feed grain in meat, egg and milk production.
- C, 2019 The first perennial grain, Kernza™ (a wheat) will be farmer-ready for limited acreage.
- D, 2029 Educate farmers and consumers about new perennial grain crops.
- E, 2044 New perennial grain varieties will be ready for expanded geographical range. Also potential for grazing and hay.
- F, 2054 High-value annual crops are mainly grown on the least erodible fields as short rotations between perennial crops.

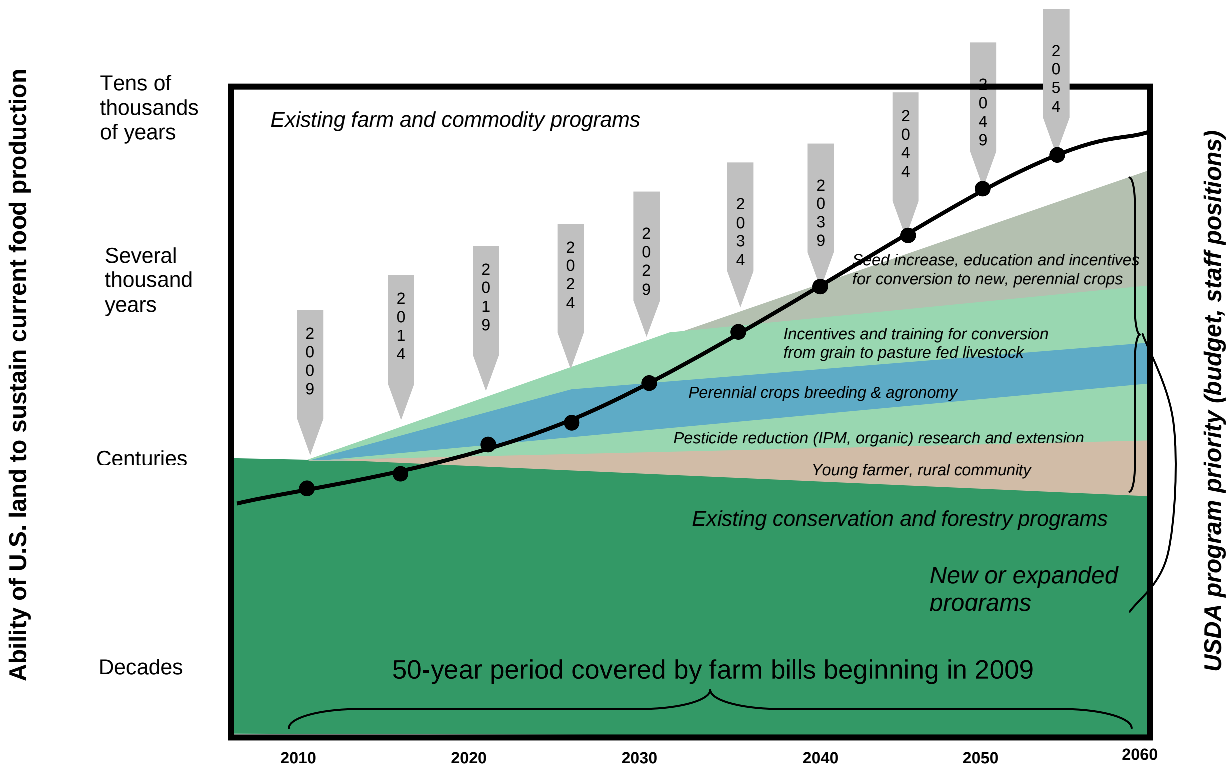
Long-term changes in U.S. agriculture



Components of agricultural sustainability



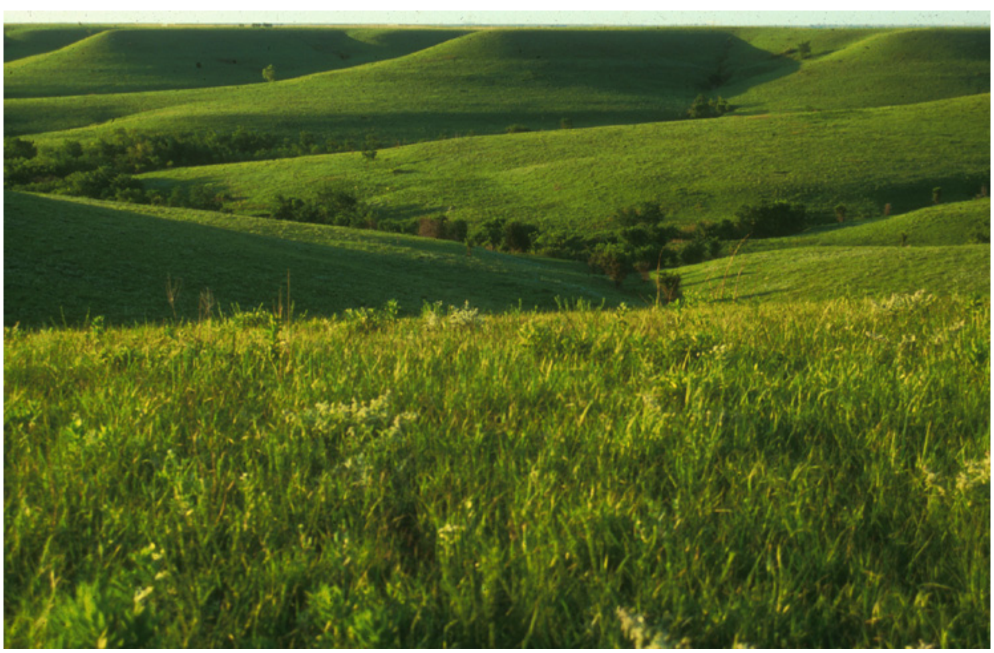
Changes in USDA program priorities
to increase the productive lifespan of US cropland



Estimates—changing over time as annual grains are replaced by perennial crops—of the remaining productive life of U.S. agriculture are shown on the left-hand axis. Colored areas and captions in italics refer to change in USDA priorities (right-hand axis) as the result of new policies in the next ten farm bills.

Erosion in Illinois
Flint Hills Prairie

Illinois cornfield, June 2008 / Kansas Native Prairie, June 2008



Attachment I

Problems and Solutions

Problems to be addressed

- According to the Millennium Ecosystem Assessment (MEA), agriculture is the "largest threat to biodiversity and ecosystem function of any single human activity."

- Agriculture is responsible for 70% of U.S. water contamination.

- 40% of US waters are unfit for swimming and fishing.

- "No Pesticide-Free Zones" – pesticides are present in nearly every water and fish sample in agricultural areas.

- Global agricultural expansion (assuming the business as usual approach):
  - 18% increase in cropland.
  - 300% increase in fertilizer.
  - 75% increase in pesticide production.
  - Primarily onto less resilient soils where, "if there is a choice, these soils must not be used for grain crop production." (Eswaran et al, 1999)

- Global implications:
  - 2.4 – 2.7 fold increase in eutrophication.
  - Increase greenhouse gas emissions.
  - Further soil degradation.
  - Loss of biodiversity.
  - Loss of critical ecosystem services: water and nutrient cycling, biocontrol, pollination.

Which forces the following conclusion:

The key ecological question: …intensive management with high yields, versus…lower-yielding systems" (Mooney et al, 2005) is a dichotomy forced upon us because our grains are annuals.

Conclusion: Production at the expense of conservation OR conservation at the expense of production.

Solutions proposed

- Diverse, perennial plant communities, domestic or wild, have been successful micro-managers of landscapes for millions of years.
  - This is due to perennial roots of varying architectures, alive year-round.
  - The same roots also bind the soil, making it less susceptible to wind and water erosion.

    - Perennials have greater access to water and nutrients over a longer growing season.

- From the point of view of the plant breeder, perennials have “excess capacity” that can be reallocated to grain production.

- The revolutionary transformation of wild species into crops has been done before (with annuals).

Conclusion: Conservation as the consequence of production is possible.

Attachment II

Perennial Grains Research at The Land Institute

Wheat has been hybridized with several different perennial species to produce viable, fertile offspring. We have produced thousands of such plants. Many rounds of crossing, testing and selection will be necessary before perennial wheat varieties are available for use on the farm.

Kernza™ is our trademark name for **Intermediate wheatgrass** (*Thinopyrum intermedium*). It is a perennial relative of wheat. Using parental strains from the USDA and other sources, we have established genetically diverse populations. We will harvest 30 acres in 2009 and an additional 100 acres will be planted in 2009. The overall quality is superior to annual wheat.

Grain sorghum is a drought-hardy feed grain in North America and a staple human food in Asia and Africa, where it provides reliable harvests in places where hunger is always a threat. It can be hybridized with perennial species *Sorghum halepense*. We have produced large plant populations from hundreds of such hybrids and have selected perennial strains with seed size and grain yields up to 50 percent those of annual grain sorghum.

Illinois bundleflower (*Desmanthus illinoiensis*) is a native prairie legume that fixes atmospheric nitrogen and produces abundant protein-rich seed. It is one of our strongest candidates for domestication as a crop. We have assembled a large collection of seed from a wide geographical area and have a breeding program. We see it as a partial substitute for soybean.

Sunflower is another annual crop we have hybridized with perennial species in its genus, including *Helianthus maximiliani*, *H. rigidu*s and *H. tuberosus* (commonly known as Jerusalem artichoke). Breeding work has turned out strongly perennial plants. Genetic stabilization will improve their seed production.

Perennial upland rice: Uplands fields of annual rice are highly vulnerable to erosion. Yet millions of people in Asia depend on it. In the 1990s, the International Rice Research Institute achieved significant progress toward breeding a perennial upland rice using crosses between annual rice, *Oryza sativa*, and the two wild perennial species, *Oryza rufipogon* and *O. longistaminata*. The project was terminated in 2001, but the breeding and genetic populations were transferred to the Yunnan Academy of Agricultural Sciences in southwestern China, where work has been continued with funding support from The Land Institute. The focus is on the more difficult work with the distantly related *O. longistaminata*, which, when crossed with rice, produces plants with underground stems called rhizomes. In recent breakthroughs, a small number of perennial plants with good seed production have been produced.

Corn and **soybeans** are two species, one could argue, which more than any other crop, need to be perennialized. **Corn** is a top carbohydrate producer and is grown on 70 million acres annually. Until soybean acres increased, corn caused the greatest amount of soil erosion in the United States. It is always number one or two. It will be a challenge to perennialize this crop, but serious consideration is being given to doing so by exploring two main paths. 1) We could obtain genes from a few distant relatives of corn which are in the genus *Tripsicum*. All are perennial and at least one is winter-hardy. 2.) The other, more likely route would be to cross with two much closer perennial relatives of corn. Unfortunately, both species (*Zea perennis* and *Zea diploperennis*) are tropical and non-winter-hardy. Professor Seth Murray at Texas A&M favors using them in crosses rather than *Tripsicum*. Dr. Jim Holland, a USDA corn geneticist at North Carolina State University says that perennial corn development comes down to a few technical issues which need solved.

Several Australian species of the **soybean** genus *Glycine* are perennial; they are difficult to breed with soybean but are potential targets for direct domestication, without crossing to soybean. Our exploration for perennializing soybeans has been very limited. We have been working to make Illinois bundleflower a satisfying substitute.

There is potential for many more perennial grain species, including **rosinseed, Eastern gamagrass, chickpea, millets, flax** and a range of **native plants**.

Ecological Research

To mimic a natural ecosystem to some degree will require some degree of crop diversity. We have elected not to wait until perennial grain crops are fully developed to gain experience about the ecological context in which they will grow. At The Land Institute we have established long-term ecological plots of close analogs in which to compare methods of perennial crop management. These perennial-grain prototypes, including Kernza™ and bundleflower, are allowing us to initiate long-term ecological/ production research in these plots. Eventually, true perennial grain mixtures will succeed them. Additionally, ongoing studies of natural ecosystems, such as tallgrass prairie, provide insight into the functioning of natural plant communities. The prairie is now and likely always will be a valued teacher.

The Road Ahead

At The Land Institute we have laid out a route to follow in breeding perennial grains and developing the agro-ecosystems in which they will grow. To expand research on perennial grains across the nation and planet, we freely distribute germplasm—seed of perennials and hybrids. Other plant breeders are using these seeds as parents in establishing or enhancing their own perennial grain programs. Seeds are available for basic research to answer fundamental questions. We are building a body of knowledge about perennial grain systems through publication in the refereed journals.

Attachment III

Frequent Questions

Over the past three decades, interested people have asked some good questions. The most frequently asked follow and are followed by our best answer.

1. **It is expected to take at least twenty-five years to achieve more than two or three profitable, productive perennial grain crops. Isn't that too late to address the problems facing the world today?**

   We do expect two or three of our grains to be available within 10-15 years. But in answer to the question— as with the climate and population problems with no quick solutions—we need to move as fast as possible. New strategies are needed that emphasize efficient nutrient use in order to lower production costs and minimize negative environmental impacts. The sooner that successful alternatives are available, the more land we can save from degradation. It is likely that global agricultural acreage will expand over the next two to three decades especially if the human population increases to 8 to 10 billion people. Recent projections predict an 18% or more increase in agricultural land by 2020. The best soils on the best landscapes are already being used for agriculture. Much of the future expansion of agriculture will be onto marginal lands (Class IV, V, and VI) where risk of irreversible degradation under annual grain production is high. As these areas become degraded, expensive chemical, energy, and equipment inputs will become less effective and much less affordable.

   Thirty-eight percent of global agricultural lands are currently designated as degraded, and the area is increasing. To minimize encroachment onto non-agricultural lands in the future, currently degraded lands will need to be kept in production AND restored to higher productive potential. In regions of the world where high inputs of fertilizers, chemicals and fuels are not an option, agricultural systems that are highly efficient, productive, and conservative of natural resources are needed—and will be needed even more 25 years from now.

2. **Can we expect perennial grain crops to be as productive as annual grain crops and, if not, won't they actually worsen environmental problems by requiring more land for agricultural production?**

   a) There is sufficient evidence that "reasonable reference yields" of annual crops can be matched on high-quality lands and exceeded on poor-quality lands by diverse perennial systems with fewer negative impacts.

   b) It depends on which annual yields are used as a standard. For example, the world record wheat yield was harvested in the Palouse region of Eastern Washington State where wheat yields can top 100 bushels per acre. Annual wheat production in that region, though, has resulted in extensive erosion. All of the topsoil has been lost from over ten percent of the region's landscapes. On eroded sites Palouse wheat yields may be less than 25-30 bushels per acre. Crop yields that come at such a high cost to the soil resource—or that depend on an extravagant use of chemical fertilizers—should not be used as a standard of comparison.

3. But won't the seed yield of perennials always be limited by the need to save some energy for overwintering that could have been used to produce seed?

The short answer is no. The theoretical limitations to seed yield in perennials are no more serious than in annuals. In annuals, yield is limited by shorter growing seasons, water shortage due to short roots and poor seedling establishment. In perennials, yield can be constrained by the need to overwinter, but rapid spring growth of perennials, combined with season-long access to water deep in the soil profile, means that perennials such as alfalfa are over-all more productive than related annuals like soybeans. Much of the journey-work of plant breeders has been to shift the allocation of resources from leaves, stems, crowns, and roots toward seed in the development of perennial grain crops.

4. With advances in no-till production of annual grain crops, do we need perennial grains to mitigate the environmental problems associated with agriculture?

Unfortunately, yes. Although no-till technology has reduced erosion in many areas, some problems remain due to the biological limitations of annual plants. Chief among the problems associated with no-till is water quality. Annual crops, even in no-till situations, are relatively inefficient in capturing nutrients and water. In the Midwest, as much as 45% of precipitation may be lost through the soil profile under annual cropping. Rates of water loss through profiles may be five times greater under annuals than under perennials. No-till compared with conventional tillage systems can have losses as great or greater.

Annual crop plants are either absent or too small to use and manage water during times of precipitation. Water flowing through the soil profile transports downward soil nutrients and agrichemicals. Poor water quality is the consequence. This problem can be compounded under no-till production which often requires greater inputs of agrichemicals and fertilizers. A 2002 EPA survey of the nation's water quality shows a downward trend from the late 1990s. The problem is getting worse, despite widespread adoption of no-till and minimum-till systems.

Crop seeds need warm, well-drained seedbeds in order to properly germinate. No-till limits this. That is why tillage remains an attractive practice in northern regions. Warming and drying of the seedbed can be hastened. Advances in plant breeding may eventually allow for optimal germination in cooler, wetter conditions, but in the Midwest, seedlings will still be small when the rains come.

5. If our farming systems "mimic," to some degree, natural ecosystems, what level and kind of plant diversity is needed and how will it be deployed?

The answer to both parts of the question is, "It depends." It depends on the resilience and fertility of the soil, climate, disease pressures, and types of crops. Nearly all of nature's land-based ecosystems feature perennial plants grown in diverse mixtures. Natural ecosystems, in general, use and manage water and nutrients most efficiently and build and maintain soils. For that reason alone nature is our standard. The level and spread of diversity varies. The characteristics of the region in which they are to be grown will have to be assessed.

Diversity is of two kinds: multiple species and genetic diversity within species. Current grain production practices commonly involve planting a single genotype (near-zero genetic diversity) across a field often larger than 100 acres. Furthermore, that single genotype and other genetically similar plants are being grown on millions of acres in a region. Increases in genetic diversity at the species, field, and landscape levels are needed. The final ordering of the components of that diversity will be determined by what is useful and can be practically achieved by local farmers.

6. Several serious attempts have been made in the past to perennialize grain crops and we have none to date. What has changed that offers promise of success now?

History need not be a source of discouragement. In the case of wheat, most involvement with perennials had to do with bringing desirable genes—for resistance, say—from a wild perennial relative into the annual crop. The perennialization effort, in most cases, was carried on, more or less as a hobby, by an interested researcher but with no institutional commitment for a sustained program to guarantee continuity. When the researcher retired, the effort ended. The Soviets had the most ambitious perennial wheat program, but political decisions halted these efforts in the late '50s or early '60s.

We are now in a new era in two ways:

a) In recent years, the costs to our soils and waters due to annual cropping are increasingly weighed against bushels per acre, making some reduction in yields acceptable.

b) With recent advances in plant breeding, more knowledge of the genome and greatly increased computational power, thinking about breeding limits has changed.

7. Since mechanical tillage and annual rotations are largely eliminated in perennial systems, don't the perennial plants become "sitting ducks" for pests and disease?

Here proof is in the pudding. Perennials dominate most native landscapes and constitute roughly 80% of North America's native flora. Perennials have thrived throughout the evolutionary history despite the pressures of pests and disease.

In some fields or some regions, some perennial crops will prove to be more problematic than others and breeding for complex traits like yield and perenniality can unintentionally purge genes involved in resistance responses. There will undoubtedly be pest and disease problems. But these problems also afflict our most productive annual crops. And there are many examples of herbaceous perennial plants—alfalfa, switchgrass, brome—that remain highly productive for many years despite exposure to pests or disease. Diversity (whether at the field or landscape scale or over time), field burning, and selecting for resistance in a plant breeding program are essential elements of our work.

8. How do alternative methods of production such as permaculture, biointensive, or organic fit in with perennial grain crops? What about vegetables and fruits? How do community-supported agriculture farms fit in?

We focus on the crops that occupying 68 percent of global cropland and provide about the same percentage of food calories: annual grain crops grown primarily in monocultures. Any number of approaches, alternative or conventional, could be used in managing perennial crops and distributing the harvest.

This is not to say that efforts aimed at reducing the scale of industrial agriculture and increasing local food security are misguided. They are not! They are necessary to transform our food system over the long term. While promoting local, small-scale, organic agriculture we must also assess how and where the bulk of our calories can best be produced. If all or even a large portion of the calories consumed by New Yorkers came from New York state there would be few trees left and the state's thin, poor soils would be quickly degraded. The bulk of the calories consumed by New Yorkers must come directly or indirectly from grain crops which grow well in the Midwest and Great Plains states.

9. Will the public eat perennial grains?

People like our Kernza™ (a perennial wheat) and we see little reason for people to find significant or undesirable taste differences in perennial grains generally. Greatest short-term success in developing suitable perennial crops will come with perennializing current grain crops with which the public are already familiar. Indeed, one of the strongest arguments for perennializing those grains is that it does not require large dietary shifts.

10. Finally, how are you going to harvest a perennial grain polyculture?

This question arose so frequently over the years that we finally decided to plant a polyculture of four annual crop species: corn, soybean, sorghum, and sunflower. The seed mixture was planted with an air drill. At harvest we opened the concave on the combine and cut the air (so as not to blow the sunflower seeds out the back). Progress through the field was slow, but not prohibitively so. Seeds were separated with a seed cleaner. The point is that mechanical equipment already in existence, with a little fine tuning can do the job. The larger problems are agronomic, not engineering.