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OPPORTUNITIES FOR ALIGNING THE INTERESTS OF AGRICULTURE AND ENVIRONMENTALISTS

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"Opportunities for Aligning the Interests of Agriculture and Environmentalists"

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Introduction

The number of farmers in developed countries has decreased steadily during the past century with the advent of mechanization and rapid development in other economic sectors. Today, less than 2% of the USA population is engaged in agricultural production, which has significant implications for development of policies and regulations that affect agriculture in a democracy. Even in farm states like Nebraska and Iowa, the steady decrease in farm numbers and rural population is shifting political power towards urban interests. Given these trends, and the fact they are likely to continue, it is becoming increasingly important to ensure that urban audiences appreciate the importance of a profitable agricultural sector and agriculture's role as guardian of environmental quality and natural resources.

Unfortunately, since publication of *Silent Spring* by Rachel Carson in the 1960s, there has been growing hostility between environmentalists and conventional agriculture. Likewise, agriculture is increasingly portrayed in a negative manner in the popular press and is often cited as the primary cause of many high visibility environmental problems. Nitrate and pesticide contamination of ground water, eutrofication of surface waters, hypoxia in the Gulf of Mexico, pesticide safety concerns, and loss of biodiversity are examples of environmental problems linked to agriculture.

In response, farmers, commodity groups, and agricultural industries (such as the fertilizer industry) often view environmentalists as an 'enemy' because of their perceived bias against conventional agriculture. While agricultural groups recognize that farming practices have contributed to some of the environmental problems cited above, they believe environmentalists exaggerate the problems and often do not base their concerns on "good science." Farmers and agricultural industries also resent the fact that environmentalists give little credit for the substantial improvements in environmental stewardship achieved as a result of investment in new crop and soil management technologies. Increased efficiencies in use of nitrogen (N) fertilizer, irrigation, and energy, as well as conservation tillage to minimize soil erosion have all significantly reduced the negative impact of agriculture on the environment in the past 30 years.

It is the premise of this paper that despite distrust of the environmental movement, there is an urgent need and tremendous opportunity to recruit urban support for agriculture, and in particular, the active support of key environmental groups. There are three simple reasons that underpin this need: (1) political power of the agricultural community will continue to erode and urban interests will continue to gain due to continuing demographic trends, (2) environmental groups are extremely efficient at mobilizing political support for their agenda because these non-profit organizations have large memberships and deep pocketbooks, and (3) the interests of agriculture and environmentalists are converging in new, mutually supportive ways that now offer opportunities for partnership. This paper explores these opportunities and calls for a proactive strategy to exploit them.

Interests of the General Public

In a democracy, the voting public ultimately determines policies and regulations that govern civil society. The public has vested interests in agriculture and the environment, and these interests are relatively straightforward (Table 1). All citizens need a safe, nutritious, and affordable food supply. And, as incomes rise, people desire greater diversity and quality in their food supply. The public needs access to clean drinking water; pristine rivers, lakes and oceans for recreation; state and national parks for communing with nature; and access to reliable and affordable energy supplies. The need for a reliable energy supply is also becoming a major concern for many developed countries because they are dependent on imported oil to meet their energy requirements. Homegrown renewable energy supplies based on production of ethanol and biodiesel fuels from feed and oilseed grains and biomass provide options to increase energy self-sufficiency while also contributing to a reduction in greenhouse gas emissions.

Interests of the Environmental Movement

Environmentalists have deep-felt connections to nature and give a high priority to protecting natural resources for future generations. Although most environmentalists recognize the need for a balance between use of natural resources for economic development and environmental protection, they choose to err on the side of caution when weighing the risks and benefits from various policy and regulatory options that govern access and use of natural resource endowments. Environmentalists are deeply concerned about conservation of biodiversity, which requires protection of habitat that supports plant and animal species threatened by extinction (Table 1). They are highly motivated to protect the integrity of natural ecosystems through the establishment of state and national parks and wild land areas. Minimizing anthropogenic emissions of greenhouse gases and atmospheric deposition of nitric oxides are also considered environmental threats because such emissions can have a negative impact on ecosystem function through effects on global climate change and acidification of soils, lakes, and streams (Matson et al., 2002; Rabalais, 2002; Vitousek et al., 2002).

Burning of fossil fuels is the driving force behind increases in emission of carbon dioxide, which is the greenhouse gas of greatest concentration in the atmosphere. While agriculture is a relatively small user of fossil fuel energy compared to other economic sectors, it is the largest emitter of two other greenhouse gases, methane and nitrous oxide, which have a much more potent greenhouse forcing potential than carbon dioxide per unit change in atmospheric concentration. Agricultural systems may also contribute to or help alleviate greenhouse gas accumulation in the atmosphere depending on the soil carbon balance. While net carbon dioxide emissions occur through a decrease in soil organic matter content as a result of inappropriate soil management practices or low input systems that severely limit crop productivity, some cropping systems actually store more carbon than they lose in a process called carbon sequestration. Recent studies indicate substantial carbon sequestration is possible in cereal cropping systems that achieve relatively high yields through appropriate nutrient and pest management practices and conservation tillage systems to minimize soil disturbance and avoid soil erosion (Lal et al., 1998; Paustian et al., 1997).

Interests of Farmers and Agricultural Industries

Farmers are applied ecologists because they must understand and manage natural resources (soil, water, wildlife) in response to environmental conditions (climate and atmospheric conditions) to produce food, fiber, and fuel. As owners and inhabitants of the land, they care about environmental stewardship and conservation for future generations. Over the short term, however, farmers must focus on making a profit to earn a livelihood. Reasonable commodities prices are required to obtain a decent profit without the need for government subsidies (Table 1). Price stability is also important to avoid extended periods of low commodity prices that place even well run farms at risk of bankruptcy and limit the potential for investment in technologies that conserve natural resources and protect the environment. Like any business, to remain competitive farmers must continually invest in new technologies that improve production efficiency by increasing crop output value faster than the increase in input costs. Such improvements require robust research in both the public and private sectors to ensure a steady stream of innovation. Over the longer term, farmers are also keenly aware of the need to protect soil quality because soil degradation reduces profit as a result of greater input requirements for fertilizers, other soil amendments, pest control, and deep tillage to maintain productivity.

Perhaps most disturbing to farmers is the lack of appreciation by the general public for the safe, nutritious and affordable, food supply they provide. Indeed, today's cost of an adequate food supply for the average USA citizen represents a smaller proportion of disposable income than at any time in modern human history! Despite this important contribution to society, the urban population does not hold farming in high esteem. As a result, agriculture is typically portrayed in a negative light in the popular press. When coupled with slim profits caused by consistently low commodity prices of recent decades, it is no wonder that few young people are choosing farming as a profession or enrolling in agronomic majors at our universities. Therefore, the average age of farmers continues to rise (it is currently 58 in Nebraska!), and the number of undergraduate agronomy majors is shrinking to the point where some universities have eliminated the major altogether. While increased commodity prices and greater farm profits are necessary, they are not sufficient to reverse these trends. In addition, there is an urgent need for a significant change in the esteem with which the urban population holds the farming profession and related agricultural industries. Fortunately, I believe there are unique opportunities to achieve a strong, functional alliance between the interests of agriculture and those of the environmental movement to promote issues of concern to both groups. Such an alliance would also help raise the esteem of farmers because environmental protection is recognized as a high priority for all segments of society.

Convergence of Interests

Of all human activities, agriculture is practiced on the greatest land area representing about 33% of the earth's surface, and it utilizes a majority of the world's available freshwater supply and nitrogen of anthropogenic origin (Cassman et al., 2003). Because it appropriates so much of the world's natural resources, it is no wonder that agriculture receives the attention of environmental groups. At issue is whether farmers and agricultural industries can help address the concerns of the general public and environmental groups and gain their support for a more profitable and vibrant agricultural sector. I contend that recent research and development of new technologies have laid the foundation for such an alliance as illustrated in the following examples.

Biodiversity

The single greatest threat to biodiversity worldwide is the expansion of agriculture into natural ecosystems such as rainforests, grasslands, and wetlands—especially in developing countries (Waggoner, 1994; Tillman et al., 2002). The key to avoiding a substantial increase in cultivated area is to ensure that crop yields on existing farmland continue to increase at a rate that exceeds population growth. If yields and food output do not keep pace with population growth on the arable land currently in production, it will be impossible to protect the remnant natural ecosystems from the expansion of agriculture. Much of this expansion would occur on marginal lands not suited for continuous cropping, and such expansion leads to a vicious and sometimes irreversible cycle of soil degradation and permanent loss of wildlife habitat.

Sustaining increases in crop yields will require improved crop cultivars and hybrids as well as improved pest protection, crop nutrition, and maintenance of soil fertility. Because fertilizer use on much of the cultivated area in developing countries does not currently provide adequate crop nutrition or maintain soil fertility, there is an urgent need for substantial increases in both the amount and balance of nutrient applications in these cropping systems. While organic nutrient sources should be fully utilized wherever organic sources are available and cost-effective, the potential supply of organic nutrients is simply not large enough to be a significant factor in raising crop yields and maintaining soil fertility. Therefore, environmentalists concerned with protecting natural ecosystems and biodiversity must eventually come to recognize the need for increasing crop yields on existing cultivated land through appropriate use of fertilizer nutrients.

A similar argument can be made for intensive agricultural systems in developed countries, such as the USA and nations in the European Union, and countries with emerging economies like Argentina and Brazil. Taken together, these countries produce the surplus food needed for export to countries that cannot meet their food demand but can afford to import it—such as Japan, China, the Middle East, and other oil-producing countries such as Mexico, Indonesia, and Venezuela. For example, the USA, Canada, Argentina, and Brazil produce more than 70% of the maize and 90% of soybeans traded across national borders, and global demand for maize and soybeans is projected to increase by 1.4% annually for the next 25 years (Rosegrant et al., 2002). While production of both crops will increase in other countries endowed with good soils and climate, the total area available to produce these crops in a sustainable manner outside the USA, Canada, Argentina and Brazil is not large. Hence, maintaining an adequate supply of these crops to meet global demand will depend on maintaining an annual rate of increase in production of at least 1.4% in these major producing countries. An even higher rate of growth in yield will be required if these crops are increasingly used for bioenergy and bio-based feedstocks for industry (see below).

The required increase in production could be achieved by expanding agricultural area in Argentina and Brazil (as it is currently being expanded), or by increasing yields on existing farmland in these two countries and in the USA and Canada as well. To protect biodiversity and natural ecosystems, it is much preferable to increase yields on existing farmland, and I suspect that the environmental movement will soon come to embrace intensification of agriculture in order to avoid agricultural expansion in Argentina and Brazil at the expense of biodiversity, native grasslands, wetlands, and rainforest. Ultimately, I can envision a time when maize and soybean could be 'branded' as eco-friendly to differentiate it from production of these commodities in systems undergoing rapid expansion of crop area at the expense of biodiversity.

Water Quality

The greatest threats to water quality are soil erosion and leaching and runoff of N and P from agricultural systems. Both can be greatly reduced by adoption of conservation tillage methods and use of improved nutrient management practices. In the USA, no-till and other reduced tillage systems have been widely adopted on sloping land at high risk of erosion. Likewise, investment in research and extension to improve nutrient management has substantially increased N fertilizer use efficiency in the past 25 years. For example, N fertilizer use on USA maize reached a peak in 1980 and has remained constant since then although maize yields have steadily increased by 109 kg ha^{-1} yr^{-1} (Figure. 1). Taken together, these trends have contributed to a 35% increase in N fertilizer efficiency—from about 43 kg of maize produced per kg of N fertilizer applied in 1980 to 58 kg grain kg^{-1} of applied N fertilizer in 2000. Improved efficiency resulted from large investments during the 1970s and 1980s in research to develop improved fertilizer recommendations based on a realistic yield goal, soil testing, and improved fertilizer application timing, placement, and formulations. Large investments in extension education were also required to facilitate adoption by farmers.

Despite this progress, however, average N fertilizer uptake efficiency by maize and the other major cereals averages 30-50% of the applied N, which means that 50%-70% of the applied N is at risk of being lost to the environment via leaching, volatilization, and denitrification (Cassman et al., 2002). Recent research continues to develop technologies that can further improve nutrient use efficiency. Geospatial analysis of soil properties, GIS-capable application equipment, crop simulation models, and improved fertilizer formulations all offer new options for increasing nutrient efficiency and minimizing nutrient losses. Transgenic crops with greater resistance to major pests help alleviate constraints to crop yields from insects and diseases, which indirectly contribute to improved fertilizer efficiency through more robust crop health and growth. Herbicide tolerant transgenic crops facilitate the adoption of conservation tillage where such practices have not been adopted because of chronic weed problems that previously defied control without aggressive tillage. Together these new technologies hold tremendous promise for further increases in nutrient use efficiency while reducing soil erosion and sustaining increases in crop yields—all of which are critical for protecting natural resources while achieving global food security.

The potential scope for improvement is illustrated by recent results from a production-scale field study conducted by faculty in the University of Nebraska Carbon Sequestration Program. In this study, irrigated and rainfed continuous maize and maize-soybean rotations are being evaluated in 50-ha fields using state-of-the-art crop and soil management practices that optimize yield, water and N fertilizer efficiency, and C sequestration. Results obtained thusfar have demonstrated the potential to achieve substantial increases in both crop yields (+30-45%) and N fertilizer efficiency (25-60%) compared to average yields and efficiencies achieved by farmers. The potential to sequester carbon in soil organic matter, which contributes to improved soil quality and a reduction in carbon dioxide emissions, is also being measured. Our working hypothesis is that progressive crop and soil management practices make it possible to achieve substantial increases in yield and nutrient use efficiency while improving soil quality and achieving a net reduction in greenhouse gas emissions. Likewise, simulation modeling studies based on data obtained from these studies indicate tremendous untapped potential to increase carbon inputs to soil through return of stover in irrigated continuous maize systems that consistently achieve yields near the yield potential ceiling of current hybrids (Figure 2).

Renewable Energy

Substitution of renewable energy for imported oil is a goal that resonates strongly with both the general public and the environmental movement. Ethanol production from maize grain, and eventually from crop biomass, is one option to produce renewable energy and decrease net emissions of greenhouse gases by burning renewable fuels rather than fossil fuels. While the Energy Bill currently being debated in USA Congress contains provisions for a substantial increase in renewable energy from maize-derived ethanol, these provisions are under attack from the environmental lobby and the oil industry (strange bedfellows?) on the grounds that maize-based ethanol production is not energy efficient or environmentally sound. To quote from an editorial in the Wall Street Journal entitled *More Corn Pone*: "Scientists have been looking for a cheap, clean miracle fuel for years. But the problem with most replacements—including ethanol from corn—is that they are manufactured in processes that are both energy intensive and expensive. A study last year by Cornell University agricultural scientist David Pimentel shows that it takes so much energy to create ethanol that we end up with a net energy loss. Ethanol pollutes and it costs more too!" (May 20, 2002). A more recent article in the Wall Street Journal entitled *Battle Over Ethanol Intoxicates Congress* stated: "There are plenty of reasons for Congress to grapple with energy policy this year. In the wake of the September 11, 2001 terrorist attacks, the U.S. needs to reduce its dependence on imported oil; it needs to calm growing angst against global warming; and it needs to modernize an outdated electrical-transmission system. So which issue has tied negotiators up in knots? Well, none of the above. Instead, the battle has been over ethanol—a corn-based alcohol that does little for energy security or the environment, but leaves legislators thoroughly intoxicated." (August, 2003).

Therefore, the pivotal question is whether ethanol can be produced from maize in a manner that is energy efficient and without negative effects on the environment. It turns out that N fertilizer efficiency has a major impact on both energy and environmental aspects of ethanol from maize because N fertilizer represents about 50% of the total energy used in maize production systems, and losses of N have a major influence on ground and surface water quality. Unfortunately, most of the published data on energy and N efficiency of maize systems in the USA are based on aggregate data using average yields and N fertilizer rates from the 1980s or mid-1990s, and general assumptions about other energy inputs to maize production, grain transport, and ethanol conversion. I would argue that the most relevant analysis of energy efficiency in maize-to-ethanol systems should be based on progressive crop and soil management technologies used by the top 5-10% of maize farmers—farming methods that are likely to be widely adopted within 10-15 years (or more quickly with appropriate policies and investment in extension). The trajectories in both yields and N fertilizer efficiency of the past 25 years suggest that such progress will continue into the foreseeable future (Figure 1).

Using data from the University of Nebraska Carbon Sequestration Program, which includes the actual energy values for all inputs used in producing the maize as well as the energy costs of transportation to the ethanol plant and in conversion to ethanol, we found a net energy surplus equivalent to 897 L ha^{-1} of diesel fuel for irrigated maize, and 682 L ha^{-1} for rainfed maize (Table 2). Achieving such a large net energy surplus depended upon attaining yield levels that were 30% greater than average farm yield levels while, at the same time, increasing N fertilizer efficiency by more than 50% compared to current average levels of N efficiency. Total renewable energy yield was 4071 L ha^{-1} of diesel fuel equivalent in irrigated systems and 2633 L ha^{-1} under rainfed conditions.

At the yield levels achieved in this study, which are comparable to yields achieved by today's best farmers, about 19 billion liters of biodiesel fuel equivalent could be produced from 25%

of the current USA maize area, which is enough energy to meet the annual fuel requirements of 9 million passenger cars.

These results document the potential to produce large quantities of renewable energy in a manner that is both energy efficient and environmentally friendly in terms of reducing N losses and associated effects on water quality. It is also possible that these systems can sequester carbon in soil, thereby improving soil quality and contributing to a net reduction in greenhouse gas emissions when all greenhouse gases and offsets are considered in a life cycle analysis of these maize-to-ethanol systems.

Conclusions

While I firmly believe that agriculture can play a critical role in protecting biodiversity, improving water quality, and reducing greenhouse gas emissions, the key limitation to convincing environmentalists of this capability is lack of good science and data. Few studies have sought to measure all of the critical parameters in well-designed production-scale field research to obtain the required data sets. Such research is not cheap because it requires substantial investment in environmental monitoring equipment, technical support, and field operations involving close coordination between crop production managers and researchers. Compared to research investments currently made by federal agencies in crop genomics or global climate change research, however, the amount required for a comprehensive series of definitive field studies throughout the world would be relatively small. I suspect that if such an effort were made using progressive crop and soil management practices, it would unequivocally document the potential to improve environmental quality and produce grain yields that are 30% greater than today's average yield in production systems that are highly energy efficient.

Given this scenario, it should then be possible to convince both environmentalists and the general public that agricultural policies at the national and international levels should provide incentives that encourage ecological intensification of the major cereal production systems worldwide. Coupled with the steady increase in demand for these commodities to meet human nutritional needs and demand for livestock feed, the additional consumption for renewable energy and bio-based industrial products will cause a substantial increase in the average prices paid for these grains. Such an increase would help ensure higher and more consistent farm profits in both developed and developing countries. Eventually, there will be a need to utilize plant biomass, rather than grain, for ethanol production, and technologies are under development to allow this progression (Wyman, 1999). Convincing environmental groups of the benefits of ecological intensification of crop production systems for both food and renewable energy production would unleash their powerful lobbying forces on policy-makers and help develop policies that support this vision.

Perhaps most important, such a change in perspective would place agriculture in a new light that is considerably more favorable than today. Ultimately, such a change would attract talented young people to the agricultural sector because they would see that a career in agriculture provides exciting opportunities to address the world's most challenging issues of global food security, protection of biodiversity and environmental quality—all of which are goals of tremendous importance to idealistic youth throughout the world.

Acknowledgements

The opinions expressed in this paper are based on the author's cumulative experience in conducting agronomic research and extension on agricultural systems—including most of the world's major cropping systems. The recent research findings of our interdisciplinary team at the University of Nebraska working on the ecological intensification of cropping systems in the USA Corn Belt have strongly contributed to this vision. This effort was funded in part by grant support from the Potash and Phosphate Institute, the Foundation for Agronomic Research, the Fluid Fertilizer Foundation, and IMC Global. I am grateful to my collaborators on this project for their outstanding contributions and teamwork, and also to collaborators in the University of Nebraska Carbon Sequestration Program, which is a project funded by the US Department of Energy. Collaborators include Achim Dobermann, Daniel Walters, Haishun Yang, Shashi Verma, Tim Arkebauer, John Lindquist, Rhae Drijber, and Lenis Nelson.

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Table 1. Interests of the general public, environmentalists, and farmers.

General Public	Environmentalists	Farmers
Safe, nutritious, and affordable food supply	Biodiversity conservation	Higher and more stable commodity prices
Adequate water quality (drinking, recreation)	Protecting the integrity of natural ecosystems	Greater yields and lower input costs per unit of yield
Parks and wildlands for recreational activities	Avoiding climate change, reduced greenhouse gas emissions	Maintenance of soil quality
Affordable energy and reduced reliance on imported oil	Reduced reliance on fossil fuels	Greater esteem for the farming profession and contributions to society

Table 2. Life-cycle energy balance* (in diesel fuel equivalents) in a high-yield continuous irrigated maize production systems in which grain is used for ethanol production in Nebraska (Data of D. Walters et al., Univ. of Nebraska).

System	Energy output	Energy Inputs	Net energy gain (output/input ratio)
	----------- diesel fuel equivalent in L ha^{-1} ------------		
Irrigated	4071	3174	897 (1.3 to 1)
Rainfed	2633	1951	682 (1.4 to 1)

*Energy balance includes all energy inputs used in maize production (fertilizer, irrigation, field oprations, etc), transport from the field to the ethanol plant, and ethanol production. Energy outputs include the energy content of the ethanol produced and the energy replacement value of the wet distillers grain when used in cattle rations.

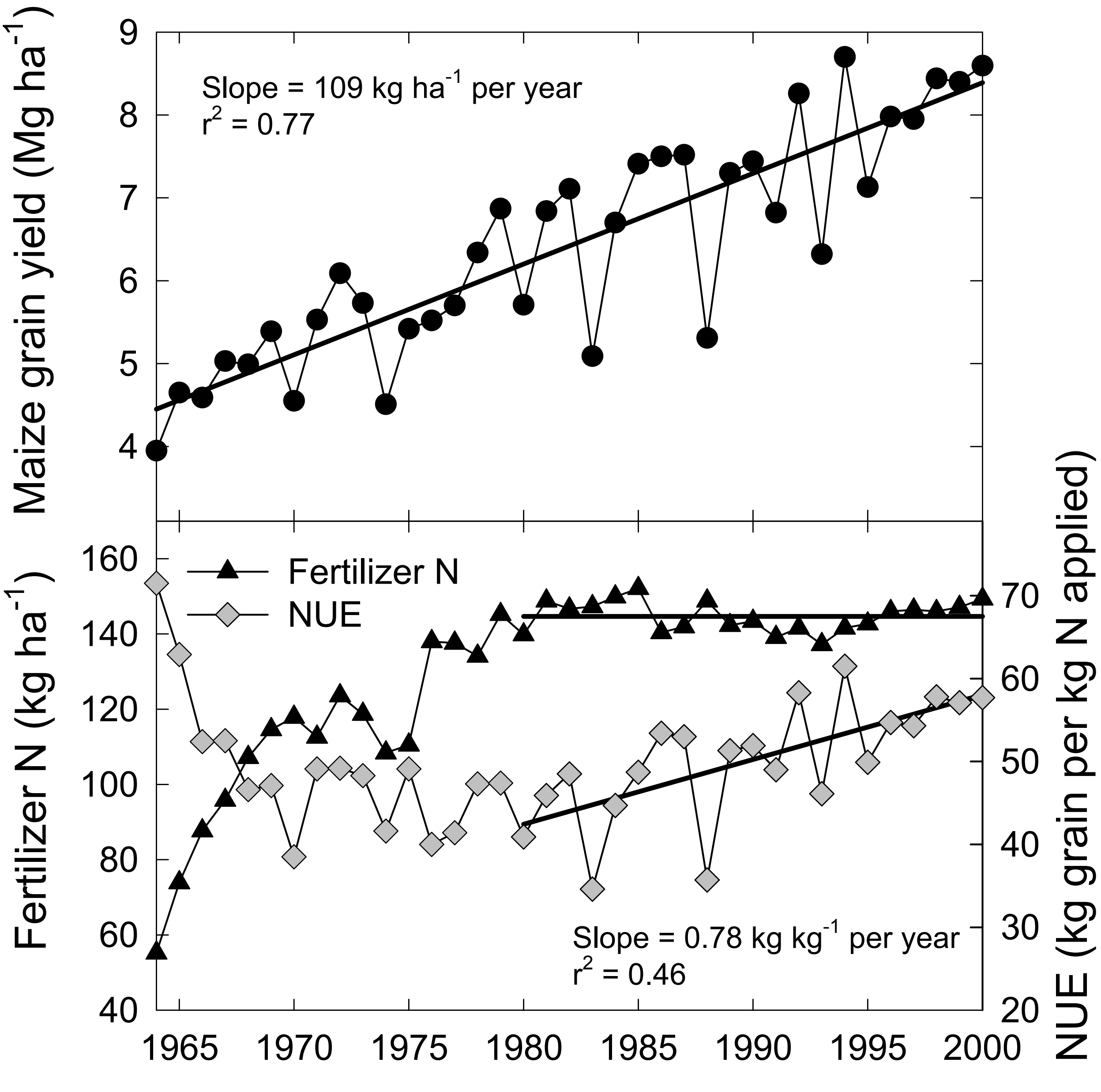


Figure 1. Trends in maize grain yield, use of N fertilizer, and NUE in the USA. Modified from (Cassman et al., 2002).

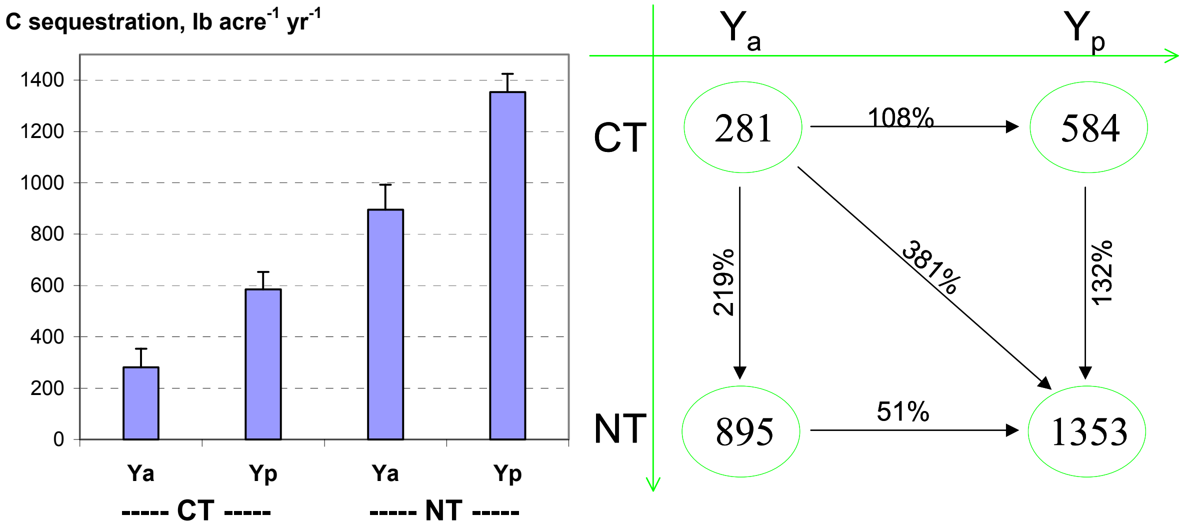


Figure 2. Annual C sequestration over 20 years predicted by the Century model as influenced by maize productivity (Y_a = actual yield levels, Y_p = yield potential as simulated by Hybrid-Maize model) and tillage method (NT = no-till, CT = conventional tillage). Absolute annual rates are shown in the left panel. In the right panel, values in circles are absolute annual rates (in lb C ac^{-1} yr^{-1}) while percent increases are shown for the effects of tillage and increased yield levels. From: Yang et al., 2002.

Current Situation

- Only 2-8% of population of developed couintries engaged in agriculture (and declining!)
- Policies and regulations determined by 92-98% of the population who lack direct knowledge of agriculture
- Negative portrayal of agriculture in popular press
- Farmers and ag industry distrust environmentalists
- Need for reconciliation
  - Political base of ag community will continue to decline
  - Environmental groups extremely influential and respected
  - Emerging opportunities to exploit mutual interests

Negative Portrayal of Agriculture

- Agriculture is seen as the cause of environmental problems that are important to society at large and environmentalists
  - ➢ Nitrate and pesticide contamination of ground water
  - ➢ Soil erosion
  - ➢ Eutrophication of surface waters
  - ➢ Hypoxia in Gulf of Mexico; algal blooms in Chesapeake Bay
  - ➢ Negative impact on biodiversity (GMOs, pesticides, extensive monoculture, etc.)
- Subsidized by taxpayer dollars

Farmer Distrust of Environmentalists

- Environmental groups exaggerate negative effects of agriculture and don’t use “good science”
  - ➢ Monarch butterflies
  - ➢ Effects of nitrate in groundwater on human health
- They seem to ignore the tremendous benefits of a safe, nutritious, and affordable food supply
- Little recognition of tremendous improvements in environmental stewardship in agriculture
  - ➢ Substantial increases in N and water use efficiencies
  - ➢ Reduction in pesticide load
  - ➢ Reduced erosion through conservation tillage practices

Aligning USA farmers' interests with those of urban populations and environmentalists

- **Farmers' interests**
  - Higher and more stable commodity prices
  - Greater yields with lower input costs
  - Greater respect and esteem for the farming profession
- **Urban/Envir interests**
  - Plentiful, affordable, safe, nutritious food
  - Affordable and reliable energy supplies
  - Alleviate GH gases
  - Clean water and air
  - Conservation of wildlife and biodiversity

Projected changes in population, cereal demand, yields, area, and prices

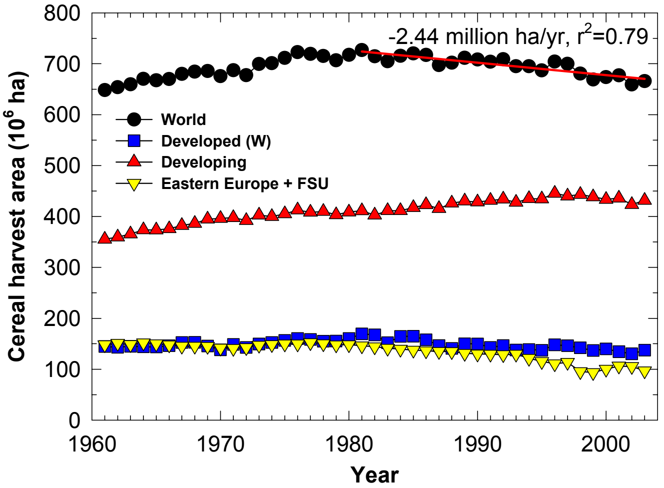
Indices	1995	2025	Annual rate of change (%)
Global population (billion)	5.66	7.90	1.12
Global demand for rice, wheat, and maize (10^6 Mg)	1657	2436	1.29
Total rice, wheat, and maize area (10^6 ha)	506	556	0.31 ?
Mean rice, wheat, maize yield (Mg ha^{-1}) [1]	3.27	4.38	0.98
World rice price (US$ Mg^{-1}, milled rice)	285	221	-0.84
World wheat price (US$ Mg^{-1})	133	119	-0.37
World maize price (US$ Mg^{-1})	103	104	0.03

Population projections: medium scenario of the UN 1998 projection.
Food projections: 'business-as-usual' scenario of food and water demand and supply, IMPACT model.

Source: Rosegrant et al. 2002. IFPRI

University of Nebraska Lincoln

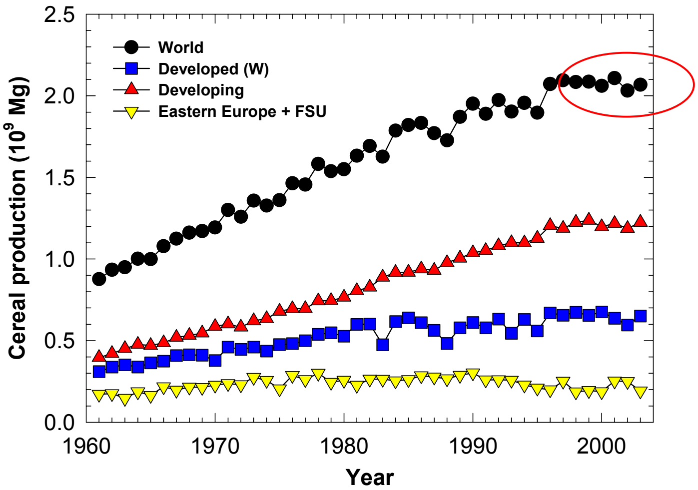
Actual global trends in cereal harvest area



1981: 727 million ha → 2003: 666 million ha

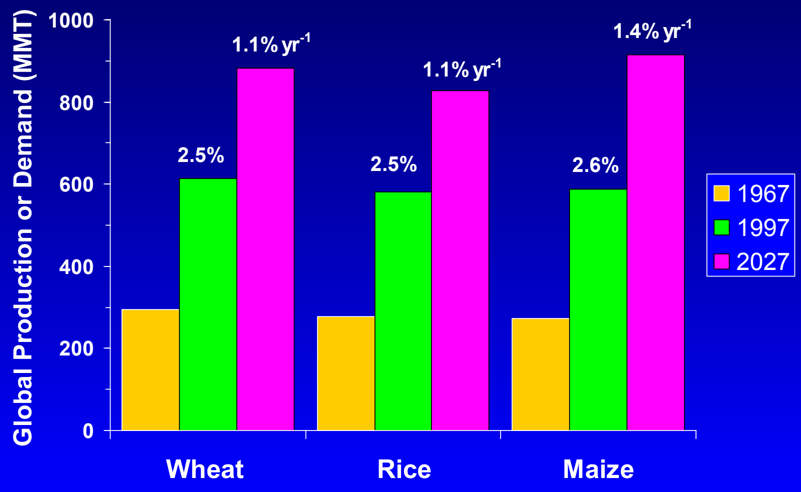
Source: FAOSTAT

Actual trends in cereal production



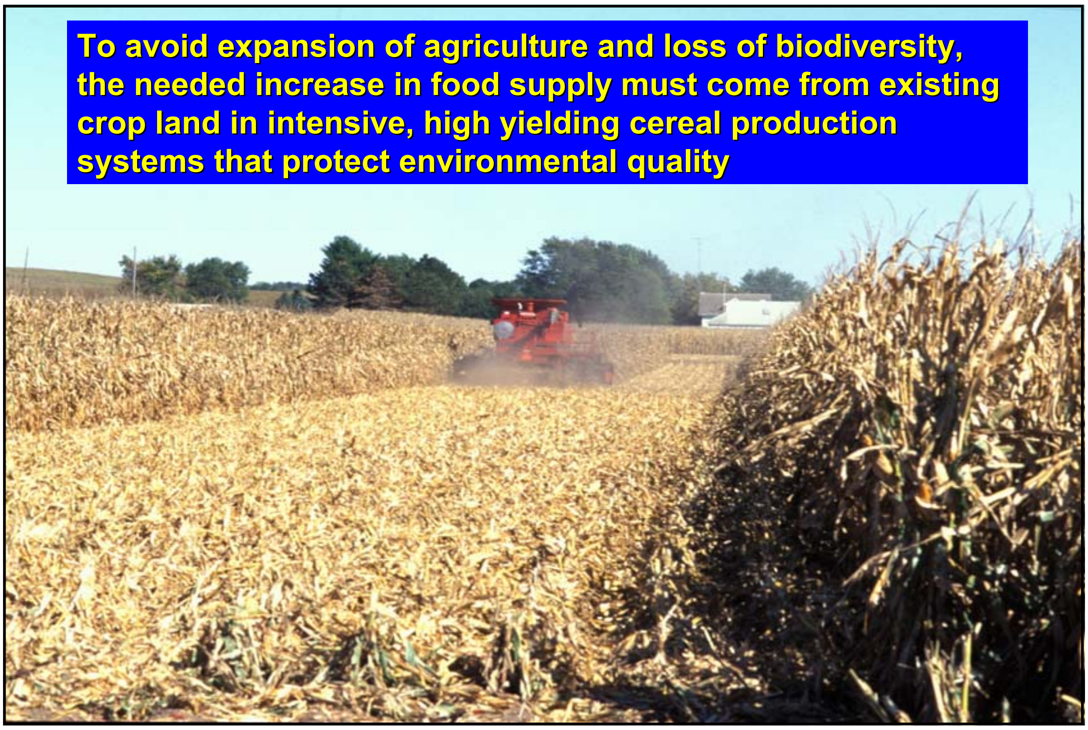
Source: FAOSTAT

Growth in Grain Supply-Demand



Fact is, the greatest threat to protection of biodiversity is the expansion of low-input, subsistence agriculture into remaining natural ecosystems: rainforests, grassland savannahs, and wetlands.

Where will the additional food, including both crops and livestock, be produced without expanding cropped area?



Protecting Water Quality in High-Yield Systems

- Significant progress made in past 30 years
- Must continue to make substantial improvements in N-fertilizer efficiency
  - Organic agriculture can't do it
  - Must be achieved in cereal production systems that produce yields near the yield potential ceiling
- Positive impact of increased N-fertilizer efficiency
  - Decreased losses protect water quality and reduce greenhouse gas emissions
  - Higher efficiency increase farmers' profits

Can organic N sources replace N fertilizers?

Nitrogen inputs in agriculture (10^6 Mg/yr)

Region	Biological N fixation[1]	Mineral Fertilizers	Manure[2]
Africa	1.8	2.1	1.7
Asia	13.7	44.2	17.0
Europe+FSU	3.9	12.9	8.1
Latin America	5	5.1	3.0
North America	6	12.6	3.8
Oceania	1.1	0.7	0.7
Total	**31.5**	**77.6**	**34.3**

[1] Includes legumes, forage and other crops with N fixation
[2] N available as manure from livestock excreta (Sheldrick et al., 2003)

Source: Boyer et al., SCOPE Nitrogen fertilizer RAP, Kampala, January 2004

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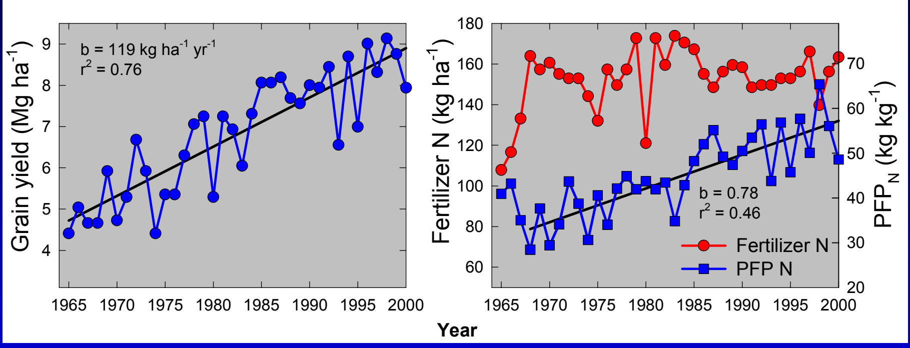
Trends in maize yields and N use: Nebraska



- Greater stress tolerance of modern maize hybrids
- Improved management of factors other than N (tillage, seed quality, higher plant densities, weed and pest control, balanced fertilization, irrigation)
- Improved N fertilizer management (research & extension, local policies & incentives to use better management techniques)

Source: NASS, USDA-ERS cropping practices surveys

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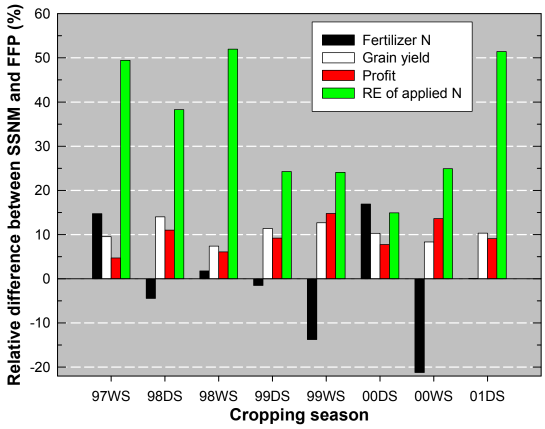
New technologies for nitrogen management

Gains in irrigated rice yield, profit and RE_N through field-specific nutrient management



Nueva Ecija province, Philippines, 1997 – 2001.
Relative differences between permanent site-specific nutrient management plots (SSNM) and the farmers' fertilizer practice (FFP) in the same 27 fields, including wet (WS) and dry (DS) season rice crops.

Source: Dobermann et al. 2002, Field Crops Res. 74: 37-66 and RTOP database, IRRI

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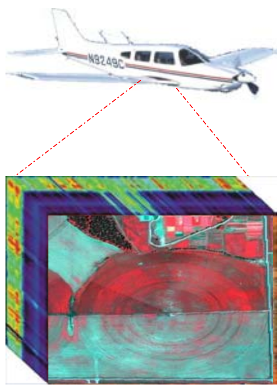
CAS MGS

Concern about Greenhouse Gases

- Atmospheric levels of carbon dioxide (CO_2), nitrous oxide (N_2O), and methane have been increasing steadily since 19
- The major sources of these greenhouse gases are the burning of fossil fuels and agriculture
- These gases are radiatively active and may contribute to global climate change and ecosystem integrity

Monitored Greenhouse Gas Emissions



Leaf/plot Level → Landscape Level → Regional

The University of Nebraska Carbon Sequestration Project (CSP)

Goals

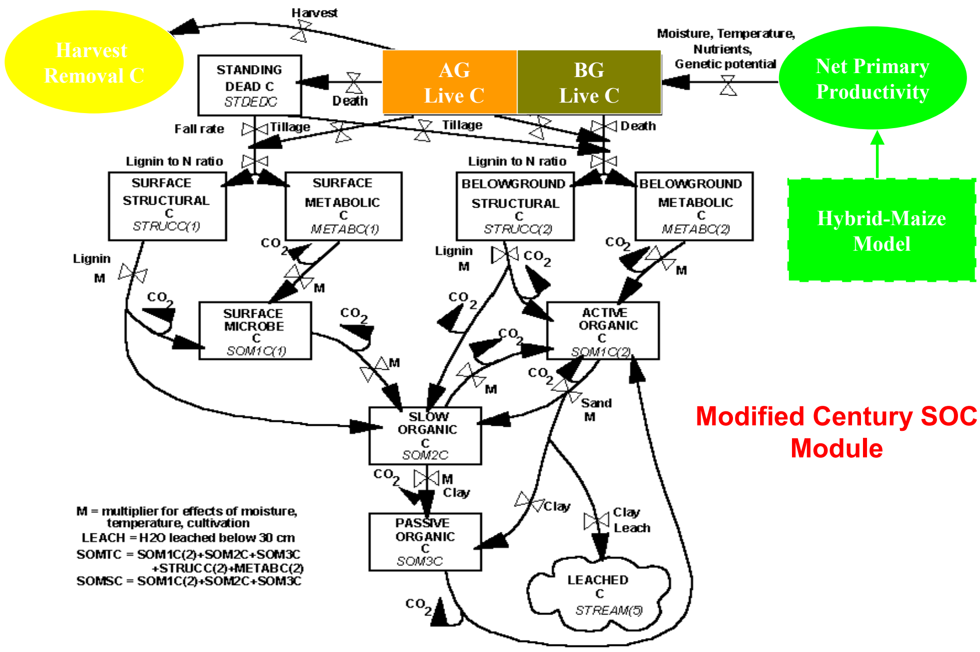
- Quantify annual amounts of carbon stored in major dryland and irrigated crop production systems.
- Improve our understanding of processes controlling soil carbon storage in high-yielding systems with progressive crop management.

What is the carbon sequestration potential with progressive management that achieves high yields and high input efficiencies: N fertilizer and irrigation management, Bt hybrids, RR beans, higher plant densities, minimum tillage?

The CSP field sites utilize progressive production-scale management practices that achieve high yields and high N fertilzer and water-use efficiency.

System	Yield* (kg ha^{-1})	N fertilizer (kg ha^{-1})	N fert. eff (kg kg^{-1})
Irrigated			
Maize-soybean	13,610	153	89
Maize-maize	13,110	196	67
Rainfed Maize	8,900	128	70
USA **Maize** (ave.)	8,470	157	54

* Based on 2001 combine harvest yields from the three CSP field sites.



- Greenhouse gas emissions can also be 'offset' by renewable energy production if there is a net surplus of energy?
- Can maize-soybean systems produce more energy than they use for crop production, drying, transport, and ethanol production?

Accounting for embodied energy 'costs' and GHG emissions of all production inputs

- CO_2-C emissions calculated on the basis of fossil fuel type and consumption used to produce inputs
- N_2O and methane emissions measured directly
- On-farm fuel use was measured
- Irrigation energy consumption based on lift, gpm and pump pressure using NPP
- "Depreciable" costs are associated with the manufacture of equipment used on farm
- All transport and ethanol production energy inputs are included in the analysis

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Greenhouse gas emissions from irrigated and rainfed maize grown and processed for ethanol production. CSP 2001

Greenhouse gas emission equivalents (gCO_2-C m^{-2})

	Irrigated System	Rainfed system
Outputs		
EtOH	268.5	174.0
Co-products	45.7	28.4
Total outputs	314.1	202.4
Inputs		
grain production	-47.8	-24.1
EtOH conversion	-206.2	-133.7
Total inputs	-254.0	-157.8
N_2O + CH_4 emissions	- 37.7	- 20.0
Net balance	**+22.5**	**+24.6**

Bottom line:
Net reduction in atmospheric greenhouse gas concentration!!!

Ethanol energy balance: irrigated vs rainfed maize, CSP 2001 growing season.

System	Outputs*	Inputs**	Net Balance
	------------- Liters per ha***		---------------
Irrigated	4071	3174	897 (1.3:1)
Rainfed	2633	1951	682 (1.4:1)

*Energy contained in ethanol produced from grain and energy value of co-products.
**Energy required for production inputs, drying, transport, and processing to ethanol
***Diesel fuel equivalents

Agriculture: Villain or Hero?

- **Villan?**
  - Soil degradation
  - Water pollution
  - Decreased biodiversity
  - Greenhouse gas emissions and climate change
  - Heavy reliance on fossil fuel inputs
- **Hero!**
  - Improves soil quality through C sequestration
  - Improves water quality
  - Protects wildlife habitat and biodiversity
  - Produces renewable energy, decreases dependence on foreign oil, and reduces greenhouse gas emissions

Concluding Remarks

- We have exciting technologies available and under development that will contribute to higher yields, greater input use efficiency, profits, and environmental stewardship……….to the benefit of farmers, society, and the world.
- We need unimpeachable scientific documentation of this potential to convince urban colleagues, environmental groups, and policy makers about the promise and importance of agriculture!

Thanks to Collaborators!

• Achim Dobermann	Univ. of Nebraska
• Dan Walters	Univ. of Nebraska
• Haishun Yang	Univ. of Nebraska
• Shashi Verma	Univ. of Nebraska
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• V. Balasubramanian	Intl. Rice Res. Inst.
• Christian Witt	PPI/PPIC/IPI
• Dan Olk	USDA Soil Tilth Lab

The Wall Street Journal, Editorial, May 20, 2002

More Corn Pone

Majority Leader Tom Daschle recently pulled off a coup d'corn, mandating billions of gallons of ethanol use across the country in the new Senate energy bill. If We've already noted how this would raise gas prices by as much as a dime a gallon. But recent news suggests that the damage from subsidizing the corn-made fuel is far worse than even we thought.

Reading their Archer-Daniels-Midland cue cards, ethanol supporters make two arguments. They say that as a replacement for fossil fuels ethanol lessons U.S. oil dependence. They add that ethanol, an oxygenate, reduces tailpipe pollution. If this sounds too good to be true, read on.

Scientists have been looking for a cheap, clean "miracle fuel" for years. But the problem with most replacements—including ethanol—is that they have to be manufactured in processes that are both energy-intensive and expensive. A study last year by Cornell University agricultural scientist David Pimentel shows that it takes so much fossil fuel to create ethanol, that we end up with a net energy *loss*.

The numbers go like this: It takes 131,000 BTUs to grow and convert enough corn for one gallon of ethanol. A gallon of ethanol, however, has an energy value of just 77,000 BTUs. In other words, it takes about 70% more energy (which comes from fossil fuels, by the way) to produce ethanol than the energy ethanol creates. It'd be easier—and less costly—for consumers to pour most of every gallon of gas they buy down a sinkhole.

Professor Pimentel also looked at the cost of making ethanol. He found that ethanol costs $1.74 a gallon to produce, compared with 95 cents to produce a gallon of gas. That's why "fossil fuels—not ethanol—are used to produce ethanol," he says.

Ethanol pollutes, and it costs more too!

"The growers and processors can't afford to burn ethanol to make ethanol." We might add that drivers can't afford ethanol either, which is why the government subsidizes it at the pump.

And then there's the question of clean air. Last week, the Environmental Protection Agency announced it was investigating ethanol-producing companies for pollution. The EPA says factories are producing carbon monoxide, methanol and "additional emissions that weren't anticipated" at levels "many times greater" than the companies promised.

This might be acceptable, if ethanol made skies bluer. But it doesn't. Annual emissions of the worst auto exhaust pollutants have dropped by more than half since the 1960s, but most gains have come from better emissions equipment and cleaner engines. Two years ago the National Academy of Sciences concluded that ethanol had "little impact in improving ozone air quality." In short, the U.S. pumps out pollution to make a product that itself does little or nothing to help air quality. And under Mr. Daschle's plan, the amount of that pollution will triple by 2012.

Which raises the question, if there are no energy or pollution gains, why use ethanol at all? The answer is that it is an easy way for Mr. Daschle to transfer billions of dollars in taxpayer subsidies to farmers in his native Midwest. Farm-state senators get corn votes this November, while Americans get to pay more for gas and breathe dirtier air. What a deal.

Majority Leader Tom Daschle recently pulled off a coup d'corn, mandating billions of gallons of ethanol use across the country in the new Senate energy bill. If

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The Wall Street Journal, August 2003

POLITICAL CAPITAL

By Alan Murray

Battle Over Ethanol As Additive to Fuel Intoxicates Congress

Washington

THERE ARE PLENTY of compelling reasons for Congress to grapple with energy policy this year. In the wake of the Sept. 11, 2001, terrorist attacks, the U.S. needs to reduce its dependence on Saudi Arabia; it needs to calm growing angst over global warming; and it needs to modernize an outdated electrical-transmission system.

So which issue has tied congressional negotiators up in knots for the past two weeks? Well, none of the above.

Instead, the big battle has been over ethanol—a corn-based fuel alcohol that does little for either energy security or the environment, but leaves legislators thoroughly intoxicated.

The Senate energy bill mandates a doubling of production of this gasoline additive. In addition, ethanol's powerful lobbyists also want to deal a knock-out blow to their only competition by banning methyl tertiary-butyl ether, or MTBE, a petrochemical product that has had an unfortunate tendency to leach into groundwater. That has caused a classic standoff between the corn-producing states of the Midwest, which hold sway in the Senate and support the MTBE ban, and the oil-producing states of the South, which have power in the House and oppose the ban.

Once upon a time, the idea of making fuel from corn had promise. For one thing, corn, unlike oil, is renewable. For another, corn-based ethanol includes oxygen. A major source of smog in the 1970s was fuel that wasn't fully burned in the engine. Adding oxygen-laden ethanol to the fuel was a neat way to ensure that the fuel burned more cleanly.

BUT MAKING ETHANOL turned out to be very expensive. Even with a generous federal subsidy, which has cost taxpayers more than $10 billion over the years, the fuel remains uneconomical, particularly for states such as New York and California, which have to ship it in from the Farm Belt. Making ethanol also has turned out to consume much energy—some say more than it produces.

Moreover, by the mid-1980s, auto makers had learned how to make gasoline burn cleaner by using car computers that monitor fuel-oxygen levels, and then control the mix of fuel and air as necessary. The result: "There is no point in pouring ethanol into the fuel mix anymore," says Erik Stork, who was director of Mobile Source Pollution for the Environmental Protection Agency during the '70s. As for ethanol's effects on global warming, the science is mixed, but the General Accounting Office, the investigative arm of Congress, concluded it is no better, and may be worse, than conventional gasoline.

Even as ethanol's economic [illegible] environmental value was [illegible], however, its political [illegible] was on the rise. The early [illegible] caucuses in Iowa, [illegible] particular, turned into a quadrennial ethanol pander fest.

In 1988, Vice President George Bush, who was trailing his opponent Bob Dole in Iowa, announced new EPA guidelines promoting the use of ethanol in meeting clean-air standards. Later, he signed into law the Clean Air Act amendments of 1990, mandating the use of oxygenates such as ethanol and MTBE in parts of the country that fail to meet standards.

Democrat Bill Bradley refused to submit to the ethanol forces in his 2000 campaign, and he got clobbered. Republican Sen. John McCain, a critic of ethanol subsidies, kept out of the state's caucuses altogether. Democratic Sen. Joseph Lieberman learned his lesson on his first trip to Iowa after becoming Al Gore's running mate. When he stepped off the campaign's Mississippi riverboat, the first question a reporter asked was: "How do you feel about ethanol?"

TODAY, MR. LIEBERMAN—and most of the other Democrats chasing the presidential nomination—make praise of ethanol a standard part of their Iowa stump speeches. Agribusiness giant Archer-Daniels-Midland, the largest producer of ethanol, also helps boost [illegible] fuel's political appeal by donating [illegible] of dollars of campaign contributions to both Republicans and Democrats.

The [illegible] industry offered MTBE as its own, cheaper alternative to ethanol. But the additive [illegible] been prohibited by many states [illegible] of its tendency to pollute drinking [illegible]. The ethanol forces in the Senate now hope to ban all use of MTBE, while [illegible] industry's defenders in the House [illegible] to leave the decision to individual states, and also shield the MTBE industry [illegible] lawsuits over environmental damage.

This is a parable of Washington at its worst: a political solution in search of a problem. Ethanol's only undisputed effect is to boost the income of ADM and corn farmers, at everyone else's expense. Instead of the size of the ethanol mandate being doubled, as pending legislation would do, it ought to be repealed.

It won't be. Unless, of course, the nation's first presidential primary were to be held in Idaho. But then, the government would require us all to power our cars with potatoes.

Alan Murray is Washington Bureau Chief of CNBC and cohost of "Capital Report," which airs Tuesday-Friday at 9 p.m.