In Latin America, the frontiers to soybean production are being pushed back aggressively in all directions at a breathtaking rate. Driven by export pressures and supported by government incentives, soybean fields are taking over forests and savannah in an unprecedented manner. The implications of the monoculture model and its supporting machinery for the environment, farmers and communities are discussed below.

GM soybean: Latin America's new coloniser

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In 2005, the biotech industry and its allies celebrated the tenth consecutive year of expansion of genetically modified (GM) crops. The estimated global area of approved GM crops was 90 million hectares, a growth of 11% over the previous year (see map on p14). In 21 countries, they claim, GM crops have met the expectations of millions of large and small farmers in both industrialised and developing countries; delivering benefits to consumers and society at large through more affordable food, feed and fiber that are more environmentally sustainable.[1]

It is hard to imagine how such expansion in GM crops has met the needs of small farmers or consumers when 60% of the global area of GM crops is devoted to herbicide-tolerant crops. In developing countries, GM crops are mostly grown for export by big farmers, not for local consumption. They are used as animal feed to produce meat consumed mostly by the wealthy.

The Latin America countries growing soybean include Argentina, Brazil, Bolivia, Paraguay and Uruguay. The expansion of soybean production is driven by prices, government and agro-industrial support, and demand from importing countries, especially China, which is the world's largest importer of soybean and soybean products. Brazil and Argentina experienced the biggest growth rates in GM soybean expansion in 2005.[2] The expansion is accompanied by massive transportation infrastructure projects that destroy natural habitats over wide areas, well beyond the deforestation directly caused by soybean cultivation. In Brazil, soybean profits justified the improvement or construction of eight industrial waterways, three railway lines and an extensive network of roads to bring inputs and take away produce. These have attracted private investment in logging, mining, ranching and other practices that severely impact on biodiversity that have not been included in any impact assessment studies.[3]

[1] Clive James (2005), *Global review of commercialised transgenic crops: 2005.* International Service for the Acquisition of Agri-Biotech Application Briefs, No 23-2002. Ithaca , New York.

[2] *Ibid.*

[3] PM Fearnside (2001), "Soybean cultivation as a threat to the environment in Brazil", *Environmental Conservation* 28: 23-28.

In Argentina, the agro-industry for transforming soybean into oils and pellets is concentrated in the Rosario region on the Parana river. This area has become the largest soy-processing estate in the world, with all the infrastructure and the environmental impact that entails. Spurred on by the export market, the Argentinean government plans further expansion of the soybean industry, adding another 4 million hectares to the existing 14 million hectares of soy production by 2010.[4]

Soybean deforestation

The area of land in soybean production in Brazil has grown on average at 3.2% or 320,000 hectares per year since 1995, resulting in a total increase of 2.3 million hectares. Today soybean occupies the largest area of any crop, covering 21% of the cultivated land. The area has increased by a factor of 57 since 1961, and production volume by a factor of 138. In Paraguay, soybeans occupy more than 25% of all agricultural land. All this expansion is at the expense of forests and other habitats. In Argentina, where 5.6 million hectares of non-agricultural land has been converted to soya production in less than ten years, forest conversion rates are three to six times the global average. In Paraguay, much of the Atlantic forest has been cut.[5] In Brazil, the *cerrado* (woodland-savanna) and the grasslands are rapidly falling victim to the plow.

Forcing small farmers out

Biotech promoters always claim the expansion of soybean cultivation as a measure of the successful adoption of the transgenic technology by farmers. But these data conceal the fact that soybean expansion leads to extreme land and income concentration. In Brazil, soybean cultivation displaces 11 agricultural workers for every one who finds employment in the sector. This is not a new phenomenon. In the 1970s, 2.5 million people were displaced by soybean production in Parana, and 0.3 million 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 is expanding, there is relatively low displacement because the area is not widely populated.[6]

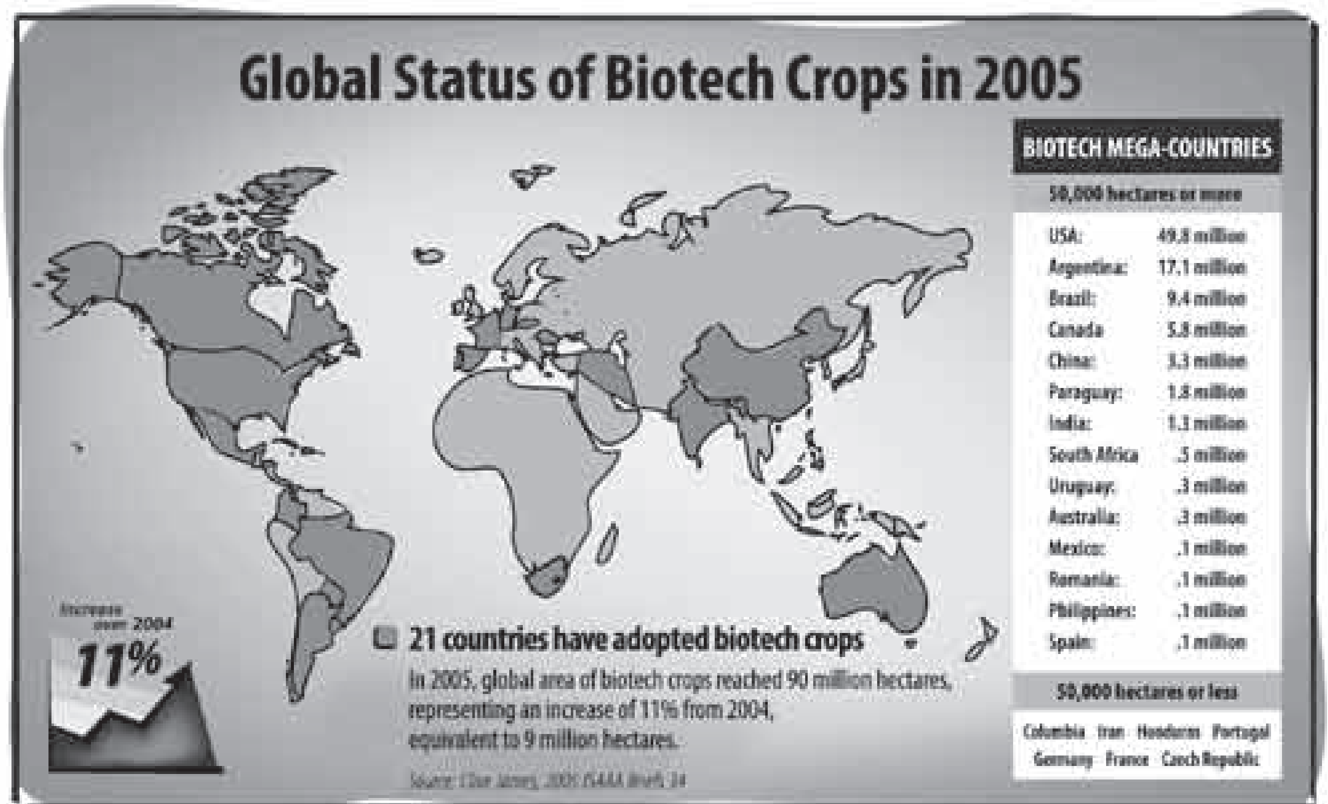
In Argentina, the situation is quite dramatic. Some 60,000 farms went out of business while the area of Roundup Ready soybean almost tripled. Between 1998 and 2002, one quarter of farms in the country were lost. In one decade, soybean area increased 126% at the expense of dairy, maize, wheat and fruit 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.[7] For the biotech industry,

4 Charles Benbrook (2005), *Rust, resistance, run down soils, and rising costs – problems facing soybean producers in Argentina.* Ag BioTech InfoNet, Technical Paper No. 8.

5 C Jason (2004), *World agriculture and the Environment*. Island Press. Washington.

6 PF Donald (2004), "Biodiversity impacts of some agricultural commodity production systems," *Conservation Biology* 18:17-37.

7 Walter Pengue (2005), "Transgenic crops in Argentina: the ecological and social debt," *Bulletin of Science, Technology and Society* 25: 314-322.



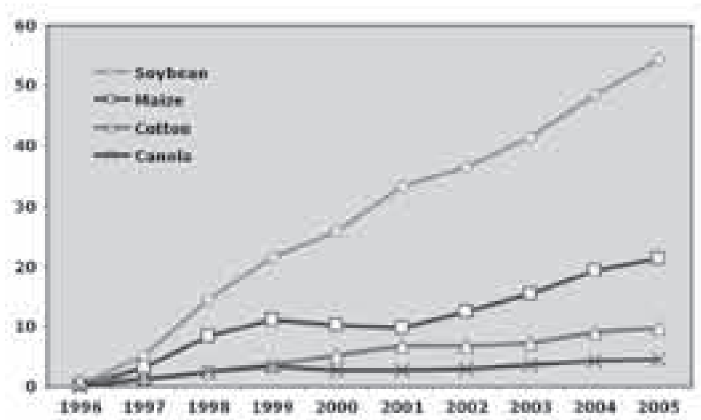
huge increases in the soybean area cultivated and more than a doubling of yields per unit area are an economic and agronomic success. For the country, that means more imports of basic foods at teh expense of food sovereignty, and for poor small farmers and consumers, increased food prices and more hunger.[8]

Soybean expansion in Latin America is also related to biopolitics and the power of multinationals. Millions of hectares of Roundup Ready soybean were planted in Brazil during 2002 and 2003, despite a moratorium on GM crops being in effect. Through their political influence, multinationals have managed to expand dramatically the cultivation of transgenic crops in developing countries. During the early years of GM soybean production in Argentina, Monsanto did not, and said they would not, charge farmers royalties to use the technology. But now that farmers are hooked, the multinational is pressuring farmers, via the government, for payment of intellectual property rights, despite the fact that Argentina signed UPOV 78, which allows farmers to save seeds for their own use. Paraguayan farmers have also recently signed an agreement with Monsanto to pay the company $2 per tonne.

Soybean cultivation degrades the soil

Soybean cultivation has always led to erosion, especially in areas where it is not part of a long rotation. Soil loss has reached an average rate of 16 tonnes per hectare per year (t/ha/y) in the US Midwest, far greater than is sustainable; and soil loss levels in Brazil and Argentina are estimated at between 19-30 t/ha/y depending on management, slope and climate. Farmers wrongly believe that no-till systems mean no erosion. No-till agriculture can reduce soil loss, but with the advent of herbicide tolerant soybean, many farmers now cultivate in highly erodible lands. Research shows that despite improved soil cover, erosion and negative changes in soil structure can still be substantial in highly erodible lands if weed cover is reduced.

Large-scale soybean monocultures have rendered Amazonian soils unusable. In areas of poor soils, fertilisers and lime have to be applied heavily within two years. In Bolivia, soybean production is expanding towards the east, and in many areas soils are already compacted and suffering severe soil degradation. One hundred thousand hectares of soybean-exhausted soils were abandoned for cattle-grazing, which in turn further degrades the land. As land is abandoned, farmers move to other areas where they again plant soybeans and repeat the vicious cycle of soil degradation.



Global area (million hectares) of GM crops, 1996-2005. Source: ISAAA

In Argentina, intensive soybean cultivation has led to massive soil nutrient depletion. Continuous soybean production has extracted an estimated 1 million tonnes of nitrogen and about 227,000 tonnes of phosphorous. The estimated cost of replenishing this nutrient loss via fertilisers is US$ 910 million.[9] The increased levels of nitrogen and phosphorus found in several river basins of Latin America is certainly linked to the increase of soybean production.

A key technical factor in the rapid spread of soybean production in Brazil was the claim that soybean's symbiotic relationship with nitrogen-fixing rhizobium bacteria in the plant's root nodules meant that the crop could be grown without fertilisers. What the companies failed to tell farmers was that the glyphosate herbicide packaged with the GM seeds is directly toxic to the bacteria, rendering the soybeans dependent on chemical fertilisers for nitrogen. Moreover, the common practice of converting uncultivated pasture to soybeans results in an overall reduction in the levels of nitrogen-fixing bacteria, again making soybean dependent on synthetic nitrogen.

Monocultures and ecological vulnerability

The link between biodiversity reduction caused by the monoculture expansion and increased insect pest outbreaks and disease epidemics is well established. In poor and genetically homogenous landscapes insects and pathogens find ideal conditions to thrive. This leads to the increased use of pesticides, which after a while are no longer effective due to the development of pest-resistance or ecological upsets typical of the pesticide treadmill. Pesticides also cause major problems of soil and water pollution, elimination of biodiversity and human poisoning. The humid and warm conditions of the Amazon are also favourable for fungal growth, resulting in the

[8] JF Jordan (2001), "Genetic engineering, the farm crisis and world hunger," *BioScience* 52: 523-529.

[9] Walter Pengue (2005), "Transgenic crops in Argentina: the ecological and social debt," *Bulletin of Science, Technology and Society* 25: 314-322.

increased used of fungicides. In Brazil, the soybean crop is increasingly being affected by stem canker and sudden death syndrome.

Soybean rust is a new fungal disease increasingly affecting soybeans in South America, which is increasing fungicide applications. In addition, since 1992, more than 2 million hectares have been infected by cyst nematodes. Many of these pest problems are linked to the genetic uniformity and increased vulnerability of soybean monocultures, and also to the direct effects of Roundup on the soil ecology, through the depression of mycorrhizal[10] fungal populations and the elimination of antagonists that keep many soil-borne pathogens under control.[11]

A quarter of all pesticides applied in Brazil are used on soybean, which amounted to 50,000 tonnes in 2002. Pesticide use is increasing at a rate of 22% per year. While biotech promoters claim that one application of Roundup is all that is needed for whole season weed control, studies show that in areas of transgenic soybean, the total amount and number of herbicide applications have increased. In the USA, the use of glyphosate rose from 6.3 million pounds in 1995 to 41.8 million pounds in 2000. In Argentina, Roundup applications reached an estimated 160 million litre equivalents in the 2004 growing-season. Herbicide usage is expected to increase as weeds develop resistance to Roundup.

Yields of transgenic soybean average 2.3 to 2.6 t/ha in the region, about 6% less than conventional varieties, and are especially low under drought conditions. Due to pleiotropic effects (stems splitting under high temperatures and water stress), transgenic soybean suffer 25% higher losses than conventional soybean. Some 72% of the yields of transgenic soybeans were lost in the 2004/2005 drought in Rio Grande do Sul, which is expected to translate into a 95% drop in exports with dramatic economic consequences. Most farmers have already defaulted on one third of government loans.

Other ecological impacts

By creating crops resistant to its herbicides, a biotech company can expand the market for its patented chemicals. The market value of herbicide-tolerant crops increased 10-fold between 1995 and 2000, from $75 to $805 million. In 2002, herbicide-tolerant soybean occupied 36.5 million hectares around the world, making it by far the number one GM crop in terms of area.[12] Global herbicide sales (especially glyphosate) continue to increase. The continuous use of herbicides, and especially the use of glyphosate with herbicide-tolerant crops, can lead to serious ecological problems. When a single herbicide is used repeatedly on a crop, the chances of herbicide-resistance developing in weed populations greatly increases. About 216 cases of pesticide resistance have been reported in one or more herbicide chemical families.[13]

Given industry pressures to increase herbicide sales, the acreage treated with broad-spectrum herbicides will expand, exacerbating the resistance problem. Weed resistance has already been documented with Australian populations of annual ryegrass, quackgrass, birdsfoot trefoil, *Cirsium arvense*, and *Eleusine indica*.[14] In the Argentinian pampas, eight species of weeds, among them two species of Verbena and one species of *Ipomoea,* already exhibit resistance to glyphosate.[15]

Herbicide resistance becomes more of a problem as weeds are exposed to fewer and fewer herbicides. Transgenic soybean reinforces this trend on account of market forces. In fact, weed populations can even adapt to tolerate or "avoid" certain herbicides. In the US state of Iowa, populations of common waterhemp have demonstrated delayed germination, which allows them to avoid planned glyphosate applications. The GM crop itself may also assume 'vounteer' weed status. In Canada, volunteer canola resistant to three herbicides (glyphosate, imidazolinone, and glufosinolate) has been detected. Farmers have to resort to the highly

10 Symbiotic associations between fungi and plant roots.

11 Miguel Altieri (2004), *Genetic engineering in agriculture: the myths, environmental risks and alternatives,* Food First Books, Oakland.

12 Clive James (2004), *Global review of commercialised transgenic crops: 2004.* International Service for the Acquisition of Agri-Biotech Application Briefs, No 23-2002. Ithaca , New York.

13 Jane Rissler and Margaret Mellon (1996), *The ecological risks of engineered crops,* MIT Press, Cambridge, Mass.

14 Miguel Altieri (2004), *Genetic engineering in agriculture: the myths, environmental risks and alternatives,* Food First Books, Oakland.

15 Walter Pengue (2005), "Transgenic crops in Argentina: the ecological and social debt," *Bulletin of Science, Technology and Society* 25: 314-322.

toxic 2,4-D to control the volunteer canola. In northern Argentina, there are several "superweeds" than demonstrate this kind of "stacked' or "multiple" resistance to glyphosate.

Biotech companies claim that when properly applied, herbicides should not pose a threat to humans or the environment. But in practice, the large-scale planting of GM crops encourages the aerial application of herbicides and much of what is sprayed is wasted through drift and leaching. The companies contend that glyphosate degrades rapidly in the soil, does not accumulate in ground water, has no effect on non-target organisms, and leaves no residue in food, water or soil. Yet glyphosate has been reported to be toxic to some non-target species in the soil – both to beneficial predators such as spiders, mites, and carabid and coccinellid beetles, and to detritivores such as earthworms, including microfauna as well as to aquatic organisms, including fish.

Glyphosate is a systemic herbicide (which means it is absorbed into and moves through the whole plant), so it is carried into the harvested parts of plants. Exactly how much glyphosate is present in the seeds of herbicide-tolerant corn or soybeans is not known, as grain products are not included in conventional market surveys for pesticide residues. The fact that this and other herbicides are known to accumulate in fruits and tubers raises questions about food safety, especially now that more than 100 million pounds of this herbicide are used annually in the US alone.[16] Even in the absence of immediate (acute) effects, it might take 40 years for a potential carcinogen to act in enough people for it to be detected as a cause. Moreover, research shows that glyphosate seems to act in a similar fashion to antibiotics by altering soil biology in a yet unknown way and causing effects like:

- Reducing the ability of soybeans and clover to fix nitrogen.
- Rendering bean plants more vulnerable to disease.
- Reducing growth of beneficial soil-dwelling mycorrhizal fungi, which are key for helping plants extract phosphorous from the soil.

Farm-scale evaluations in the UK showed that herbicide-resistant crop management within and in the margins of beet and oilseed rape production led to reductions in beetle, butterfly and bee populations. Counts of predacious carabid beetles that feed on weed seeds were also smaller in GM crop fields. The abundance of invertebrates that are food for mammals, birds, and other invertebrates were also found to be generally lower in herbicide-resistant beet and oilseed rape.[17] The absence of flowering weeds in GM fields can have serious consequences for beneficial insects which require pollen and nectar for survival.

Conclusions

Soybean expansion in Latin America represents a recent and powerful threat to biodiversity in Brazil, Argentina, Paraguay and Bolivia. GM soybeans are much more environmentally damaging than other crops, partly because of their unsustainable production requirements, and partly because their export focus requires massive transportation infrastructure projects, which open up vast tracts of land to other environmentally unsound economic and extractive activities.

The production of herbicide-resistant soybean leads to environmental problems such as deforestation, soil degradation, pesticide and genetic contamination. Socio-economic consequences include severe concentration of land and income, the expulsion of rural populations to the Amazonian frontier and to urban areas, compounding the concentration of the poor in cities. Soybean expansion also diverts government funds otherwise usable in education, health, and alternative, far more sustainable agroecological methods.

The multiple impacts of soybean expansion also reduce the food security potential of target countries. Much of the land previously devoted to grain, dairy products or fruits has been converted to soybean for exports. As long as these countries continue to embrace neoliberal models of development and respond to demand from the globalised economy, the rapid proliferation of soybean will increase, and so will the associated ecological and social impacts.

16 http://bogota.usembassy.gov/wwwsglyp.shtml

17 www.defra.gov.uk/environment/gm/fse/index.htm

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