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The Ecological Impacts of Large-Scale Agrofuel Monoculture Production Systems in the Americas

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This article examines the expansion of agrofuels in the Americas and the ecological impacts associated with the technologies used in the production of large-scale monocultures of corn and soybeans. In addition to deforestation and displacement of lands devoted to food crops due to expansion of agrofuels, the massive use of transgenic crops and agrochemical inputs, mainly fertilizers and herbicides used in the production of agrofuels, pose grave environmental problems.

Keywords: *biofuels; monoculture; deforestation; ecological impacts*

Agrofuels are being promoted as a promising alternative to petroleum by several corporations, some governments, scientific institutions, and a few environmental organizations claiming that they will serve as an alternative to peaking oil, mitigate climate change by reducing greenhouse gas emissions, enhance farmer incomes, and promote rural development (Demirbas, 2009). But rigorous research and analysis conducted by respected ecologists and social scientists suggest that the large-scale industrial boom in agrofuels is already proving to be disastrous for small-medium farmers, the environment, biodiversity, and consumers, particularly the poor (Bravo, 2006).

In this article, the ecological implications of agrofuel production systems are addressed, arguing that contrary to the false claims of corporations that promote these “green fuels,” the massive cultivation of corn, sugarcane, soybean, oil palm, and other crops presently pushed by the fuel crops industry—many 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 deforestation and deepen the ecological footprint of the industrial agriculture model bringing a variety of new economic, environmental, and social problems. The unprecedented consolidation and power of a series of corporations, which take advantage of weak national policies that favor agrofuel expansion, have set in motion the expansion of a specialized production system based on large farms with crop monocultures managed with high levels of external agrochemical inputs, in particular herbicides and nitrogenous fertilizers, which when massively applied poses grave environmental consequences (Altieri & Bravo, 2007). In regions already under water stress, agrofuel production may further decrease the future availability of water for irrigation and other development options (Shattuck, 2008).

Agrofuels are being introduced into a world run largely on neoliberal policies with trade rules that have a strong bias against regulation and any “trade restrictions” to protect the environment, the climate, or communities. Which crops are grown, how much, how and where is, by and large, determined by a market that favours the cheapest agrofuels, that is, higher yield tropical plants such as palm oil and sugarcane. Lower yield crops can capture the market if costs are kept low and governments guarantee an unlimited supply of new land and subsidies—soy biodiesel and corn ethanol being prime examples (Shapouri & McAloon, 2004). Forests, biodiversity, healthy soil and clean water, and greenhouse gas emissions remain “externalities” in the accounts, which inevitably are being sacrificed for real quick profits. Despite the fact that in some countries, such as Argentina, Brazil, and the United States, the agrofuel production model appears successful at the

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macroeconomic level, environmental impacts associated with agrofuel production accrue at alarming rates and are not reflected in the economic indicators. So far there is no clear system to account for the environmental costs of these new development models.

Agrofuels: Extent, Expansion, and Production Levels

While the United States, Brazil, and the European Union accounted for 75% of global biofuel production in 2006, it is spreading rapidly to other parts of the world, reaching about 3% of the global agricultural area harvested in 2005, which was about 850 million hectares (Scharlemann & Laurance, 2008).

The global area cultivated with transgenic crops reached 114.3 million hectares in 2007, with much of the transgenic corn and soybean being used for biofuel production. Of the global area, 57% (58.6 million hectares) is devoted to Roundup Ready (RR) soybean. In Brazil alone, about 750,000 ha of RR soybean were used in 2007 for biodiesel production. In Argentina in 2007/2008, 16.0 million hectares were used to cultivate biotech soybean and 2.8 million hectares were used to cultivate transgenic corn (James, 2007). Researchers are genetically engineering sugarcane and corn varieties that contain the enzyme alfa-amilase, which would facilitate the elaboration of ethanol.

Ethanol Production

There has been exponential growth in the biofuel sector since 2000. Between 2004 and 2005 alone, global ethanol production went up nearly 13% from 10.77 billion gallons to 12.15 billion gallons; between 2005 and 2006 there was a further increase of 11% to 13.49 billion gallons. Ethanol derived from corn constitutes 99% of all biofuel use in the United States, 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 United States from 18 million tons in 2001 to 55 million tons in 2006 (Bravo, 2006). Corn acreage in the United States went up from 78 million acres in 2006 to 92 million acres in 2007.

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 2 billion liters were slated for export.

Dedicating all present U.S. corn and soybean production to biofuels would meet only 12% of the country's gasoline needs. Agricultural land area in the United States totals 625,000 square acres. At present rates, meeting oil demand from biofuels would require 1.4 million square miles of corn for ethanol. 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 U.S. corn harvest was dedicated to ethanol production in 2006, it met only 3% of the U.S.'s total fuel needs (Pimentel & Patzek, 2005).

Biodiesel

Biofuel production has also being expanding. By 2006, biodiesel accounted for 12.35%of the global biofuel production, that is, 15.39 billion gallons. The major biodiesel-producing countries (accounting for at least 10% of global land area under agrofuel cultivation) are China, India, and Canada for rapeseed; the Russian Federation, Ukraine, and India for sunflower seed; Malaysia, Indonesia, Colombia, and Nigeria for oil palm; and the United States, Brazil, Argentina, and China for soybean. Currently, more than 95% of biodiesel feedstock is supplied by rapeseed (84%), sunflower seed (13%), oil palm (1%), and soybean (1%). Even if half the agricultural output of these major feedstocks were committed to biodiesel production, the current global land area under biodiesel crops (150.6 million hectares)—with an effective biodiesel production capacity of 120 million tons/year—would still be approximately 60% (156.7 million tons/year) short of the capacity required for 2050 (Pahl, 2008).

In the United States, biodiesel production tripled from 25 million gallons in 2004 to 75 million gallons in 2005. In 2006, the United States produced 250 million gallons of biodiesel, a 10-fold increase from 2004. 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 0.1% 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; about 8.8 million square miles of soy would be required for self-sufficiency in biodiesel (Pimentel & Patzek, 2005). Because the United States will not be able to produce sufficient biomass for biofuel domestically to satisfy its energy appetite, energy crops are increasingly being cultivated in the Global South. Large sugarcane, oil palm, and soy plantations are already supplanting forests, grasslands, and food crops in Brazil, Argentina, Colombia, Ecuador, and Paraguay.

Ecological Impacts of the Agrofuel Production Model

Deforestation and Habitat Loss

Increases in demand for biofuels in the United States and the European Union have a profound impact on the pattern of global agricultural production and land use, placing considerable pressure on forest lands throughout the developing world. Increasing the production of agrofuels to fulfill the energy requirements of industrial countries entails a substantial increase in the expansion of cultivation of agrofuel crops, which will lead to potential land-use conflicts, in particular with the need to preserve the world's remaining natural habitats (Donald, 2004). Conservative estimates suggest that, using the crops with the highest net energy values, a minimum of 2.5 to 27.5 times the global potential arable land would be required to produce enough biofuels to meet global fossil fuel demands. Obviously this could dramatically alter the environment by increasing habitat loss and fragmentation, decreasing biodiversity, and negatively impacting soil and water quality and availability (Jason, 2004).

Conservative calculations suggest that the scenario of soybean-based biodiesel production to meet future global biodiesel demand would likely result in the highest amount of habitat loss (76.4-114.2 million hectares) compared with alternative scenarios of biodiesel production from sunflower seed (56.0-61.1 million hectares), rapeseed (25.9-34.9 million hectares), and oil palm (0.4-5.4 million hectares). Brazil is a good example, where total land for soybean production increased 3.2% per year (320,000 ha per year). Soybean today—along with sugarcane—occupies the largest area of any crop in Brazil at 21% 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. Brazil would need to increase its production by an additional 135 billion liters per year, and agrofuel-based agriculture is expected to expand into forest lands (Morton et al., 2006). The planted area is rapidly expanding in the Cerrado region, whose natural vegetation cover is expected to have disappeared by 2030. Sixty percent of sugarcane-growing lands are managed by 340 large distilleries that control more than 60% of the sugarcane acreage (Klink & Machado, 2005).

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 (mainly sugarcane) to displace 10% of world gasoline use in the next 20 years. This would require a fivefold increase in the land area devoted to sugar production, from 6 to 30 million hectares. New cultivation will lead to land clearing in new areas that will likely face deforestation comparable with that in the Pernambuco region, where only 2.5% of the original forest cover remains (Fearnside, 2001). In Paraguay, soybeans occupy more than 25% 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 & Pengue, 2006).

In the past 9 years, according to official figures, 2.5 million hectares of native forests have been lost, especially in northern Argentina, due to the expansion of soybean, an equivalent in 2007, of an average 821 ha of forest lost per day. Between 1972 and 2001, 588,900 ha (approximately 20% of the forests) were deforested in the semiarid of Chaco. Deforestation has been accelerating, reaching >28,000 ha/year after 1997. The initial deforestation was associated with black bean cultivation following an increase in rainfall during the 1970s. In the 1980s, high soybean prices stimulated further deforestation. Finally, the introduction of soybean transgenic cultivars in 1997 reduced plantation costs and stimulated a further increase in deforestation, reaching levels of more than 300,000 ha (Grau, Gasparrin, & Mitchell., 2005).

The Ecological Footprint of Corn

The scale of production needed to yield the projected crop mass for ethanol encourages industrial methods of monoculture corn production, which rely on heavy use of herbicides and chemical nitrogenous fertilizers, with drastic environmental side effects. Corn production leads to more soil erosion than any other U.S. crop. As ethanol use pushes corn prices higher, farmers are increasingly abandoning the traditional corn-soybean, encouraging farmers to plant corn year after year, an intensification that boosts soil erosion but also fertilizer and pesticide requirements (Pimentel et al., 1995).

Throughout the Midwest, average soil erosion increased from 2.7 tons per acre annually to 19.7 tons in lands that abandoned crop rotations (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 United States, about 41% of all herbicides and 17% of all insecticides are applied to corn; Pimentel & 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. This sort of crop vulnerability can be expected to grow in our increasingly volatile climate, causing ripple effects throughout the food supply (Cassman, 2007).

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 nitrogenous fertilizer, which leads to pollution of surface and groundwater. Fertilizer runoff that travels down the Mississippi River has depleted oxygen from a portion of the Gulf of Mexico called the dead zone that in the past few years reached the size of New Jersey. Median rates of nitrate application on U.S. farmland range from 120 to 550 kg of nitrogen 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 United States, it is estimated that more than 25% of drinking water wells contain nitrate levels above the 45 parts per million safety standard (Conway & 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 cancers in adults (Altieri, 2007).

Synthetic nitrogen fertilizers can also become air pollutants and have recently been implicated in contributing to global warming and the destruction of the ozone layer. N_2O is released to the atmosphere through nitrogen fertilizer application and has nearly 300 times the global warming potential of the same mass of CO_2. For rapeseed biodiesel, available analysis indicates that the global warming by N_2O is on average about 1.0 to 1.7 times larger than the cooling effect due to "saved fossil CO_2" emission, excluding the fossil energy input (Searchinger et al., 2008).

The excessive use of chemical nitrogenous fertlizers can lead to nutritional imbalances in plants, resulting in a higher incidence of damage from insect pests and diseases (Conway & Pretty, 1991; McGuiness, 1993). In reviewing 50 years of research relating to crop nutrition and insect attack, Scriber (1984) found 135 studies showing increased damage and/or growth of leaf-chewing insects or mites in nitrogen-fertilized crops, versus fewer than 50 studies in which herbivore damage was reduced by normal fertilization regimens. In aggregate, these results suggest a hypothesis with implications for fertilizer use patterns in agriculture, namely, that high nitogen inputs can precipitate high levels of herbivore damage in crops.

The ethanol boom has sent water demands skyrocketing. 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 United States. In parts of Arizona, groundwater is already being pumped at a rate 10 times the natural recharge rate of these aquifers (Pimentel, Tariche, Schreck, & Alpert, 1997).

Environmental Impacts of Soybean Cultivation

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 U.S. Midwest. It is estimated that in Brazil and Argentina soil loss averages between 19 and 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 1 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 US$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).

Most soy in the United States is transgenic, engineered by Monsanto to resist their own herbicide, Roundup, made from the systemic chemical, glyphosate (30.3 million hectares of RR soy was grown in 2006, more than 70% of the domestic crop). In Brazil, 14.5 million hectares were planted to RR soybean in 2007 (James, 2007). 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 RR. 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 RR-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 (Cerdeira & Duke, 2006). Glyphosate-resistant crops have greater potential to become problems as volunteer crops than do conventional crops. Glyphosate-resistant transgenes have been found in fields of canola that are supposed to be nontransgenic. Under some circumstances, the largest risk of glyphosate-resistant crops may be transgene flow (introgression) from glyphosate-resistant crops to related species that might become problems in natural ecosystems. Glyphosate resistance transgenes themselves are highly unlikely to be a risk in wild plant populations, but when linked to transgenes that may impart fitness benefits outside of agriculture (e.g., insect resistance), natural ecosystems could be affected (Rissler & Mellon, 1996).

In the Argentinian Pampas, the application of glyphosate to GMO soyben fields increased from 1,000,000 to 160,000,000 liters in 8 years. Continual application of this herbicide has caused the appearance of glyphosate-tolerant weeds: *Parietaria debilis*, *Petunia axilaris*, *Verbena litoralis*, *Verbena bonariensis*, *Hybanthus parviflorus*, *Iresine diffusa*, *Commelina erecta*, and *Ipomoea* sp. The appearance of resistance implies a further increase in use of herbicides including combinations of glyphosate with other herbicides, reestablishing the use of the old herbicide 2,4-D (Pengue, 2005).

Data do 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 United States), it is carried into the harvested parts of plants and is not readily metabolized, thus accumulating in meristematic regions including roots and nodules (Duke, Baerson, & Rimando, 2003).

Furthermore, information on the biological effects of this herbicide on soil is incomplete, yet research has demonstrated that glyphosate applications are likely linked to the following effects (Buffin & Topsy, 2001, Cerdeira & Duke, 2006; Motavalli, Kremer, Fang, & Means, 2004):

1. Experimental research suggests that some important beneficial soil bacteria and fungi, including nitrogen-fixing bacteria and fungi responsible for breaking down organic matter, are affected by glyphosate. Some studies have shown that the impacts of glyphosate treatment can last for several months. This suggests glyphosate can remain active and may be released from soil and taken up by soil organisms.
2. In addition to affecting nitrogen-fixing bacteria, glyphosate has been found to inhibit mycorrhizal fungi that help plants absorb nutrients and help protect from cold or drought. The formation of nitrogen-fixing nodules on clover roots was inhibited at levels of between 2 and 2,000 mg/kg glyphosate. The effect persisted 120 days after treatment. 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, can drastically affect soil fertility and crop growth.
3. Glyphosate has also been found to adversely affect earthworms. A study in New Zealand

found that repeated biweekly applications of low rates of glyphosate (1/20 of typical rates) caused a reduction in growth, an increase in time to maturity, and an increase in mortality of the most common earthworm found in agricultural soils.

4. Glyphosate and its commercial formulations have been found to have direct toxicity effects and indirect habitat impacts on both test and field populations of beneficial insects, mites, and spiders. A study found that exposure to glyphosate killed more than 80% of a test population of predatory beetle and 50% of parasitoid wasp, lacewing, ladybird, and predatory mite. A study of winter wheat fields in North Carolina found that populations of large carabid beetles declined after treatment with a glyphosate formulation and did not recover for 28 days. As early as the 1970s, the decrease in numbers of predatory arthropods and weed density following the use of herbicides was suggested as a cause for the increased frequency of cereal aphid outbreaks in treated fields.
5. Applications of glyphosate can render certain crops more vulnerable to disease. Glyphosate increased the pathogenicity and survival of a disease causing fungi, *Gaemannomyces gramminis*. The fungus causes "take-all disease" in wheat crops. In addition, the proportion of soil fungi that was antagonistic to the take-all fungus decreased. Glyphosate increased the susceptibility of bean plants to the parasitic disease anthracnose. Also, it was found that spraying Roundup prior to planting barley increased *Rhizoctonia* root rot disease in the crop and decreased its yield.
6. While it may be intended for terrestrial use, glyphosate can contaminate surface water either directly as a result of aquatic weed control or indirectly when glyphosate bound to soil particles is washed into rivers or streams or Roundup gets into aquatic habitats, through inadvertent (or unavoidable) aerial overspray. Glyphosate, which contains the surfactant polyethoxylated tallowamine, is toxic to fish and to some aquatic invertebrates. Polyethoxylated tallowamine is about 30 times more toxic to fish than glyphosate.

Studies have shown that the acute toxicity of glyphosate varies according to species and age of fish and under different environmental conditions, such as water hardness, pH, and temperature. A study in Louisiana tested the effect of sublethal concentrations of glyphosate on an aquatic snail species, *Pseudosuccinea columella*. The study found that low levels of glyphosate adversely affect snail reproduction and development (Buffin & Topsy, 2001). Relyea (2005) found that Roundup caused a 70% decline in amphibian biodiversity and an 86% decline in the total mass of tadpoles. Leopard frog tadpoles and gray tree frog tadpoles were completely eliminated, and wood frog tadpoles and toad tadpoles were nearly eliminated.

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 these data conceals the fact that soybean expansion leads to extreme land and income concentration. In Brazil, soybean cultivation displaces 11 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 & Pengue, 2006).

In Argentina, 60,000 farms foreclosed while the area planted to RR 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% 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. In the northeastern province of Chaco, where cotton was the traditional crop, the encroachment of soy reduced the rural population from 40% to 20%. For the country, this means more imports of basic foods, therefore loss of food sovereignty, increased food prices, and hunger, especially in the northeastern region, where soy is king, and where 37% of the people are below the poverty line, unable to feed themselves properly (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. Soon the price of corn, soybean, and sugarcane will be determined by their value as feedstock for biofuel rather than their importance as human food or livestock feed. Large-scale farmers in countries that account for a majority of the world's biofuel crop production will enjoy the promise of markedly higher commodity prices and incomes. In contrast, urban and rural poor in food-importing countries will pay much higher prices for basic food staples and there will be less grain available for humanitarian aid (Shattuck, 2008).

As more corn is planted, it displaces wheat and soybeans, increasing their market prices. Because U.S. corn accounts for some 40% of global production, U.S. agrofuel expansion affects global markets for all food grains and exacerbates food price inflation worldwide. In the United States, the ethanol boom has led to a rapid run-up in corn and other commodity prices in 2006-2007, as land has been diverted from other crops to corn, in particular soybeans. In a year's time the price of corn went from $2.20/bu ($87/mt) to $3.50/bu ($138/mt) or higher—an increase of 60%. Food prices have increased but not in like proportion to the price of biofuels as other factors are involved in food price hikes. Poultry meat and eggs are facing the largest shock as corn constitutes about two thirds of the poultry ration. As a consequence, the total cost of producing poultry meat and eggs has increased by about 15%, passing the cost increase on to consumers. Depending on the source, recent estimates put the consumer food bill increase to date, due to corn ethanol, between 1.5% and 25%; whatever the correct figure, overall U.S. consumers paid about $22 billion more for food in 2007 due to biofuels. Demand for biofuels in the United States was also linked to a massive rise in the price of corn, which led to a recent 400% increase in tortilla prices in Mexico (Holt-Gimenez & Peabody, 2008).

Conclusions

Peak oil has provided an opportunity for the creation of 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 the 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 losers are small-medium farmers, consumers, and the environment.

Today, agrofuel crop monocultures are increasing at dramatic rates worldwide, mainly through a geographical expansion at the expense of forests with loss of natural habitats and displacement of areas devoted to food crops, threatening the food security of whole regions. The technologies that facilitate this shift toward these large-scale monocultures are mechanization, the improvement of crop varieties via genetic engineering, and the application of massive amounts of chemical fertilizers and herbicides. Corporate investment and the biofuel seduction of governments have been key in the encouragement of agrofuel expansion. Clearly, the ecosystems of areas in which biofuel crops are being produced are being rapidly degraded, not only due to deforestation but also due to the ecological impacts associated with the crop production technologies (nitrogenous fertilizers, herbicides, and transgenic crops). For these and other reasons, agroefuel production is neither environmentally nor socially sustainable now or in the future.

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 or the environment. 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 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 monocultures, dependent on the 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 and ecological 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 ha, and to clear 100,000 ha 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).

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 important, 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.

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