# The ecological and social tragedy of crop-based biofuel production in the Americas

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The nations of the OECD—the Organization for Economic Cooperation and Development, who account for 56% of the planet's energy consumption, are desperately in need of a liquid fuel replacement for oil. Worldwide petroleum extraction rates are expected to peak this year, and global supply will likely dwindle significantly in the next fifty years. There is also a great need to find substitutes for fossil fuels, which are one of the major contributors to global climate change through the emission of $CO_2$ and other greenhouse gases.

Biofuels have been promoted as a promising alternative to petroleum. Industry, government and scientific proponents of biofuels claim that they will serve as an alternative to peaking oil, mitigate climate change by reducing greenhouse gas emissions, enhancing farmer incomes, and promoting rural development. But rigorous research and analysis conducted by respected ecologists and social scientists suggests that the large-scale industrial boom in biofuels will be disastrous for farmers, the environment, biodiversity preservation and consumers, particularly, the poor.

In this paper we address the ecological, social and economic implications of biofuel production. We argue that contrary to the false claims of corporations that promote these "green fuels," the massive cultivation of corn, sugar cane, soybean, oil palm and other crops presently pushed by the fuel crops industry—all to be genetically engineered—will not reduce greenhouse gas emissions, but will displace tens of thousands of farmers, decrease food security in many countries, and accelerate the deforestation and environmental destruction of the Global South.

## Biofuels in the US: extent and impacts

### --Ethanol production

The Bush Administration is committed to significantly expanding biofuels to reduce its dependence upon foreign oil. (The US imports 61% of the crude oil it consumes, at a cost of $75 billion per year.) Although a range of prospects for biofuels exists, ethanol derived from corn and soy currently constitutes 99% of all biofuel use in the US, and its production is expected to exceed 2012 targets of 7.5 billion gallons per year (Pimentel 2003). The amount of corn grown to produce ethanol in the distilleries has tripled in the US from 18 million tons in 2001 to 55 million in 2006 (Bravo 2006).

Dedicating all present U.S. corn and soybean production to biofuels would meet only 12% of the country's gasoline needs and 6% of diesel needs. Agricultural land area in the US totals 625,000 square acres. At present rates, meeting oil demand from biofuels would require 1.4 million square miles of corn for ethanol or 8.8 million square miles of soy for biodiesel (Korten 2006). South Dakota and Iowa already devote more than 50% of their corn to ethanol production, which has led to a diminishing supply of corn for animal feed and human consumption. Though one fifth of the US corn harvest was dedicated to ethanol production in 2006, it met only 3% of the US's total fuel needs (Bravo 2006).

The scale of production needed to yield the projected crop mass will encourage industrial methods of monoculture corn and soybean production with drastic environmental side effects. Corn production leads to more soil erosion than any other US crop. Farmers throughout the Midwest have abandoned crop rotations to grow corn and soy exclusively, increasing average soil erosion from 2.7 tons per acre annually to 19.7 tons (Pimentel et al 1995). Lack of crop rotation has also increased vulnerability to pests, and therefore necessitates higher inputs of pesticides than most crops (in the U.S., about 41% of all herbicides and 17% of all insecticides are applied to corn—(Pimentel and Lehman 1993)). Specialization in corn production can be dangerous: in the early 1970s when uniform high-yielding maize hybrids constituted 70% of all corn grown, a leaf blight that affected these hybrids led to a 15% loss in corn yields throughout the decade (Altieri 2004). . This sort of crop vulnerability can be expected to grow in our increasingly volatile climate, causing ripple effects throughout the food supply. We should be considering the implications of tying our energy economy to that same fluctuating and volatile food system. Corn cultivation generally involves use of the herbicide atrazine, a known endocrine disruptor. Low doses of endocrine disruptors can cause developmental harm by interfering with hormonal triggers at key points in the development of an organism. Studies show that atrazine can result in sexual abnormalities in frog populations, including hermaphrodism (Hayes et al 2002).

Corn requires large amounts of chemical nitrogen fertilizer, a major contributor to the ground and river water pollution responsible for the "dead zone" in the Gulf of Mexico. Median rates of nitrate application on US farmland range from 120 to 550 kg of N per hectare. Inefficient use of nitrogen fertilizers by crops leads to nitrogen-laden runoff, mostly in surface water or in groundwater. Aquifer contamination by nitrate is widespread and at dangerously high levels in many rural regions. In the U.S., it is estimated that more than 25% of drinking water wells contain nitrate levels above the 45 parts per million safety standard (Conway and Pretty, 1991). High nitrate levels are hazardous to human health, and studies have linked nitrate intake to metahemoglobinemia in children and gastric, and bladder and esophageal cancer in adults.

Expansion of corn into drier areas, such as Kansas, requires irrigation, increasing pressure on already depleted underground sources such as the Ogallala aquifer in the Southwestern US. In parts of Arizona, groundwater is already being pumped at a rate ten times the natural recharge rate of these aquifers (Pimentel et al 1997).

**--Soy for biodiesel**

In the US, soy is currently the main fuel crop for the production of biodiesel. Between 2004 and 2005 biodiesel consumption increased by 50%. About 67 new refineries are under construction with investments from agribusiness giants such as ADM and Cargill. About 1.5% of the soy harvest produces 68 million gallons of biodiesel, equivalent to less than .1%

of gasoline consumption. Therefore, if the entire soybean harvest were dedicated to biodiesel production, it would meet only 6% of the nation's diesel needs (Pimentel and Patzek 2005).

Most soy in the US is transgenic, engineered by Monsanto to resist their own herbicide, Roundup, made from the systemic chemical, Glyphosate, (30.3 million hectares of Roundup-Ready soy was grown in 2006, more than 70% of the domestic crop). Reliance on herbicide-resistant soy leads to an increase in problems with weed resistance and natural vegetation loss. Given industry pressure to increase herbicide usage, increasing amounts of land will be treated with Roundup. Glyphosate resistance has already been documented in Australian populations of annual ryegrass, quackgrass, birdsfoot trefoil and Cirsium arvense. In Iowa, populations of the weed Amaranthus rudis exhibited signs of delayed germination that enabled them to better adapt to earlier sprayings, the weed velvetleaf demonstrated glyphosate tolerance, and the presence of a Roundup-resistant strain of horseweed has been documented in Delaware. Even in areas where weed resistance has not been observed, scientists have noted increases in the presence of stronger weed species, such as Eastern Black Nightshade in Illinois and Water Hemp in Iowa (Certeira and Duke 2006, Altieri 2004).

Data does not presently exist on levels of Roundup residues in corn and soy, as grain products are not included in conventional market surveys for pesticide residues. Nevertheless, it is known that as Glyphosate is a systemic herbicide (applied on about 12 million acres of farmland in the U.S.) is carried into the harvested parts of plants, and is not readily metabolized thus accumulating in meristematic regions including roots and nodules (Duke et al 2003).

Further, information on the effects of this herbicide on soil quality is incomplete, yet research has demonstrated that glyphosate application are likely linked to the following effects (Motavalli et al 2004):

- A reduction in the ability of soybeans and clover to fix nitrogen by indirectly affecting symbiosis.
- A rendering of soy and wheat more vulnerable to disease, as evidenced by last year's increase in Fusarium wheat Head Blight in Canada.
- A decrease in the presence of soil microorganisms, which perform necessary regenerative functions including organic matter decomposition, nutrient release and cycling, and suppression of pathogenic organisms.
- Potential changes include altered soil microbial activity due to differences in the composition of root exudates, alteration of microbial populations, and toxicity in metabolic pathways that may prevent the normal growth of bacteria and fungi.

Glyphosate also has negative effects upon amphibian populations, especially that of the highly susceptible North American tadpole (Relyea 2005).

**Implications and impacts in Latin America**

**--Soybean**

The United States will not be able to produce sufficient biomass for biofuel domestically to satisfy its energy appetite. Instead, energy crops will be cultivated in the Global South. Large sugarcane, oil palm, and soy plantations are already supplanting forests and grasslands in Brazil, Argentina, Colombia, Ecuador, and Paraguay. Soy cultivation has already resulted in the deforestation of 21 million hectares of forests in Brazil, 14 million hectares in Argentina, two million hectares in Paraguay and 600,000 hectares in Bolivia. In response to global market pressure, Brazil alone will likely clear an additional 60 million hectares of land in the near future (Bravo 2006).

Since 1995, total land for soybean production in Brazil has increased 3.2 percent per year (320,000 hectares per year). Soybean today—along with sugar cane—occupies the largest area of any crop in Brazil at 21 percent of the total cultivated land. The total land used for soybean cultivation has increased by a factor of 57 since 1961, and the volume of production has multiplied 138 times. Fifty-five percent of the soy crop, or 11.4 million hectares, is genetically modified. In Paraguay, soybeans occupy more than 25 percent of all agricultural land. Extensive land clearing has accompanied this expansion: for example, much of Paraguay's Atlantic forest has been cleared, in part for the soy production that comprises 29% of the country's agricultural land use (Altieri and Pengue 2006).

Particularly high rates of erosion accompany soy production, especially in areas where long cycles of crop rotation are not implemented. Soil cover loss averages 16 tons per hectare of soy in the US Midwest. It is estimated that in Brazil and Argentina soil loss averages between 19-30 tons per hectare, depending on management practices, climate and incline. Herbicide tolerant soy varieties have increased the feasibility of soy production for farmers, many of whom have begun cultivation on fragile lands prone to erosion (Jason 2004).

In Argentina, intensive soybean cultivation has led to massive soil nutrient depletion. It is estimated that continuous soybean production has resulted in the loss of one million metric tons of nitrogen and 227,000 metric tons of phosphorous from soils nationwide. The cost of replenishing this nutrient loss with fertilizers is estimated U.S. $910 million. Increases in nitrogen and phosphorus in several river basins of Latin America is certainly linked to the increase in soy production (Pengue 2005).

Monocultural production of soy in the Amazon Basin has rendered much of the soil infertile. Poor soils necessitate increased application of industrial fertilizers for competitive levels of productivity. In Bolivia, soybean production is expanding eastward, and areas in the east already suffer from compacted and degraded soils. One hundred thousand hectares of depleted former soy-growing lands have been abandoned to cattle-grazing, which leads to further degradation (Fearnside 2001). Biofuels are initiating a new cycle of expansion and devastation in the Cerrado and Amazon regions. As Latin American countries increase their investment in soy cultivation for biofuel production, the associated ecological implications can be expected to intensify.

**--Sugarcane for ethanol in Brazil**

Brazil has produced sugar for ethanol fuel since 1975. As of 2005, there were 313 ethanol processing plants with a production capacity of 16 million cubic meters. Brazil is the largest producer of sugarcane in the world, and produces 60% of the world's total sugar ethanol with cane grown on 3 million hectares (Jason 2004). In 2005, production reached a record 16.5 billion liters, of which two billion were slated for export. Monocultures of sugarcane alone account for 13% of the nation's herbicide application. Studies conducted in 2002 by EMBRAPA (The Brazilian Agricultural Research Corporation) confirmed the presence of water contamination linked to pesticide use in the Guarani Aquifer, attributable primarily to cane growth in the State of Sao Paulo.

The US is the largest importer of Brazilian ethanol, importing 58% of the nation's total produced ethanol in 2006. This trade relation was reinforced by the Bush administration's recent ethanol agreement with Brazil. Far from good news for Brazil, if the renewable fuel standards for ethanol proposed by the Bush administration were to be met by Brazilian sugarcane, Brazil would need to increase its production by an additional 135 billion liters per year. The planted area is rapidly expanding in the Cerrado region, whose natural vegetation cover is expected to have disappeared by 2030. Sixty percent of sugar-growing lands are managed by 340 large distilleries that control more than 60% of the sugarcane acreage (Bravo 2006).

Given the new global energy context, Brazilian politicians and industry officials are formulating a new vision for the economic future of the country, centered on production of energy sources to displace 10% of world gasoline use in the next 20 years. This would require a five-fold increase in the land area devoted to sugar production, from six to 30 million hectares. New cultivation will lead to land clearing in new areas that will likely face deforestation comparable to that in the Pernambuco region, where only 2.5% of the original forest cover remains (Fearnside 2001).

**Energy efficiency and economic implications**

Ethanol production is extremely energy intensive. To produce 10.6 billion liters of ethanol, the U.S. uses about 3.3 million hectares of land, which in turn requires massive energy inputs to fertilize, weed and harvest the corn (Pimentel 2003). These 10.6 billion liters of ethanol only provide 2% of the gasoline utilized by cars in the U.S. per year.

Despite the studies of Shapouri et al (2004) from the USDA that report a net energy positive return for ethanol production, Pimentel and Patzek (2005), utilizing data from all 50 states and accounting for all energy inputs ( including farm machinery manufacture and repair and fermentation-distillation equipment) conclude that ethanol production does not provide a net energy benefit. Rather, they claim it requires more fossil energy to produce than it produces. In their calculations, corn ethanol production requires 1.29 gallons of fossil fuels per gallon of ethanol produced, and soy biodiesel production requires 1.27 gallons of fossil energy per gallon of diesel produced. In addition, because of the relatively low energy density of ethanol, approximately three gallons of ethanol are needed to displace two gallons of gasoline.

American ethanol production has benefited from $3 billion in federal and state subsidies annually ($0.54 per gallon), most of which accrues to agribusiness giants. In 1978 the US introduced a tax on ethanol, but made an exception of 54 cents per gallon for that used for gasohol (gasoline with 10% ethanol). This resulted in subsidies to Archer Daniels Midland of 10 billion dollars from 1980 to 1997 (Bravo 2006). In 2003 more than 50% of the ethanol refineries in the US were farmer owned. By 2006, 80% of new refineries were absentee owned, with US $556 million in projected earnings benefiting the largest producers. By 2007 the figure is expected to reach U.S. $1.3 billion.

**Food security and the fate of farmers**

Proponents of biotechnology champion the expansion of soybean cultivation as a measure of the successful adoption of the transgenic technology by farmers. But this data conceals the fact that soybean expansion leads to extreme land and income concentration. In Brazil, soybean cultivation displaces eleven agricultural workers for every new worker it employs.

This is not a new phenomenon. In the 1970s, 2.5 million people were displaced by soybean production in Parana, and 300,000 were displaced in Rio Grande do Sul. Many of these now landless people moved to the Amazon where they cleared pristine forests. In the Cerrado region, where transgenic soybean production is expanding, displacement has been relatively modest because the area is not densely populated (Altieri and Pengue 2006).

In Argentina, 60,000 farms foreclosed while area planted to Roundup Ready soy nearly tripled. In 1998, there were 422,000 farms in Argentina while in 2002 there were only 318,000, a reduction of a quarter. In one decade, soybean area increased 126 percent at the expense of dairy, maize, wheat and fruit production. In the 2003/2004 growing season, 13.7 million hectares of soybean were planted, but there was a reduction of 2.9 million hectares in maize and 2.15 million hectares in sunflowers. For the biotech industry, huge increases in the soybean area cultivated and a doubling of yields per unit area are an economic and agronomic success. For the country, this means more imports of basic foods, therefore loss of food sovereignty, increased food prices and hunger (Pengue 2005).

The advancement of the “agricultural frontier” for biofuels is an attempt against the food sovereignty of developing nations as land for food production is increasingly being devoted to feed the cars of people in the North. Biofuel production also affects consumers directly by increasing the cost of food. Due to the fact that more than 70% of the corn grain in the US is used for feedstock, doubling or tripling ethanol production can be expected to increase corn prices, and as a consequence, the price of meat. Demand for biofuels in the US has been linked to a massive rise in the price of corn which led to a recent 400% increase in tortilla prices in Mexico.

**Climate change**

One of the main arguments of biofuel advocates is that these new forms of energy will help mitigate climate change. By promoting large-scale mechanized monocultures that require agrochemical inputs and machinery, an overall increase in CO2 emissions is more likely to be the end result. As carbon-capturing forests are felled to make way for biofuel crops, CO2 emissions will increase, not decrease (Bravo 2006, Donald 2004).

As countries in the Global South enter biofuel production, the plan is to export much of their production. Transport to other countries will greatly raise fuel use and gas emissions. Moreover, turning plant biomass into liquid fuels at the refineries produces immense quantities of greenhouse gas emissions (Pimentel and Patzek 2005).

Global climate change is not going to be remedied by the use of industrial biofuels. There will need to be a fundamental shift in consumption patterns in the Global North The only way to stop global warming is to transition away from large-scale, industrial farming to small-scale and organic agriculture, and to decrease worldwide fuel consumption through conservation.

**Conclusions**

The energy crisis—driven by over-consumption and peak oil—has provided an opportunity for powerful global partnerships between petroleum, grain, genetic engineering, and automotive corporations. These new food and fuel alliances are deciding the future of the world’s agricultural landscapes. The biofuels boom will further consolidate their hold over our food and fuel systems and allow them to determine what, how and how much will be grown, resulting in more rural poverty, environmental destruction and hunger. The ultimate beneficiaries of the biofuel revolution will be grain merchant giants, including Cargill, ADM and Bunge; petroleum companies such as BP, Shell, Chevron, Neste Oil, Repsol and Total; car companies such as General Motors, Volkswagen AG, FMC-Ford France, PSA Peugeot-Citroen and Renault; and biotech giants such as Monsanto, DuPont, and Syngenta.

The biotech industry is using the current biofuel fever to greenwash its image by developing and deploying transgenic seeds for energy, not food production. Given the increasing public mistrust for and rejection of transgenic crops as food, biotechnology will be used by corporations to improve their image claiming that they will develop new genetically modified crops with enhanced biomass production or that contain the enzyme alfa-amilase which will allow the ethanol process to begin while the corn is still in the field—a technology they claim has no negative impacts on human health. The deployment of such crops into the environment will add one more environmental threat to those already linked to GMO corn which in 2006 reached 32.2 million hectares: the introduction of new traits into the human food chain as has already occurred with Starlink corn and rice LL601.

As governments are persuaded by the promises of the global biofuel market, they devise national biofuel plans that will lock their agro-systems into production based on large scale, fuel monocultures, dependent upon intensive use of herbicides and chemical fertilizers, thus diverting millions of hectares of valuable cropland from much needed food production. There is a great need for social analysis to anticipate the food security and environmental implications of the unfolding biofuel plans of small countries such as Ecuador. This country expects to expand sugarcane production by 50,000 hectares, and to clear 100,000 hectares of natural forests to give way to oil palm plantations. Oil palm plantations are already causing major environmental disaster in the Choco region of Colombia (Bravo 2006).

Clearly, the ecosystems of areas in which biofuel crops are being produced are being rapidly degraded, and biofuel production is neither environmentally and socially sustainable now nor in the future.

It is also worrisome that public universities and research systems (i.e. the recent agreement signed by BP and the University of California-Berkeley) are falling prey to the seduction of big money and the influence of politics and corporate power. In addition to the implications of the intrusion of private capital on the shaping of the research agenda and faculty composition—that erodes the public mission of universities in favor of private interests—it serves as an attack against academic freedom and faculty governance. These partnerships divert universities from engaging in unbiased research and preclude intellectual capital from exploring truly sustainable alternatives to the energy crisis and climate change.

There is no doubt that the conglomeration of the petroleum and biotech capital will increasingly decide the fate of the rural landscapes of the Americas. Only strategic alliances and coordinated action of social movements (farmers organizations, environmental and farm labor movements, NGOs, consumer lobbies, committed members of the academic sector, etc) can put pressure on governments and multinational companies to ensure that these trends are halted. More importantly, we need to work together to ensure that all countries retain the right to achieve food sovereignty via agroecologically-based, local food production systems, land reform, access to water, seeds and other resources and domestic farm and food policies that respond to the true needs of farmers and all consumers, especially the poor.

## References


Altieri, M.A. and W. Pengue 2006, GM soybean: Latin America's new colonizer. Seedling January issue.

Altieri, M.A. 2000, The ecological impacts of transgenic crops on agroecosystem health. Ecosystem Health 6: 19-31

Altieri, M.A. 2004, Genetic engineering in agriculture: the myths, environmental risks and alternatives, Food First Books, Oakland.

Bravo, E. 2006, Biocombustibles, cutlivos energeticos y soberania alimentaria: encendiendo el debate sobre biocommustibles. Accion Ecologica, Quito, Ecuador.

Certeira, A.L. and S.O. Duke 2006, The current status and environmental impacts of Glyphosate-resistant crops. J. Environ.Qual 35: 1633-1658

Conway, G.R. and J.N. Pretty 1991, Unwelcome harvest: agriculture and pollution. Earthscan publications, London

Donald, P.F. 2004, Biodiversity impacts of some agricultural commodity production systems. Conservation Biology 18:17-37.

Duke, S.O., Baerson, S.R., Rimando, A.M. 2003, Herbicides: Glyphosate. Available from: HTTP://WWW.MRW.INTERSCIENCE.WILEY.COM/EOA/ARTICLES/AGR119/FRAME.HTML. Encyclopedia of Agrochemicals.

Fearnside, P.M. 2001, "Soybean cultivation as a threat to the environment in Brazil", Environmental Conservation 28: 23-28.

Hayes, TB, A Collins, M Lee, M Mendoza, N Noriega, AA Stuart, and A Vonk. 2002, Hermaphroditic, demasculinized frogs after exposure to the herbicide, atrazine, at low ecologically relevant doses. Proceedings of the National Academy of Sciences (US) 99:5476-5480.

James, C. 2006, Global review of commercialised transgenic crops: 2006. International Service for the Acquisition of Agri-Biotech Application Briefs, No 23-2002. Ithaca, New York.

Jason, C. 2004, World agriculture and the Environment. Island Press. Washington.

Motavalli, P.P. et al 2004, Impacts og genetically modified crops and their management on soil micribially mediated plant nutrient transformations. J. Environ. Qual 33: 816-824.

Pengue, W 2005, Transgenic crops in Argentina: the ecological and social debt. Bulletin of Science, Technology and Society 25: 314-322.

Pimentel, D and H. Lehman 1993, The pesticide question. Chapman and Hall, New York

Pimentel, D. 2003, Ethanol fuels: energy balance, economics and environmental impacts are negative. Natural Resources Research 12: 127-134

Pimentel, D. et al 1997, Water resources: agriculture, environment and society. BioScience 47: 97-106

Pimentel. D. et al 1995, Environmental and economic costs of soil erosion and conservation benefits. Science 276: 1117-1123

Pimentel, D and T.W. Patzek 2005, Ethanol production using corn, switchgrass, and wood; biodiesel production using soybean and sunflower. Natural Resources Research 14: 65-76

Relyea, R.A. 2005, The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities, Ecological Applications 15 : 618-627

Shapouri, H. et al 2004, The 2001 net energy balance of corn ethanol. USDA, Washington DC.