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THIRST FOR CORN: WHAT 2007 PLANTINGS COULD MEAN FOR THE ENVIRONMENT

LIZ MARSHALL

Now that legislation in the United States has jump-started the ethanol industry, policy priority should be directed less at the expansion of the industry and more at directing the evolution of the industry along routes that offer the most benefits in terms of the environment and energy security.

FARM POLICY RECOMMENDATIONS

1. Resist the pressure to allow farmers penalty-free "early outs" from their CRP contracts.
2. Increase funding for working lands conservation programs such as CSP and EQIP.
3. Extend "sodbuster" compliance requirements for receipt of commodity payments to all acreage in production, not just highly erodible lands.
4. Create a pilot TMDL project for the Chesapeake Bay with joint USDA/EPA jurisdiction.
5. Extend compliance requirements for receipt of commodity payments to include nutrient management requirements in TMDL non-attainment watersheds.
6. Establish a new program in the Farm Bill to encourage riparian buffers.
7. Require all projects that receive federal funds to explore crop yield improvements to explicitly address the soil, water, and GHG implications of the new production methods.
8. Promote conservation tillage in corn production and provide research resources directed explicitly at use of slow-release fertilizers and use of precision nitrogen management in row crop production.
9. Task the USDA with development of a consistent methodology for calculating the environmental impacts of biofuels feedstock production.

INTRODUCTION

Thanks in large part to the Renewable Fuels Standard (RFS)—a legislative mandate for increased renewable fuels use that passed as part of the Energy Policy Act of 2005—the corn ethanol industry is expanding at an unprecedented rate in the United States. The 115 ethanol plants operating in April 2007 have the capacity to produce 5.75 billion gallons per year (BGY) of ethanol, and an estimated 86 plants under construction are expected to produce an additional 6.34 BGY of capacity within the next 18 months (RFA, 2007). The cumulative total capacity—more than 12 BGY by 2009—far exceeds the RFS blending mandate of 7.5 BGY by 2012, and has been the driving force behind skyrocketing corn prices in the last 12 months.

Now that legislation such as the Renewable Fuels Standard and the Volumetric Ethanol Excise Tax Credit (VEETC) has jump-started the ethanol industry, policy priority should be directed less at the expansion of the industry and more at directing the evolution of the industry along routes that offer the most benefits in terms of the environment and energy security. Although ethanol is widely promoted as a green alternative to gasoline, there are many different ways to produce ethanol, using many different feedstocks, and some ways are greener than others. Production of the feedstock represents a significant share of the environmental footprint of ethanol production; to ensure sustainability of production, we need to pay close attention to the environmental impacts of producing those feedstocks and have policies in place to avoid or mitigate those impacts.

Although cellulosic conversion technologies appear to be on the cusp of commercialization, the vast majority of plants constructed over the next five years will require corn as a feedstock. For the corn necessary to feed these plants, the ethanol industry will be competing with the livestock industry, the export market, and processing sector demands. In large part due to anticipated shortages in supply, the price of corn responded vigorously in 2006, with the seasonal average price, once finalized, likely to lie somewhere between \$3.00 and \$3.40 per bushel. In mid-January 2007, corn was trading for \$3.50 per bushel in the cash market—representing a near two-fold increase in the price of corn from 2005 levels.

This explosive growth of the ethanol industry, and the associated spike in the price of corn, threatens to radically change the agricultural landscape and its environmental footprint at a rate that is much faster than anticipated. With corn prices remaining high, the question for spring of 2007 has evolved from *whether* acreage will be moved into corn production to *how much*, and what will be the impact of that shift. In its spring planting projections, the USDA predicted that corn acreage in the United States would increase by 12 million acres, or 15%, during the 2007 planting season (NASS, 2007).

The potential environmental impacts from a shift toward increased corn production take many forms. The issues of greatest concern include water quality impacts from erosion and agrochemical use, such as fertilizers and pesticides; soil health issues related to erosion and loss of soil organic content; habitat impacts associated with conversion of natural ecosystem to cropping systems; and increased greenhouse gas (GHG) emissions from nitrogen and pesticide production, nitrogen application, and carbon flux from the soil. Of course, the net environmental impacts of a shift toward corn production are highly sensitive to where the new acreage comes from; replacing an existing cropping use with corn, for instance, would have a much lower net impact than pulling land out of the Conservation Reserve Program (CRP)--a voluntary land retirement program in which farmers take land out of production and instead plant native prairie grasses to provide erosion control and enhance habitat quality. In this study we explore the implications of several different land availability scenarios.

The Farm Bill, currently up for reauthorization in 2007, represents a powerful opportunity for establishing the framework necessary to influence and manage the impacts of ethanol feedstock production. The urgency of addressing feedstock sustainability issues is twofold: The explosive growth of the corn ethanol industry means that the environmental impacts associated with that production will occur over a much shorter time horizon than was anticipated. Equally important, however, is that the efforts we expend now to ensure that environmental impacts of feedstock production are internalized through policy will set the precedent for sustainable feedstock production in the future as new feedstocks come online. This study explores the potential environmental impacts of producing enough corn to satisfy projected corn demands for 2008 ethanol production scenarios and suggests some policy measures to address those impacts.

Our Analysis

To evaluate the environmental and economic impacts of increased ethanol production from corn, we use a national scale agro-environmental production model, which integrates the Regional Environmental and Agricultural Production model (REAP)—a national agricultural production model developed and maintained by USDA's Economic Research Service (ERS) and formerly known as USMP—with the Environmental Policy Integrated Climate (EPIC), a plant growth and environmental impact model. The combined model allows us to project how increased corn demand will translate into regional changes in crops grown, tillage practices used, and crop rotations employed, and to then estimate the net environmental impacts of those changes. To measure environmental impacts we look specifically at agricultural GHG emissions, which are often under-represented in the dialogue about greenhouse gas reductions, as well as at nitrogen and phosphorus loads into local waterways and rates of soil erosion, which have been the focus of most existing and pilot agricultural conservation programs.

The baseline agricultural production scenario for our analysis uses the USDA's 2006 projected baseline for 2007 crop production patterns and a baseline ethanol production level of 6 BGY. Relative to that scenario, we explore how 2007 planting patterns are likely to respond to meet projected corn demands for 2008 ethanol production levels ranging from the baseline of 6 BGY up to 11 BGY.

Projected Impacts of Corn Production

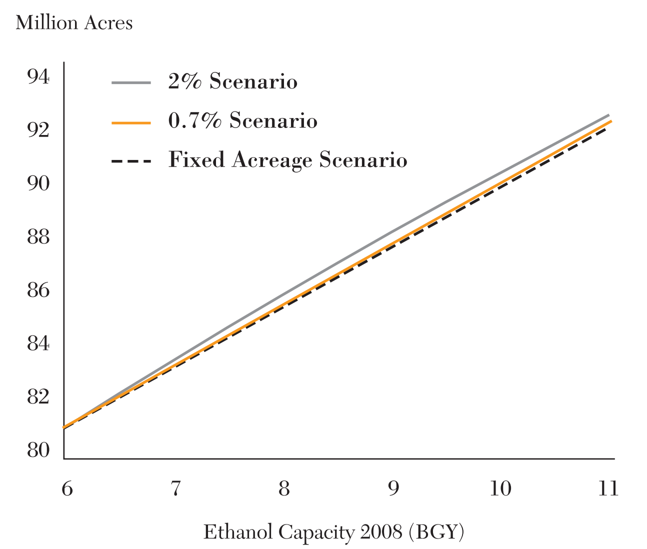
Meeting projected demands for ethanol will require a substantial reallocation of land to corn production in the United States. The new corn acreage needs will be met through a combination of existing crop displacement, new acreage brought into production, and, over the longer term, possibly a movement of land out of the Conservation Reserve Program in response to high crop prices and increased returns to crop production. The net environmental impact of that shift will depend on how the new acreage is distributed among these land source pools. Pulling land out of CRP for production would have the greatest net impact, as land in CRP is by definition land that is particularly vulnerable to erosion or nutrient loss, and that land is currently providing a habitat service that would also be lost. Re-planting idle cropland, or converting existing pasture cropland, would likely fall second in the order of decreasing impacts, followed by replacement of existing cropped acreage with feedstock production.

In early 2007, the threat of CRP withdrawals was imminent as the USDA announced its intentions to consider allowing farmers out of their long-term CRP contracts penalty-free. However, in March 2007, the Secretary of Agriculture announced that such "early outs" would not be considered for the 2007 planting season. Despite the fact that CRP losses are a legitimate long-term threat, we therefore do not consider for this analysis the worst-case land-supply scenario, in which CRP acreage becomes a significant source of land for additional crop production.

In our analysis, we consider three scenarios for short-term land availability:

- 2% Scenario: Acreage in CRP is fixed and regional acreage in crop production is allowed to expand by a maximum of 2%.
- 0.7% Scenario: Acreage in CRP is fixed and regional acreage in crop production is allowed to expand by a maximum of .7%, which is consistent with the USDA's projected increases in total acreage for Spring, 2007.
- Fixed Acreage Scenario: Acreage in crop production is fixed at current levels and CRP increases slightly to reflect continuous enrollment program for high-value lands.

FIGURE 1 Acres in Corn



Results

Our results suggest that meeting projected demands for ethanol will require a substantial reallocation of land to corn production and that the shift to corn production will have significant negative environmental impacts if we assume that existing production practices continue under the current policy framework. The results of that analysis for each land-supply scenario are summarized in Table 1 (see end of document) and described in more detail below.

Anticipated shortages of corn, due to increased demand for ethanol production together with continuing strong demand for domestic consumption, livestock consumption, and exports, has resulted in significant increases in the price of corn over the past year. The expectation of continued high corn prices in 2007 provides an incentive for farmers to move more land into corn production (Figure 1). The new corn acreage needs are met through a combination of crop displacement and new acreage brought into production, depending on the scenario considered.

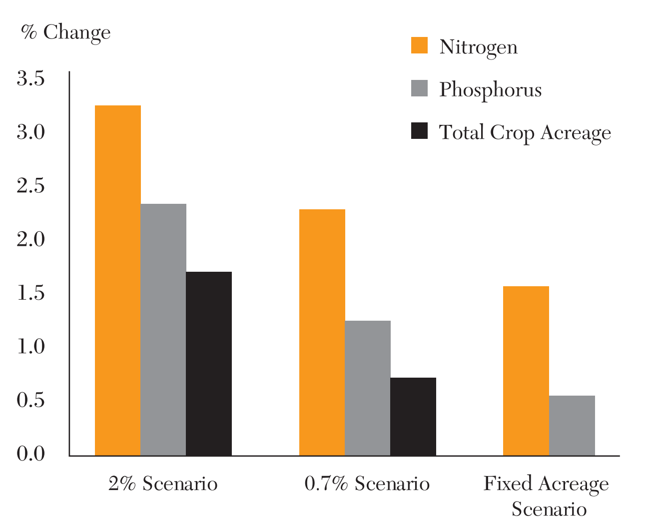
The USDA's planting projections suggest that corn growers will plant 90.5 million acres of corn in Spring 2007 (NASS, 2007). In the graphs that follow, we therefore focus on the environmental impacts associated with approximately 90-90.5 million acres of corn. Our analysis confirms that such an allocation would be consistent with an expected ethanol-industry demand for corn of 3.6 billion bushels, or enough to produce approximately 10 BGY ethanol. In the absence of major disruptions to the ethanol market, it is quite likely that such capacity will be online by late 2008, so these plantings are likely to be sustained by projected growth in demand.

Most of the increased corn production is met through scaling up continuous corn and corn-soybean rotations. The water quality impacts of these changes in production are considerable, with aggregate nitrogen and phosphorus loss into waterways increasing at a rate faster than the rate at which acreage is brought into production (Figure 2). Under scenario 2, acreage in production increases by only .7%, but nitrogen runoff increases at more than three times that rate nationwide (2.3%), and by a much higher percentage in some parts of the northern plains, lake states, and Appalachian/mid-atlantic regions. Even under the best-case production scenario (Scenario 1), nitrogen and phosphorus runoff increase by up to 9% in some regions of the Northern Plains. These figures may be conservative estimates, as well; raising corn prices relative to the price of nitrogen fertilizer provides an incentive for farmers to increase their use of N fertilizer in an effort to produce greater yields.

Downstream coastal areas have been grappling with the impacts of agricultural nutrient runoff for decades. Nutrient runoff from agricultural lands in the Mississippi River Basin is the prime culprit in driving the size and duration of the annual "Dead Zone"—a seasonal phenomenon in which oxygen depletion causes an area of the Gulf of Mexico the size of Massachusetts to become uninhabitable to marine organisms. Although the dead zone no longer captures the national headlines it occupied when it was discovered in the early 1990s, the phenomenon persists and continues to grow, with adverse impacts on marine fish populations and coastal fisheries. Despite regional efforts to advance nutrient management objectives, progress has been slow in encouraging adoption of best management practices to reduce nutrient runoff, and increased production of corn to meet ethanol demand threatens to significantly exacerbate this issue.

One of the widely cited benefits of ethanol as a gasoline replacement is its potential for reducing aggregate GHG emissions from the transport sector. Recent life-cycle analyses of ethanol have shown that such benefits are in fact highly sensitive to the way in which the fuel is produced, with the use of carbon-emitting coal to power the conversion process doing much to offset the benefits derived at the point of combustion. A thorough life-cycle accounting of the GHG-intensity of ethanol also requires consideration of the impacts of feedstock production on GHG emissions in the agricultural sector. In this study, agricultural GHG emissions are measured as carbon

FIGURE 2 Changes in Nutrient Loss to Water



dioxide emitted in the grain production process (through fuel use, fertilizer production, etc.), the net carbon flux from the sequestration and release of carbon from agricultural soils (including those in the CRP), nitrous oxide released from nitrogen fertilizer use, and nitrous oxide released during nitrogen fixation by legumes such as soybeans.

Our analysis suggests that, as corn production increases to meet ethanol demand, GHG emissions from the agricultural sector also increase at a rate that is faster than the rate at which land is brought into production. (Figure 3)

GHG emissions from the agricultural sector are expected to rise due to increases in both the extent of agriculture (i.e. new land being brought under production) and in the average GHG-intensity of agriculture (because, on average, corn production is more GHG-intensive than the cropping practice that it is replacing). The analysis predicts, for instance, a decline in continuous soybean production, with its minimal nitrogen fertilizer demand, and an increase in more input-intensive corn-soybean and continuous corn rotations.

Increased GHG emissions from agriculture will serve to offset some of the GHG emissions benefits obtained at the tailpipe when ethanol use displaces gasoline use. A full life-cycle analysis of the GHG emissions associated with ethanol production would require consideration of the ag-sector number together with the GHG emissions associated with the refining process and transport of both feedstock and finished product. In their 2006 analysis of the GHG emissions associated with a typical

FIGURE 3 Change in Agricultural GHG Emissions

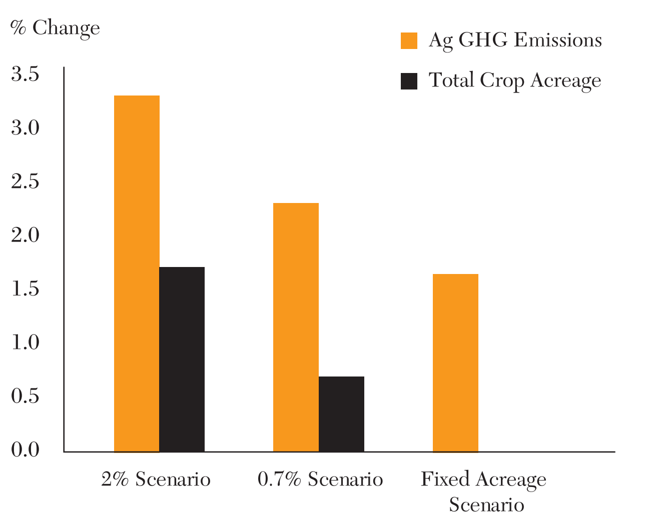
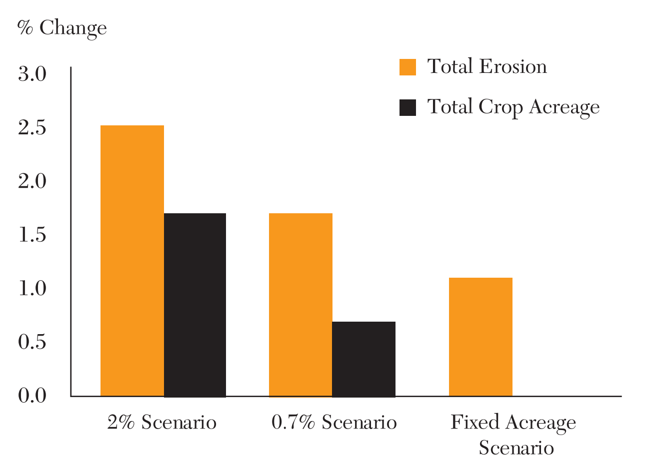


FIGURE 4 Changes in Erosion from Agriculture



ethanol production scenario using current corn-based technology, Farrell et al calculated average total GHG emissions of 77 g CO2 e/litre of ethanol, as compared to an estimate of 94 for gasoline, yielding a moderate average GHG emissions reduction from ethanol use versus gasoline. Using Farrell's estimates of emissions from refining and transport, our estimates of agricultural sector emissions, which include estimates of both direct and indirect emissions associated with changing land use patterns, raises the estimate of average total GHG emissions associated with ethanol to 85.3 g CO2e/litre of ethanol.

The adjustment based on our analysis reduces the estimated average net GHG reductions associated with corn ethanol to approximately 10%. Although this adjustment underscores the importance of performing agricultural greenhouse gas calculations that are inclusive of emissions related to land-use change in addition to those derived from direct production practices for corn, the presentation of such average calculations are of limited illustrative value. They mask wide variability in the possible GHG emissions associated with the processing and transport portions of ethanol's life cycle. Facilities that use efficient energy generation from low-carbon sources and draw their feedstock from local sources can significantly exceed the average ethanol GHG reduction of 10%, while those that generate process energy from coal and transport feedstock in from a distance may actually increase GHG emissions relative to gasoline.

This analysis also predicts a disproportionate increase in erosion, both water-borne and wind-borne, from agricultural land (Figure 4). Erosion from cropland has both water and soil quality implications, with off-site impacts arising from the delivery of sediment, chemicals, and additional nutrients to waterways, and on-site impacts arising from the potential loss of soil productivity over time. Government programs designed to reduce erosion, such as the CRP program, compliance requirements for erosion management on highly erodible land, and resource and technical assistance programs to encourage farmers to switch to less intensive tillage systems, have been successful at reducing levels of erosion since 1982 (NRCS, 2003). Nevertheless, the social costs associated with recent levels of erosion have been estimated at $37.6 billion/year (URI, 2001). Even increases in erosion of 1.0-2.5% over baseline are likely to have significant social costs, and these impacts, together with those described above, represent a step backward in our efforts to direct agriculture toward a more sustainable future.

Policy Responses

The range of environmental impacts that are described here are projected to occur within the 2007 growing season as a result of increasing corn production to meet the increased demand from an expanding ethanol industry. If renewable fuel production is to be truly sustainable, the debate about the environmental performance of corn ethanol, and more broadly all biomass-derived fuels, must expand to include the climate, soil, habitat, and water quality impacts of feedstock production. Agricultural impacts have become an inextricable part of the clean energy equation, and unprecedented levels of collaboration in design of agricultural and energy policy will be required to ensure that our new energy sources are truly clean and sustainable.

The Farm Bill, currently under debate for reauthorization in 2007, represents the most immediate and powerful tool at our disposal for establishing guidelines to ensure the sustainability of ethanol feedstock production. The timing is critical; the biomass-based ethanol industry will continue to expand, and the pressures exerted on our nation's soil, habitat, and water quality will continue to grow. Experimental markets for cellulosic feedstocks are also likely to come on line during the 2007 Farm Bill's life span, bringing with them a suite of additional, though possibly distinct, pressures on our resources. If we fail to build robust feedstock provisions into this bill, we miss the opportunity to provide critical guidance at a time when patterns of production are emerging but not yet entrenched.

Given the fragmented nature of agricultural management and incentive policies, addressing the environmental impacts of feedstock production will require a mix of policies, some of which are designed to move agriculture in general in a more sustainable direction, and some of which target specific issues associated with particular agricultural products or their use as energy feedstocks. The following list of policy recommendations reflects that mix.

Recommendations

1. **USDA should continue to resist the pressure to allow farmers penalty-free "early outs" from their CRP contracts.**

   The CRP program provides farmers with annual rental payments and cost-share assistance for establishing and maintaining approved conservation practices on qualifying land. These payments represent a considerable government investment in the approved management practice and parcel, and in return the farmers enroll in long-term contracts that ensure that those practices will remain in place for the length of the contract. The existing terms of most CRP contracts allow farmers to pull their land out of the program early. However, because an early return to production devalues the government resources invested to select, rank, and convert those land parcels, farmers exiting early must pay early withdrawal penalties as stipulated in the contract. The existing CRP terms are therefore sufficiently flexible and are appropriate to the long-term objectives of the program. Establishing a precedent for allowing farmers penalty-free withdrawals from the program makes the entire program, and its environmental benefits, vulnerable to short-term market fluctuations and reduces the incentive for good-faith negotiation on the part of potential enrollees.

2. **Increase funding for working lands conservation programs such as CSP and EQIP**.

   Farm support has traditionally taken the form of payments linked, directly or indirectly, to commodity production. For reasons related to trade compliance and environmental sustainability, however, an expanding chorus of voices is calling for a transition from commodity support programs toward support programs that reward farmers for the environmental services provided by their land, thereby providing incentives for environmentally friendly practices.

   Rewarding farmers for good environmental practices on working lands is one possible method for administering environmental services payments, and this philosophy underlies the major existing working lands programs in the Farm Bill—the Conservation Security Program (CSP) and the Environmental Quality Incentives Program (EQIP). These programs, however, receive a fraction of the funding appropriated for commodity support. Over the years 1995-2005, conservation programs made a total of $20.25 billion in payments, while commodity support programs made a total of $129.47 billion, $51.26 billion of that for corn support alone (EWG, 2007). The success of the biofuels industry provides a unique opportunity to transition funding from commodity payments to green payments; the burgeoning biofuels industry is expected to stimulate and support markets for the largest agricultural products—corn, soybeans, and wheat-- thereby relieving pressure on the major commodity support programs (Marshall and Greenhalgh, 2006). If futures prices are any indication, it may be several years before either corn or soybeans qualify to receive further counter-cyclical payments or loan-deficiency payments (Babcock, 2006).

   The success of the biofuels industry, however, could be bad news for our nation's soil and water resources. In order to mitigate the potential environmental impacts of such strong agricultural markets, increased funds, such as those freed up by the ethanol industry's price support effect, should be transferred into working lands conservation programs such as the CSP and EQIP. These programs encourage farmers to protect against potential impacts of feedstock production by giving them the incentive to produce environmental services, in addition to agricultural products, on their lands. Similarly, the $5.2 billion direct payment program, which gives farmers fixed direct payments based on historical acreage grown for commodity crops, should be phased out. Those funds should instead be committed to working lands conservation programs to support the transition to more environmentally friendly practices.

3. **Extend "sodbuster" compliance requirements for receipt of commodity payments to all acreage in production, not just highly erodible lands.**

   Current conservation compliance provisions—called "sodbuster" and "swampbuster" provisions—tie farmers' eligibility for federal farm support to minimum environmental protection criteria directed at wetlands and highly erodible land. Although highly erodible land is particularly vulnerable to erosion, significant amounts of erosion also occur on lands that are denoted Non Highly Erodible. All cropland should have to meet minimum erosion management criteria in order to receive federal support funds.

4. **Create a pilot TMDL project for the Chesapeake Bay in the Farm Bill, with joint USDA/EPA jurisdiction.**

   The nation's attempts to address agricultural nutrient runoff issues through the Clean Water Act, under EPA jurisdiction, have been mired in jurisdictional confusion, funding shortages, and regulatory and legislative delays. The 1972 Act required that states with waterways listed as "impaired" perform a Total Maximum Daily Load (TMDL) analysis on those waterways to establish the maximum level of specific pollutants that could be received by those waterways. The TMDL plan must then allocate those allowable pollutants among all sources in the watershed. Many states lack the financial resources and political will to complete the expensive and contentious TMDL development process, however, and EPA does not have the resources to shoulder the burden entirely itself. In addition, there have been numerous legislative challenges questioning EPA's authority over non-point source water pollution.

   Completion of TMDL plans for watersheds impaired by phosphorus and nitrogen would provide clear regional objectives to guide allocation of conservation dollars to nutrient management practices, and, more importantly, would create a mechanism for compulsory regulation of agricultural runoff (MD School of Public Policy, 2006). Methods of "compulsory" regulation could range from compliance requirements for farm support, as discussed above, to establishment of mandatory nutrient caps for agriculture, with nutrient credit trading programs introduced to allocate reductions most cost-effectively.

   A pilot TMDL program within a specific watershed with well-defined authority shared between the U.S. EPA and the USDA could cut through the confusion generated by 35 years of debate over the TMDL program and provide a case study for successful implementation of regional TMDLs nationwide. Extensive efforts have already been made within the six-state Chesapeake Bay watershed to design nutrient reduction objectives under the 2000 Chesapeake Bay Agreement that mimic TMDLs in setting 2010 nutrient reduction goals for each state, as well as to establish the multi-state and multi-agency institutions that would be necessary to ensure achievement of those objectives. The EPA and USDA have also already signed a memorandum of understanding and agreed to establish a joint pilot water quality trading project within the Bay. The Bay is nevertheless not likely to achieve its 2010 reduction goals; efforts have been hindered by a lack of financial resources as well as by the lack of a regulatory imperative, applicable to non-point sources such as farms, that can be used to leverage participation and compromise. The Farm Bill could provide both with a funded pilot project that gives USDA the authority to tie farm support funding to efforts to achieve TMDL goals. A successful pilot project demonstrating the feasibility of TMDL assessment and implementation could be Farm Bill 2007's most significant step toward building agriculture's capacity to absorb the increased pressures from the nation's energy demands while minimizing impacts on our nation's water resources.

5. **Extend compliance requirements for receipt of commodity payments to include nutrient management requirements in TMDL non-attainment watersheds.**

   Federal conservation compliance provisions should be broadened to include nutrient management requirements, so that in any TMDL non-attainment watershed, or in any watershed targeted for nutrient management efforts prior to establishment of TMDLs, only farmers who satisfy minimal nutrient management requirements would be eligible for farm support payments. These requirements could include annual soil tests linked to nutrient application allowances, inclusion of cover crops to capture excess residual nutrients, or maintenance of vegetative riparian buffers along farm-adjacent waterways.

6. **Establish a new program in the Farm Bill to encourage riparian buffers.**

   Vegetative riparian buffers are particularly effective at trapping sediment and nutrient runoff that result from agricultural production (FAPRI et al, 2007). Despite significant government support within the CRP program for their adoption, buffers have not been widely implemented by farmers. In order to focus resources on this high-benefit practice, and to ensure continuity of the practice, a permanent easement program should be introduced to cover land in riparian buffer strips. This program, similar to the permanent easement option of the Wetland Reserve Program, would compensate farmers for the lost production value of the land, together with all buffer establishment costs, in return for a permanent easement on that land. Although agricultural practices on that land would be restricted, farmers could continue to use the land for any activities that do not reduce the effectiveness of the buffer itself.

7. **Require all projects that receive federal funds to explore crop yield improvements to explicitly address the soil, water, and GHG implications of the new production methods.**

   Given the rapid expansion of biofuel production, there is an urgent need to both accelerate the rate of gain in crop yields to minimize the need for expansion of cropping to marginal land, while at the same time avoiding environmental degradation. Prior advances in crop yields, such as those associated with the green revolution, have not been able to avoid negative impacts on soil and water quality. Achieving these dual goals concomitantly will require a major investment in research with an *explicit* emphasis on raising yields while at the same time protecting soil and water quality and reducing GHG emissions (CAST, 2006). While such research will need to be focused initially on corn and soybean systems because of the short-term need to meet demand from ethanol production, the same approaches and methods can later be used to develop environmentally sound cellulosic production systems as these systems begin large-scale deployment.

8. **Promote conservation tillage in corn production and provide research resources directed explicitly at use of slow-release fertilizers and use of precision nitrogen management in row crop production**.

   Existing best management practices for corn production include the use of conservation tillage to minimize erosion, nutrient runoff, and GHG emissions, as well as precision nitrogen application to reduce excess nitrogen application, nutrient runoff, and GHG emissions. Despite widespread awareness of these techniques, adoption has been limited. Reasons identified for low adoption of conservation tillage have included lack of information, lack of interest in changing current practices, perceived impacts on yields and profitability, expense of machinery, etc. Potential policies to promote advancement and adoption of conservation tillage includes incentive payments, cost-share policies, erosion management plan requirements, farmer education programs, and improved access to technical information about tillage options. Precision nitrogen application is a relatively recent innovation, and obstacles to its adoption include the expense associated with developing site-specific application plans, and the limited predictive accuracy of the currently available techniques for designing those plans. Slow-release fertilizers are currently in use on high-value crops such as vegetables and ornamentals, but are relatively untested on field crops. Research and extension dollars should be directed explicitly at these practices to expand farmers' options for field-feasible nutrient management strategies.

9. **Task the USDA with development of a consistent methodology for calculating the environmental impacts of feedstock production.**

   There is currently a great deal of interest in developing sustainability criteria and certification programs for bioenergy and biofuels, both domestically and within international trade arenas. Such programs rely on the development of a consistent methodology for calculating and integrating the various dimensions of environmental impact at various stages in the fuel's lifecycle. Evaluation of the environmental impacts of feedstock production is one component of such a methodology that has received inadequate policy attention.

   An established methodology for evaluating impacts would be a first step in the development of an internationally appropriate set of production criteria. This measurement could, for instance, be used as the basis of a feedstock certification program, which could be integrated into regulatory or contractual policies to ensure sustainable feedstock production. Further integration of feedstock production impacts into a fuel-specific life-cycle based "green biofuels index" would permit such sustainability criteria to be used as a basis for national energy security incentive programs, such as the renewable fuel standard, to provide differential incentives for fuels based on environmental performance (Turner et al, 2007).

TABLE 1 Environmental Impacts of Expanded Corn-based Ethanol Production

Land Supply Scenario	Environmental Indicator		Projected Ethanol Production (in Billions of Gallons Per Year) 6.0	8.0	10.0	11.0
2%	Total Acreage Planted	Mill. Acres	314.55	318.57	319.93	320.22
		% Change	0.0	1.3	1.7	1.8
0.7%	Total Acreage Planted	Mill. Acres	314.55	316.62	316.75	316.75
		% Change	0.0	0.7	0.7	0.7
Fixed Acreage	Total Acreage Planted	Mill. Acres	314.55	314.55	314.55	314.55
		% Change	0.0	0.0	0.0	0.0
2%	Acres of Corn	Mill. Acres	81.00	85.88	90.35	92.48
		% Change	0.0	6.0	11.5	14.2
0.7%	Acres of Corn	Mill. Acres	81.00	85.63	90.00	92.16
		% Change	0.0	5.7	11.1	13.8
Fixed Acreage	Acres of Corn	Mill. Acres	81.00	85.43	89.83	92.02
		% Change	0.0	5.5	10.9	13.6
2%	Fertilizer Application	Mill. Tons	8.72	9.04	9.30	9.42
		% Change	0.0	3.6	6.6	8.0
0.7%	Fertilizer Application	Mill. Tons	8.72	9.01	9.24	9.35
		% Change	0.0	3.3	6.0	7.2
Fixed Acreage	Fertilizer Application	Mill. Tons	8.72	8.97	9.20	9.32
		% Change	0.0	2.8	5.5	6.8
2%	GHG Emissions from Ag	MMTCE	92.19	94.10	95.22	95.63
		% Change	0.0	2.1	3.3	3.7
0.7%	GHG Emissions from Ag	MMTCE	92.19	93.51	94.26	94.65
		% Change	0.0	1.5	2.3	2.7
Fixed Acreage	GHG Emissions from Ag	MMTCE	92.19	92.94	93.70	94.12
		% Change	0.0	0.8	1.6	2.1
2%	N Lost to Water	Mill. Tons	4.94	5.04	5.10	5.12
		% Change	0.0	2.1	3.3	3.7
0.7%	N Lost to Water	Mill. Tons	4.94	5.01	5.05	5.06
		% Change	0.0	1.6	2.3	2.6
Fixed Acreage	N Lost to Water	Mill. Tons	4.94	4.98	5.02	5.04
		% Change	0.0	0.9	1.6	2.0
2%	P Lost to Water	Mill. Tons	0.55	0.56	0.56	0.56
		% Change	0.0	1.7	2.3	2.5
0.7%	P Lost to Water	Mill. Tons	0.55	0.55	0.55	0.55
		% Change	0.0	1.0	1.2	1.4
Fixed Acreage	P Lost to Water	Mill. Tons	0.55	0.55	0.55	0.55
		% Change	0.0	0.3	0.6	0.8
2%	Total Erosion	Mill. Tons	1940.97	1972.06	1989.17	1995.56
		% Change	0.0	1.6	2.5	2.8
0.7%	Total Erosion	Mill. Tons	1940.97	1960.55	1972.65	1979.68
		% Change	0.0	1.1	1.7	2.1
Fixed Acreage	Total Erosion	Mill. Tons	1940.97	1949.47	1961.62	1968.90
		% Change	0.0	0.4	1.1	1.4

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About the Author

Liz Marshall is a senior economist at the World Resources Institute, 10 G. St, NE, Suite 800, Washington, DC 20002. Ph: (202) 729-7719 Email: lmarshall@wri.org

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