Environmental Challenges Associated With Corn Ethanol Production

Clay Ogg

Working Paper Series

Working Paper # 07-05
April, 2007

U.S. Environmental Protection Agency
National Center for Environmental Economics
1200 Pennsylvania Avenue, NW (MC 1809)
Washington, DC 20460
http://www.epa.gov/economics

Environmental Challenges Associated With Corn Ethanol Production

Clay Ogg

Correspondence:

Clay Ogg
U.S. Environmental Protection Agency (MC 1809T)
National Center for Environmental Economics
Washington, DC 20460
(202) 566-2315, ogg.clay@epa.gov

NCEE Working Paper Series

Working Paper # 07-05
April, 2007

Environmental Challenges Associated with Corn Ethanol Production

Clay Ogg
ogg.clay@epa.gov
202-566-2315

Abstract: Policies aimed at conserving energy support energy independence, reduce greenhouse gas emissions, and benefit consumers. In contrast, support for corn ethanol production raises world commodity prices and pressures the land and water base, as occurred in the U.S. during the plow-out of the seventies. Today, much of the deforestation/sodbusting and the resulting release of hundreds of millions of metric tons of greenhouse gas occurs in tropical countries, like Indonesia, which is the third largest source of greenhouse gases in the world. Increased concern over global warming, sea rise, and threats to life on planet earth could lead to changes in policy in the U.S. and in Europe toward more support for conservation.

Key Words: biofuel, ethanol, greenhouse gas, deforestation, energy conservation
Subject Area Classification: climate change

Environmental Challenges Associated with Corn Ethanol Production

Likely remedies to achieve energy independence and reduce global warming include energy conservation, plug-in hybrid technologies, and renewable fuels (National Research Council, 1992). Of these, conservation works on two major fronts: 1) achieving energy independence and 2) reducing greenhouse gas emissions.

Corn ethanol only supports the former, the energy independence goal. It lacks the environmental credentials of other renewable energy sources (e.g., celulosic ethanol, wind energy, and solar energy). Conservation also benefits consumers (Mufson, 2007), while ethanol programs impose certain costs on consumers.

Over reliance on corn ethanol could pressure the land and water base, contributing to a dramatic loss of prairie ecosystems in the U.S. and reducing the influence of compliance programs designed to reduce soil erosion and protect ecosystems. On a much larger scale, reductions in U.S. exports of corn and other crops lead to higher, world commodity prices (Elobeid, et al., 2006). Higher prices can contribute substantially to deforestation in tropical countries (Morton, et al., 2006). Deforestation accounts for 20 percent of the world's greenhouse gas emissions (National Research Council, 1992; World Resource Institute, 1990). These ecosystem and environmental implications of corn ethanol production largely have been ignored until very recently, but increased concern over global warming, sea rise, and potential threats to life on planet earth (Hansen, 2006), bring the environmental challenges more into focus.

Advantages of Energy Conservation and Plug-In Vehicles

In spite of their widely recognized importance, funding for conservation, plug-in vehicles, and renewable fuels has changed little in recent years (Krauss, 2007). This includes funding for environmentally friendly biofuels, such as those made from plant residues and switchgrass (celulosic ethanol). Other approaches to energy independence and reduced greenhouse gases include diesel and other fuel efficient technologies for SUV's and light trucks (U.S. Department of Transportation, 2005), plug-in, hybrid cars (Brook, 2007), much more efficient appliance and lighting systems, insulation for homes and buildings, and a variety of other fuel conserving options, which reduce fuel prices, and reduce the associated greenhouse emissions (National Research Council, 1992), *as well as* achieve independence from foreign oil. Conservation remedies could reduce greenhouse gases by 10 to 40 percent at virtually no cost (National Research Council, 1992), so in the short run, conservation is most able to achieve reductions in greenhouse gases, as well as energy independence.

California has set the bar very high for what can be accomplished through energy conservation. While energy use in the rest of the U.S. increased by nearly half since 1974, California's energy use has remained virtually unchanged. Instead of costing consumers money, the average household in California saves $800 per year as a result of these energy conservation programs (Mufson, 2007).

During the energy crisis of the Carter Administration, automobiles were required to meet certain fuel efficiency standards, while light trucks were not. In a relatively short period of time, fuel efficiency for automobiles nearly doubled, while little improvement occurred for trucks. Because SUVs and trucks now make up such a large proportion of vehicles on the road, substantial reductions in U.S. demand for oil imports could be achieved by policies aimed at emulating for SUVs and trucks what was accomplished for automobiles (U.S. Department of Transportation, 2005). Some fuel efficiency gains appear immanent, even without government action, as vehicle manufacturers respond to consumer's concern over high fuel prices. For example, availability of clean diesel fuel will soon open the way to much more fuel efficient trucks.

In the long run, plug-in hybrids offer low cost fuel from the electrical grid which provides fuel at a third of the cost of petroleum or of ethanol (Brooke, 2007). As wind energy in the high plains is now competitive with coal based electricity (Smith, 2007), wind energy potentially could fuel vehicles. This would require investment in power lines to distribute wind energy to more places than it is currently available, as well as support for plug-in hybrid technologies.

Making wind energy options for plug-in vehicles economically competitive would depend, also, on improved batteries, improved vehicle design, and other technical breakthroughs. However, wind energy potentially could support low cost options for vehicles which can greatly reduce demand for fuel, lower its price, and reduce the risks posed by climate change, while also reducing a variety of pollution problems (National Research Council, 1992).

Ethanol Production and Carbon Taxes

To achieve energy conservation, the policy tool that offers the greatest efficiency is a carbon tax. Economists extol the virtues of a carbon tax as a way to level the playing field and to most effectively reduce greenhouse gas emissions, while reducing dependence on foreign oil producers (Stiglitz, 2006) (who might actually contribute by paying part of the tax). Carbon could be taxed directly or through a much more complex, carbon trading system. If it could be administered successfully (an important policy issue in its own right), carbon trading could work much like the carbon tax, and achieve many of the same energy conservation, energy independence, and greenhouse gas reduction benefits. The carbon tax could be applied with an off-setting pay role tax reduction, so that the overall tax burden would remain unchanged.

Yet, a carbon tax would need to tax ethanol in a manner consistent with taxes on other fuels. To be fair, different forms of ethanol or other biofuels could be taxed to varying degrees, or not taxed, depending on whether they reduce greenhouse gas emissions (e.g., celulosic ethanol made from crop residues) or increase deforestation and associated greenhouse gas emissions (e.g., corn ethanol). Or, taxes could be applied to any increase in corn ethanol produced beyond some point in time, thus leaving a larger role for other, more environmentally friendly, renewable fuels.

Environmental Impacts Associated with Expansion in Ethanol Production

Recent growth in world prices is reminiscent of the 1970's when cropland use in the U.S. increased by about 25 percent. Many of today's conservation programs (Conservation Reserve Program, Sodbuster Program, Swampbuster Program, Conservation Compliance) were created in the 1985 Farm Bill to address the environmental damage due to increased land use and increased chemical use that began during that period (Ogg, 1992). Unfortunately, the above, compliance programs may loose much of their ability to influence farmer's land use and conservation decisions, just when they are needed most, partly because several billion dollars in corn ethanol subsidies (Koplow, 2006) have raised farm prices, which in turn, greatly reduces commodity payments and reduces any conservation leverage that these payments provide. And corn ethanol production could reduce enrollment in the CRP (Collins, 2006).

Since passage of the 1985 legislation, soil erosion in the U.S. was reduced by over 40 percent, and a very rapid loss of U.S. wetlands to agriculture was largely brought under control (USDA, various years). Should these compliance programs loose their influence over farmers' conservation decisions, much of the environmental/ecosystem gains of the past two decades could be lost.

Compared to countries in South America, relatively little, productive land is available for conversion to crop production in the U.S., so any further losses are very damaging to wildlife populations in our prairie regions. The Prairie Pothole region is regarded as one of the most ecologically important portions of the remaining prairie system. Studies of recent land use change within that region (Stephens, et al., 2006; Ogg, 2006) find that rates of land conversion are accelerating, and if we extrapolate based on the most recent, and most rapid loss rates, half of the remaining prairie will be gone within 33 years.

In this cold, rocky region, sodbusting was likely caused by U.S. farm policies which allowed farmers who break out additional land into crop production to become eligible for disaster and commodity payments, which then constituted a major portion of the farmer's net income on that land. These unintended incentives to convert native prairie to cropland were relatively easy to address within the context of income support payments and trade policies (Ogg, 2006). However, the effects of these past, program related incentives to convert prairie to crop production are now dwarfed by the rise in market prices, which in turn, will soon be driven by use of a fourth of the corn crop for corn ethanol production (FAPRI, 2006(b)). Since the Sodbuster Program only focuses on highly erodible land, and since price support programs loose much of their influence, as farm prices rise, sodbuster offers little protection for the great majority of the prairie landscape.

With relatively modest amounts of land left for conversion to crop production, the additional losses described above are especially damaging to our dwindling wildlife populations, including especially ducks, shorebirds, and songbirds (Allen, 2006). This lack of land available in the U.S. for conversion to crop production also implies that our farmers' opportunity to expand production is relatively modest, when compared to the vast areas which are available, and being converted to crop production in Brazil (Valdez, 2006) and in the rest of South America (Elobeid, et al., 2006). Only a fourth of the land suitable for crop production in Brazil has been converted to crop production (Valdez, 2006), leaving tremendous opportunities for further expansion.

Land in tropical countries, such as Brazil, is being cleared very rapidly. World demand, and the price of major crops, determines the rate at which clearing takes place (soybean prices in the Brazil example) (Morton, et al, 2006; FAPRI, 2001). If land in these tropical countries were converted to crop production during periods of insufficient growth in demand on the part of importing countries, world food prices would fall, and the incentive for further deforestation would be greatly reduced. However, there are two major drivers assuring continued and dramatic growth in world demand: 1) income growth in countries like China and India, which leads to greater food purchases in those countries (FAPRI, 2005), and 2) expansion in ethanol and biodiesel production around the world, led by the current U.S. expansion in corn ethanol (FAPRI, 2007).

If we assume for a moment that the ability of the above tropical countries to convert land to crop production was too slow to keep pace with the rapid expansion in ethanol production (and with the associated expansion in world demand for major crops), then prices of corn, soybeans, palm oil, and other commodities would rise very quickly, making it unprofitable to further expand ethanol and biodiesel production. There also would be insufficient food as a large portion of production that formerly went to supply food is diverted to produce ethanol, and world hunger would assert itself as a major policy issue. Instead, research regarding the potential for expansion (Elobeid, et al., 2006) suggests a synergism between those tropical farmers who ultimately supply the land, and corn ethanol producers in the U.S., who contribute so heavily to the growth in world demand for crops. At a price of $4.05 per bushel of corn, ethanol production ceases to be profitable, but the above research suggests tremendous increases in ethanol production are feasible, potentially eliminating U.S. exports of corn and substantially reducing our exports of other major crops (Elobeid, et al., 2006). Tens of millions of acres would be converted to crop production to meet the future growth in world demand and to replace U.S. food exports.

Land clearing and deforestation in tropical countries is regarded as one of the most serious ecosystem problems on the planet, and it ranks with carbon emissions as a leading contributor to global warming (National Research Council, 1992). Journalists highlight the direct impacts as tropical rainforests are cleared and burned to make way for palm oil plantations to provide feedstock for biodiesel plants in Indonesia (Barta and Spencer, 2006) and in other tropical countries. Uganda recently abandoned commitments to preserve rainforests in order to provide publicly owned land for palm oil plantations to supply a biodiesel plant (Ngunjiri, 2007). Yet, the effects of these highly visible conflicts between biofuel production and the environment are dwarfed by the above synergism between corn ethanol production and land clearing (deforestation).

The Dutch government recently apologized for promoting palm oil as a biofuel (Economist, 2007). Unfortunately, palm oil is the cheapest to produce of the vegetable oils, so when European drivers burn rapeseed oil or soybean oil in their cars, it causes vegetable oil prices to increase and causes palm oil prices to "skyrocket" (FAPRI, 2007). Consumption of various vegetable oils in automobiles, therefore, provides much the same encouragement to drain swamps in Indonesia as does the consumption of palm oil. Because of the above deforestation, Indonesia ranks third in the world, behind the U.S. and China, for its release of greenhouse gases (Hooijer, et al., 2006), and Indonesia and Malaysia, together, account for 8 percent of the world's greenhouse gases.

In the U.S., it is easy to plant less soybeans and more corn when the price of corn doubles, as occurred over the past two years. This raises the world price of soybean oil (FAPRI, 2007), so we are likely the main contributor to the increase in vegetable oil and palm oil prices. Incredibly, no one has studied the international land use effects of all of this use of biofuels, but the FAPRI Website publishes "baselines" which predict production and land use around the world for ten-year periods, both before and after the advent of the biofuels boom. Comparing 2014/15 projections for Indonesian and Malaysian palm oil production in the FAPRI 2005 U.S. and World Outlook Report (before their anticipation of the ethanol boom) with projections in the FAPRI 2007 Outlook Report (which allows for considerable biofuel expansion), we find a 9.9 million tonne increase in palm oil production. Worldwide, FAPRI's 2007 projections show acreage of corn and certain other crops grown in tropical countries also increase by several million hectares, which they also did not anticipate in the FAPRI 2005 Outlook Report. Scientists estimate that over 33 tonnes of carbon dioxide emissions are released into the atmosphere for each tonne of palm oil produced in Indonesia and Malaysia (Economist, 2007; Hooijer, et al., 2006), suggesting that increased biofuel production in the U.S., Europe, and other countries will soon cause the release of roughly 328 million tonnes, or more, of additional carbon dioxide per year in Indonesia and Malaysia, alone.

If you are a farmer, it probably seems unfair to consider the above, "indirect" effects of programs that raise the prices of farm commodities. Yet, producers of coal and certain other commodities may be asked to make sacrifices to reduce the release of greenhouse gases. U.S. and European efforts to reduce greenhouse gas emissions could easily be offset by events on the other side of the world.

Climate Modeling and the Melting in the Artic

Fifteen years ago, projections regarding the costs of global warming provided reassuring estimates, suggesting relatively modest climate change and modest rises in ocean levels, as the most likely scenario, and the changes appeared to occur far enough into the future so no one alive today (including our children) would be seriously affected (National Research Council, 1992). In contrast, the actual warming documented since that time in the polar regions are consistent with only the more pessimistic projections (Hansen et al., 2006). This could be viewed as a vindication of the most alarming climate scenarios, suggesting that policy makers may move forward to address the release of greenhouse gasses much more aggressively than previously anticipated.

A team of scientists in 2003 (National Research Council, 2003) provided more pessimistic predictions compared to those made by the similar team a decade earlier

(National Research Council, 1992). Seemingly modest amounts of global warming (such as that described above) trigger reinforcing mechanisms that will considerably accelerate the rate of warming in the next 30 years compared to warming in the past 100 years (National Research Council, 2003). During 2006, scientists then offered even more alarming scenarios, predicting runaway release of greenhouse gasses and much more rapid global warming (Hansen, 2006; Lovelock, 2006), unless warming in the Artic is brought under control very soon (in ten years).

What are these reinforcing mechanisms? The most recent analyses focus on release of very large quantities of greenhouse gases currently trapped in the frozen landscape as the artic thaws (Witze, 2006; Walter, et al., 2006; Hansen, 2006). These greatly reinforce global warming and are joined by two, other reinforcing mechanisms: 1) the ocean's adsorbing much more of the sun's warmth once the sea ice melts (Holland, et al., 2006; Lovelock, 2006) and 2) algae, which sequesters immense amounts of carbon in the ocean, only growing in the cooler parts of the ocean, which are shrinking in size as the ocean warms (Behrenfeld, et al., 2006; Lovelock, 2006).

Other, new pieces of the climate puzzle also provide cause for concern. The speed at which glaciers can slip into the ocean has surprised many scientists (Velicogna, 2006). And as noted above, very simple and believable models now predict further, acceleration of rates of warming in the Artic Region, as less of the sun's light is reflected away by the rapidly declining sea ice (which may disappear during summer months within 40 years) (Holland, et al., 2006). Some of these outcomes are relatively easy to understand compared to those provided by more complex, climate models which were the focus of attention a decade ago.

Policy Implications

It is not the intent of this paper to prove which scientific findings are most reliable regarding threats posed by global warming, but rather to note that there has been a considerable, and worrisome, change in the literature compared to the climate change literature that existed just 15 years ago. This change could lead to changes in the direction that climate policy and energy policy will take.

Policy makers may expand their focus in the near future to address both energy independence and reduction of greenhouse gases. This would include reducing deforestation, as opposed to their recent, narrow focus on supporting corn ethanol.

Such a shift in emphasis also would tend to favor expanded energy conservation initiatives. Conservation currently offers the greatest efficiency in achieving energy independence, without the environmental drawbacks posed by subsidies for corn ethanol and biodiesel. If energy conservation also leads to a reduction in the cost of energy, as expected, then it will reduce fuel prices. Conservation therefore benefits consumers (of both energy and food), reduces dependence on foreign oil, and reduces risks posed by global warming. In the long run, plug-in hybrid technologies and environmentally friendly, renewable energy sources, including celulosic ethanol, may play a larger role.

References Cited

Allen, Arthur W. 2007. Conservation Reserve Program effects on wildlife habitat, habitat management in agricultural ecosystems, and agricultural conservation policy: An annotated bibliography. Draft. U.S. Geological Survey.

Barta, P. and Jane Spencer. 2006, Dec. 5. As alternative energy heats up, environmental concerns grow. The Wall Street Journal, on Line: A1.

Behrenfeld, M. R. T. O'Malley, D. A. Siegel, C. R. McClain, J. L. Sarmiento, G. C. Feldman, A. J. Milligan, P. G. Falkowski, R. M. Letelier, and E. s. Boss. 2006. Climate-driven trends in contemporary ocean productivity. Nature 444: 752-755.

Brooke, L. 2007, Jan. 7. All the technology need for 100 M.P.G. (Batteries not included). The New York Times.

Cleveland, C., and A. Townsend. 2006. Nutrient additions to a tropical rain forest drive substantial soil carbon dioxide losses to the atmosphere. Proceedings of the National Academy of Sciences 103: 10316-10321. Washington, D.C.

Collins, K. September 6, 2006. Testimony for the U.S. Senate committee on Environment and Public Works. http://epw.senate.gov/hearing_statements.cfm?id=262516 Washington, D.C.

Economist Editors. February 24, 2007, The Economist.

Elobeid, A. S. Tokgoz, D. J. Hayes, B. A. Babcock, and Chad E. Hart. 2006. The long-run impact of corn-based ethanol on the grain, oilseed, and livestock sectors: A Preliminary assessment. Center for Agriculture and Rural Development, CARD Briefing Paper 06-BP 49, Ames, Iowa.

Food and Agricultural Policy Research Institute (FAPRI). 2005. U.S. and world agricultural outlook. FAPRI Staff Report 05-FSR 1 ISSN 1534-4533. Iowa State University and University of Missouri-Columbia, Ames, Iowa.

____. (FAPRI). 2006(a). U.S. and world agricultural outlook. FAPRI Staff Report 06-FSR 1 ISSN 1534-4533. Iowa State University and University of Missouri-Columbia, Ames, Iowa.

____. 2006(b). FAPRI July 2006 Baseline update for U.S. agricultural markets. FAPRI-UMC Report #12-06.

____. 2007. U.S. and world agricultural outlook. FAPRI Staff Report 07-FSR 1 ISSN 1534-4533. Iowa State University and University of Missouri-Columbia, Ames, Iowa.

____. 2001. Impact of a 10 percent decrease in planted acreage of all U.S. program crops. Briefing Paper 01-BP 33. University of Missouri, Columbia.

Hansen, J., M. Santo, R. Ruedy, K. Lo, D. W. Lea, and M. Medina-Elizade. 2006. Global temperature change. Proceedings of the National Academy of Sciences 103:14288-14293.

Holland, M.M., C. M. Bitz, and B. Tremblay. 2006, Dec. 7. Future abrupt reductions in arctic summer sea ice. Geophysical Research Letters 33: L23503.

Hooijer, A., M. Silvious, H. Wosten, and S. Page. 2006. PEAT-CO2, Assessment of CO2 emissions from drained peatlands in SE Asia. Delft Hydraulics report Q3943.

Koplow, D. 2006. Biofuels - At what cost? Government support for ethanol and biodiesel in the United States. Geneva, Switzerland: International Institute for Sustainable Development.

Krauss, C., 2007, Jan., 25. Energy research on a shoestring. The New York Times.

Lohr, S. 2006, Nov. 29. Energy use can be cut by efficiency. The New York Times.

Lovelock, J. 2006. The revenge of Gaia: Earth's climate in crisis and the fate of humanity. New York, New York: Basic Books.

D. C. Morton, R. S. DeFries, Y. E. Shimabukuro, L. O. Anderson, E. Arai, F. del Bon Espirito-Santo, R. Freitas, and J. Morisette. 2006, Cropland expansion changes deforestation dynamics in the southern Brazilian Amazon. Proceedings of the National Academy of Sciences 103: 14637-14641.

Mufson, S. 2007, Feb 17. Increasing conservation, California sees light. Washington Post.

National Research Council. 1992. Policy implications of greenhouse warming: Mitigation, adaptation and the science base. Academy Press: Washington, DC.

______________________. 2003. Understanding climate change feedbacks. Academy Press: Washington, DC.

Ngunjiri, P. 2007, Jan. 2. Dishing out the country's forests. The East African, Nairobi.

Ogg. C. 1992. Addressing Environmental Needs in Farm Programs. Agricultural History 66: 273-278.

_____. 2006. The vanishing prairie. Journal of Soil and Water Conservation 61: 19A-21A.

Stevens, Scott, J. Walker, D. Blunck, A. Jayaraman, and D. Naugle. 2006. "Grassland Conversion in the Missouri Coteau of North and South Dakota 1984-3003." Draft.

Smith, R. 2007, Feb. 12. "The New Math of Alternative Energy." Wall Street Journal.

Stiglitz, J. 2006. A new agenda for global warming. Economists' Voice. www.bepress.com/ev.

U.S. Department of Agriculture. Various years. National Resources Inventory. Washington, DC.

U.S. Department of Transportation. 2005. Corporate average fuel economy and the CAFÉ reform for MY 2008-2011 light trucks, Preliminary Regulatory Impact Analysis. Office of Regulatory Analysis and Evaluation, Washington, DC.

Valdez, C. 2006. Brazil's Booming Agriculture Faces Obstacles. Amber Waves, U.S. Department of Agriculture, Economic Research Service, www.ers.usda.gov/amberwaves.

Velicogna, I. and J. Wahr. Acceleration of Greenland ice mass loss in spring 2004. Nature 443: 329-331.

Walter, K. M. S. A. Zimov, J. P. Chanton, D. Verbyla, and F. S. Chapin III. 2006. Methane bubbling from Siberian thaw lakes as a positive feedback to climate warming. Nature 443:71-75.

Witze A. 2006. Shallow fuels bring bad news. Nature Publishing Group. Published On-Line, December 12.

World Resources Institute. 1990. World Resources 1990-01. New York: Oxford University Press.