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TRANSGENIC CROPS IN ARGENTINA AND ITS HIDDEN COSTS

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ABSTRACT

Almost a decade ago (1996) Argentina released the commercial use of transgenic seed. Thereafter, the characteristics of Argentinean Agriculture changed drastically. The "Transgenic Revolution" involves soybean, corn and cotton. The process occurred during the last decade and it is considered an intensification of the "external inputs technology" that is considered as the "input decade". Soybean production became a relevant crop for Argentina, with a planted surface that rose to 12 100 000 hectares and a production of almost 35 000 000 metric tons. Nowadays, soybean represented more than 50 percent of the whole agricultural exports of the country. During the nineties, for big farmers, roundup-ready soybeans came "to solve" one of the main problems for the farm management: weed control, obtaining a virtual simplification of control and cost reduction in the herbicide price. For companies of pesticides and seeds, a unique opportunity to concentrate and rearrange the business focuses on genetic engineering. The expansion of this model occurred not only in the Pampas but and also in new areas with high biodiversity, opening a new agricultural borders in important ecosystems like Yungas, Great Chaco and the Mesopotamian Forest. Landscape transformation in the rural sector is evident and there is a new critical issue: the appearance of weeds with tolerance to glyphosate. Besides that, new important phenomena appear: nutrients depletion, soil structure degradation, initial desertification and lost of species. Transgenic cropping is a powerful technology, that could produce transformations on environment and society. Some of the consequences are migration, concentration of richness by agribusiness, lost of food diversity and food sovereignty; therefore there is a urgent need of studies on risk assessments integrating ecological and socioeconomic analysis. GMO expansion in Argentina has been facilitated by a very strong pressure of big companies, developed countries involved in trade of GMOO seeds and herbicides, big farmers' organizations and part of scientific sector of local government, but there is not a real social discussion and the implantation occurs without law obeisance, and it is necessary to complete legislation and regulations. Other South American countries are at this time facing similar pressures during the releasing of transgenic crops. Big infra-structure projects for extensive production of soybean as the "Paraguay-Paraná Hidroway" will pass through floodplain wetlands, a complex set of different preserved ecosystems. The ecological economics approach, under the post-normal science focus, is used to discuss the confirmed impacts of release of GMO soybean technology.

Keywords
No Tillage, Glyphosate, GMO soybean, Tolerance, Landscape transformation, Nutrients depletion

1. INTRODUCTION

1.1. The "modernization" of the Argentine agriculture

The Pampas prairie is the vast, flat region of Argentina that comprises more than 50 million hectares of wonderful arable lands for crop and cattle production. Agriculture in the pampas has a short history (100 years), and shares several common features with North American Great Plains. Both ecosystems were mostly native rangelands until the end of the 19th century, and both were affected by the introduction of crop and cattle production on dryland conditions.

The Pampas prairie is not homogeneous in soil, weather or biodiversity patterns (MORELLO and MATTEUCCI 1997). Using soil and rainfall patterns, the Pampas can be divided into five homogeneous areas (VIGLIZZO; PORDOMINGO; CASTRO and LÉRTORA 2002): 1) Rolling Pampas, 2), Central Pampas (subdivided in Sub-humid on the East and Semiarid on the West, 3) Flooding Pampas, 4) Southern Pampas and 5) Mesopotamian Pampas (Figure 1).

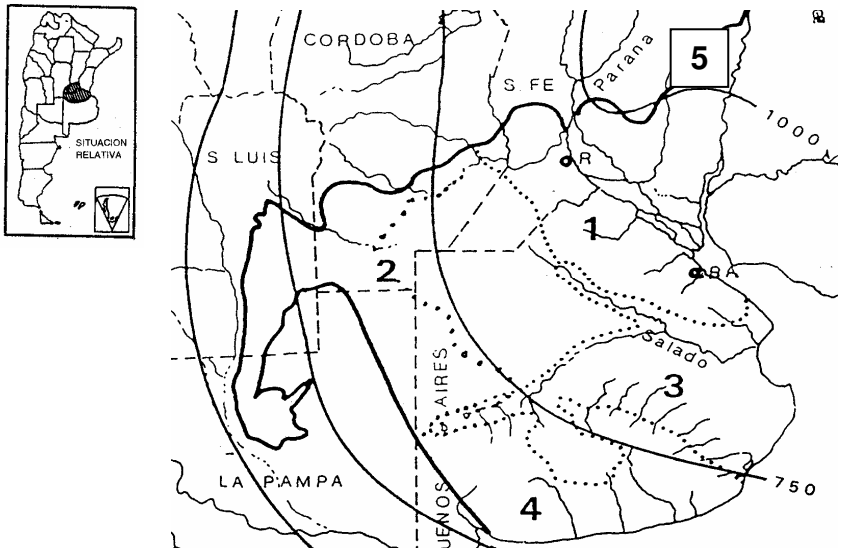

Figure 1. *The Pampas* (Modified from PENGUE 2001a)

This is the area where transgenic soybean and no tillage started to spread and were strongly adapted (PENGUE 1999).

In Argentina during the last five years, especially in the Pampas, soybean production has occupied 4 600 000 hectares that were dedicated to other production systems, like dairy, fruit trees production, horticulture, cattle and other agricultural activities. This year, more than fifty percent of the agriculture product (corresponding to 73 000 000 metric tons) stems from the soybean sector. Soybean is the main engine of agro-industrial economy of Argentina (Figure 2) and its expansion is happening not only in the Pampas but also in very marginal ecosystems.

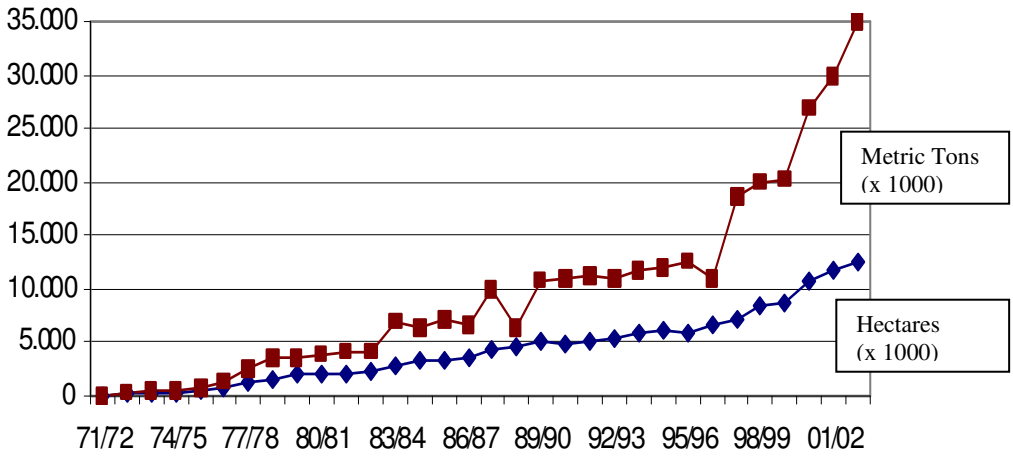

Figure 2. Soybean production (in metric tons) and surface implanted (hectares)
Data: Secretaria de Agricultura, Ganaderia, Pesca y Alimentacion da Argentina, 2004

In Argentine, the adoption of no tillage technique, transgenic seeds and the use of specific pesticides and herbicides resulted in economic success of big farmers, and in the duplication of soybean production during the last decade, called the “Input Decade”.

1.2. Transgenic soybean production in Argentina

Since 1997, private enterprises, in many cases with the support of governmental agencies, are offering a transgenic solution (soybean + glyphosate) that, in their words, brought to the country a "real competitive advantage" (PENGUE 2000). Due to this technology and natural and structural advantages, Argentina became one of the "most efficient" countries (under a crematistic economy point of view) in the production and trade of agricultural commodities. At the same time, since those years, there is a strong campaign for the commercialization of transgenic soybeans, resulting in an increase of the GMO soy acreage from 20 % to 95 % of the total soy acreage in 2003/04. Argentina does not owe GMO technology, it belongs to international companies, like Monsanto (USA) and Nidera (Netherlands).

In the past, traditional cultivation of grains was combined with fallow seasons to grow cattle pasture. The rotation system allowed the long-term maintenance of agro-ecological systems. But since the 1980s, world market prices for grains and oilseeds increased, while cattle productivity declined. Continuous agriculture become more lucrative, for example the production of soybeans in rotation with wheat or sunflower allows up to three harvests in two years (PENGUE 2000). Furthermore, the opening of Argentina's economy to global model, the end of hyperinflation due to artificial parity of Argentinean Peso with US Dollar and the abolition of export levies on agricultural products triggered investments in new technologies. This economic framework favoured the import of machinery and agricultural inputs as pesticides, fertilizers and GMO seeds at low prices in no tillage agro-system for export markets. At the beginning of the 21rst century, a new devaluation and important signals from the global market indicating rising soybean prices, strongly promote soybean production not only in *The Pampas* but also in others *ecosystems* of Argentina and neighbour countries. The intensification of the production system was followed by a decline in soil fertility and increase of soil erosion. Consequently, the fertilizer consumption stepped up from 0.3 million metric tons in 1990 to 3.5 million in 2003. The increase of no-tillage agricultural technology demanded additional more herbicide applications and special machinery for sowing. This system is associated with use of herbicide (such as glyphosate), whose application was increased even more by the release of transgenic soybeans, that are glyphosate-tolerant.

1.3. The main factors of the rapid adoption of transgenic soybean are the following:

a) Lower herbicide prices. In Argentina, glyphosate went down from $ 28/liter to $ 3/liter, much cheaper than in the USA. Four companies (Monsanto, Atanor, Nidera, and Dow) dominate 80 % of the glyphosate market in Argentina, which is imported from the USA, EU and China (LEHMANN and PENGUE (2000). Glyphosate consumption rose from less than 1 000 000 liters at the beginning of the 90´s to 150 000 000 liters in 2003/2004.
b) Fewer expenses on labor, fuel and machinery. Direct sowing and more effective herbicide application allow for crop cultivation with less labor and machinery.
c) Increased awareness by farmers of the technological package no-tillage + GMO soybean.
d) Seed prices and self-reproduction. In Argentina, farmers do not pay technology fees for seeds (UPOV 78). They reproduce the new seeds in theirs fields. This practice is against the economic aims of the companies. 2003, the "*white bag*" (those seeds without fiscal certification) is around 300 000 ton. This is the basic reason for GMO technology enterprises to put government under pressure in

order to restrict soybean seeds trade. Probably during 2004, companies will partly abandon the production of self-pollinated seeds (soybean) and put the focus on production of transgenic Roundup-Ready and *Bt* corn, with great expectations in this new business.

1.4. Some comments on Environment and Agro-industrial conditions

Biotechnology is emerging at a period of worsening inequalities between the developing countries and the industrialized world. The income gap between the fifth of the world's people living in the richest countries and the fifth in the poorest move from 30 to 1 in 1960, 60 to 1 in 1990 and 74 to 1 in 1997 (UNDP 1999). Only one tenth of the money spend in worldwide R&D (US$ 460 billion) was spent in the developing world where 80 % of the world's population resides (UNESCO 1998). These figures imply that many of developing countries are unlikely to benefit from biotechnology. In the case of Argentina, the implementation of this technology was not a tool to solve the complex situation of inequity, poverty and access to food that the country is facing at the beginning of new century.

The majority of current agricultural transgenic research efforts are driven by the markets in the developed world. The research focuses are staple varieties for animal foods, minimizing labor and maximizing comfort for farmers. Perhaps in the future, there will be some research to improve the quality of foods. Research on crop varieties, environmental and health conditions of interest for developing world population are largely ignored and stay in the level of promises.

The reality shows an intensification of agriculture that takes advantage of the extensive lands of big countries in the Southern Cone. This results in a deep transformation of land use:

1) An intensive production with high inputs technology on existing agricultural land in the whole *Pampas* and other agro-environments.
2) An extensive production on new lands, pushing forward the agricultural border with new varieties of soybeans, bred specifically to be adapted to virginal lands. This process is very pronounced in Brazil (Mato Grosso, Paraná, and others states), Bolivia (Santa Cruz de la Sierra, Beni), Paraguay and Argentina (Chaco, Formosa, Salta, Tucumán, Jujuy and Santiago del Estero).
3) An intensive movement for agricultural commodities thorough river transportation. Probably, the *Hidrovía Paraguay-Paraná* could accelerate the extension of soybean production, and facilitate the process of exportation downstream.

Three decades before, soybean was a botanical curiosity in Argentina. Nowadays, it is the main motor of MERCOSUR (The Commercial Market of the South Cone, integrated by Argentina, Brazil, Paraguay and Uruguay). It is MERCOSUR's first export commodity. But, in Brazil and Argentina the transformation followed different goals and different market perspectives. While Argentine followed the United States and continued with the intensification of GMO production, the production and release of GMO crops in Brazil is still under discussion (in 2004). The government only allowed the harvest of (illegally) planted transgenic soybeans in this season (2003/04), with an *open end* for the next future.

1.5. Current situation and trends for agriculture production in Argentina

Argentina can be considered as a "*natural*" country, free from high inputs of chemicals as fertilizers, insecticides or herbicides for its crops till the first years of the nineties

(Table Nº 1). This is a "*market value*". But, in the hands of globalization and facing an increasing soybean demand, the country is changing its system of production, following an intensification of agriculture, with high use of imported chemicals, new varieties of crops and an application of agriculture biotechnology that implies more consumption of herbicides.

Table 1. Agriculture indicators of selected countries.

Indicator	Argentina	USA	France
Insecticides (g/ha)	250	1000	3000
Fertilizer (kg/ha)	25	100	300
Herbicides (g/ha)	250	900	2000
Changes in farm landing (%)	18	5	- 2,5
Native mammals under danger extinction (%)	10	11	50
Native birds under danger extinction (%)	2	8	40
Native reptiles under danger extinction (%)	0	6	38

Source: Modified from PENGUE 1996.

As a consequence of adoption of no-tillage-herbicide-GMO seeds technology without public discussion and scientific evaluation, soil erosion and nutrients exportation become a problem. Meanwhile, the entire ecosystem is influenced by the "*new biorevolution*" (PENGUE 2001b) it will allow to intensification of agricultural processes, the reduction of fallow fields and restoration, the increase of pressure on natural resources, on social system and on economy. We are facing an overexploitation of resources.

1.6. Social and economic issues

Agriculture intensification has produced environmental, economical and social consequences that have not been evaluated comprehensively in the country. Probably, the new bio-revolution will exacerbate the weak conditions of the system: more chemical inputs, more production for external markets, large farm concentration, low levels of credit for small farmers, less diversification, dependence on imported supplies, dependence on technology, appropriation of large farms by foreign owners, and concentration of the seed and chemical business in the hands of few agricultural enterprises. Soybean monoculture has produced effects that would affect the commercial position of Argentina in the meantime: degradation of soils and biodiversity, rural migration, concentration in large farms exclusively producing commodities with high yield crops instead of more natural foods that are also demanded by the global market (agroecological systems for organic farming). There are social and economic consequences coming from changes and transformations of the national economy. Since 1991, when the period of dollar convertibility opened the Argentine market, changes in mode of production have led to a number of social transformations in the agricultural sector:

a) Dependence on imported inputs. Grains and soybean became the main commodities for foreign markets, boosting the dependence on imports. Local production of pesticides is 16.6 %, while 43.6 % are imported and 39.8 % are produced in Argentina with imported basic chemicals. A similar pattern is true for fertilizers.
b) Concentration of holdings. The new technological package is offered in a context of profit margins falling down by 50% between 1992 and 1999 that

make survival for many farmers, very difficult. Farmers are indebted with bank loans of high interest rates to pay back for investments in machinery, chemicals and seeds. This situation favors the establishment of holdings and the disappearance of individual farmers (farms summing up 14 000 000 ha are in debts with loans by banks and big companies). Between 1992 and 1999, the number of farms in *Las Pampas* declined from 170.000 to 116.000, while the average size of a producer's farm increased from 243 to 538 ha in 2003 (Table 2).

c) Land for diversified production (fruits, dairy, cattle, maize, wheat, sunflower, cotton, sugarcane) is diminishing (Table 3). Soybean acreage increased by 126 % in one decade. During this season (2003/04) 13 750 000 ha will be planted with soy (9.1 % increase). Sunflower will be reduced by 9.6 % (2 150 000 ha) and corn by 5.6 % (2 910 000 ha).
d) Dumping prices of developed countries. These practices promote the intensification of agriculture, over-exploitation of resources and sub-utilization of alternative goods in developing countries. But, usually it is not included in the valuation of externalities.
e) Argentina cannot export goods with *added values*. Only 2% of a national production of 70 000 000 metric tons, will be processed in the agro-industrial food chain because of the effects of protective systems in the importing countries.
f) Exclusion of small farmers who can not get financial support for the acquisition of technological package.
g) Adverse consequences of GMO crops for organic farming by contamination or gene flow.
h) Each Argentinean currently eats less meat that the year before (10 kg/year decrease). The alternative for poor people, promoted by private companies, is to change the diet to include more soybean protein: a substantial cultural transformation. A similar promotion to eat less high quality protein from cattle production, eggs, and milk and replace it by soybean protein occurs in other South American countries. We are facing a *Battle for the High Quality Protein* between developed and developing countries.

Table 2. Reduction of agricultural exploitations in Argentina by Regions

Year	Total	Pampas	NEA*	NOA**	Cuyo	Patagonia
1988	421 221	196 254	85 249	72 183	46 222	21 313
2002	317 816	136 345	68 332	63 848	32 541	16 750
Difference %	- 24.5	- 30.5	- 19.8	- 11.5	- 29.6	- 21.4

Source: On the basis of data from Censo Nacional Agropecuario 2002, INDEC. (*NEA: Nor east Argentina, **NOA: Norwest Argentina). www.indec.gov.ar, date: 01/12/03

Table 3. Soybean evolution during period 1996/97–2001/2002 respect other products

	Rice	Corn	Sunflower	Wheat	Soybean
1996/97	226.573	4.153.400	3.119.750	7.366.850	6.669.500
2001/02	126.519	3.064.276	2.050.365	7.108.900	11.639.240
Difference	- 44,1 %	- 26,2 %	- 34,2 %	- 3,5 %	74,5 %

Source: SAGPyA. www.sagpya.mecon.gov.ar, date 12/12/03.

It can be concluded that short-term economic objectives ignoring mid- and long-term socioeconomic and environmental effects put the future sustainability of the society at risk. However, although indicators to measure social or economic changes are abundant, indicators for assessing environmental changes are scarce. The generation and development of proper indicators for creating an agro-environmental information system are essential to enable a permanent quality assessment of rural environments.

2. ENVIRONMENTAL CONSIDERATIONS

In *The Pampas*, the application of transgenic soybean-glyphosate-GMO seeds (Figure 3) caused the appearance of glyphosate-tolerant weeds: *Parietaria debilis, Petunia axilaris, Verbena litoralis, Verbena bonariensis, Hybanthus parviflorus*, *Iresine diffusa, Commelina erecta and Ipomoea sp.* (PAPA 2000). This implies in a further increase in use of herbicides. The *change of the herbicide regime* already led to an increase of consumption of glyphosate from 1 000 000 to 160.000.000 litres in 8 years. Furthermore, farmers are using combinations of glyphosate with other herbicides, re-establishing the use of the old herbicide 2,4-D.

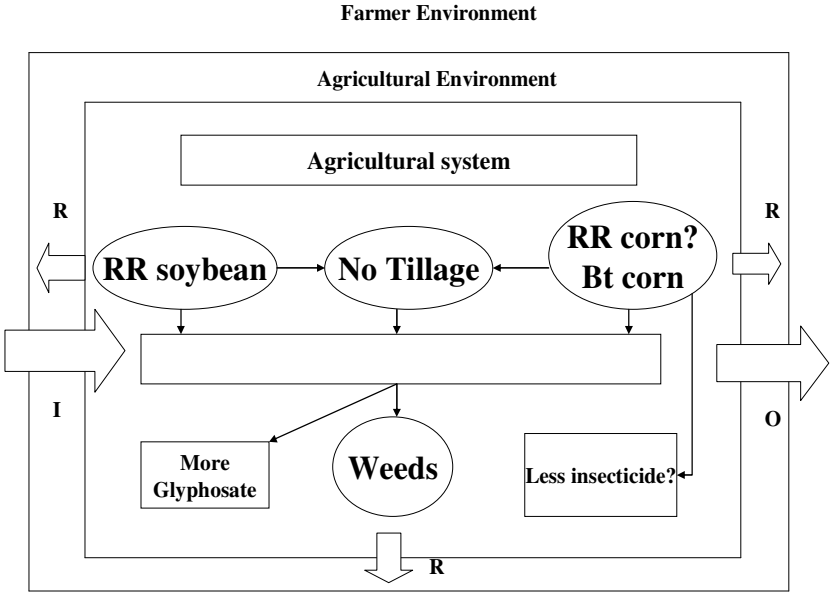

Figure 3. Diagram of agro-system in Argentinean Pampas. (*I=Input, O=Output, R=Resistance, RR=Roundup Ready, Bt=Bacillus thuringiensis tolerant*)

Coadjutants and surfactants are organic compounds used to increase the adsorption of glyphosate into the plant leaves. Some commercial products contain the surfactant POEA. This surfactant has toxicity five times higher than glyphosate alone. The expansion of the cropping area and the more intensive use of pesticides over time showed a strong increasing of relative contamination risk.

Land use is an indicator that determines the environmental status of the region (Table 4). All indicators, from fossil energy consumption to contamination risk, from erosion risk to greenhouse gas emission, are particularly sensitive to land use. Technology being

the next factor (VIGLIZZO; PORDOMINGO; CASTRO and LÉRTORA 2002 above-mentioned).

Table 4. Changes in the area allocated to predominant annual crops (soybean, maize, wheat and sunflower) in the Argentinean Pampas during the period 1960-2000

Pampas (Area /Year)	*Percentage of the Total Area*		
	1960	*1988*	*1996*
Regional Average	23.7	30.3	40.0
Rolling Pampas	28.9	47.6	63.4
Central Subsumid	31.3	38.3	53.6
Central Semiarid	21.7	38.4	39.1

Source: Modified from VIGLIZZO; PORDOMINGO; CASTRO and LÉRTORA, 2002.

Fossil energy consumption in *The Pampas* is increasing at high rates. Land productivity and fossil energy consumption doubled in ten years (1.68 to 3.31 GJ/ha/year).

In a general context, *The Pampas* used not to be fertilized, since the nutrient budget had been equilibrated by the rotation of crops and cattle. But, in the nineties things changed strongly. With its grains the country exports a considerable amount of nutrients each year – especially nitrogen, phosphorus and potassium. The processes of intensification do not allow a natural replenishment. Argentina exports around 3.500.000 metric tons of nutrients yearly – with no recognition of their market price. That helps to increased the "*ecological debt*" (MARTINEZ ALIER and OLIVERAS 2003)(MARTINEZ ALIER 2003). Soybean represent fifty percent of the average nutrient export (Table 5) (PENGUE 2003).

Table 5. Nutrients (N, P) exports and their reposition cost for soybean harvest (34.000.000 metric tons in 2003/2004)

	Nitrogen	Phosphorous	Total
Nutrient Extraction in metric tons	1.020.000	227.800	1.247.800
Mineral Fertilizers equivalent (metric tons)	2.217.400	1.109.386	3.326.786
Reposition Cost Estimation (US$)	576.524.000	332.816.000	909.340.000

Source: PENGUE, 2003.

It is estimated that for next season (2003/04) 30% of soybean area (4.500.000 hectares) will be fertilized with chemicals. It shows a trend towards substantial depletion of nutrients in soils that will be extracted completely in 50 years (VENTIMIGLIA 2003). Under the no-tillage system, indicators show that the soil erosion risk declines.

Aggressive agronomic practices, global demand for soybean and attractive prices without national regulations give support to the negative impact on natural habitats and biodiversity. Argentina established small protected areas (2.777.815 km2). It is only 4,8 %; Brazil has 16,8 %, Bolivia 22,4 %; Peru 9,9 % (BURKART 1999). In very few years, thousands of hectares of virgin lands have been transformed. Between 1998 and 2002, deforestation in *Chaco State* affected 117.974 ha (MONTENEGRO; STRADA; PARMUCHI; GASPARRI and BONO 2003), 160.000 ha in *Salta* and 223.000 ha in *Santiago del Estero*.

Industrial sector and government expect an increase in soybean area until 2008, more than 16.000.000 hectares will be planted, specially in marginal lands (Figure 4).

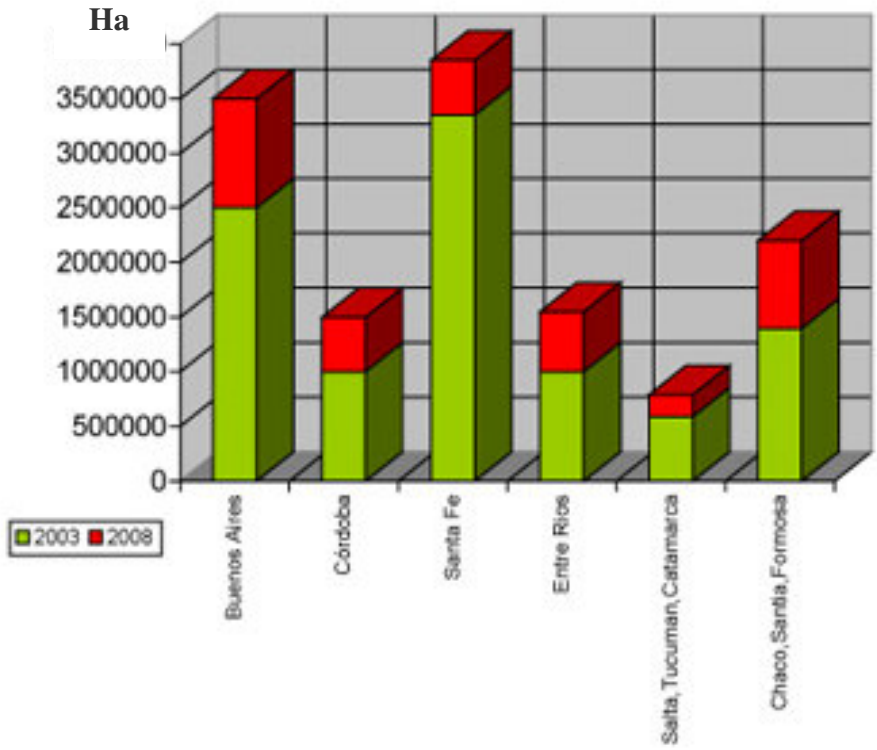

Figure 4. Soybean expansion projections for The Pampas (PENGUE, 2004).
In 2003: 12.100.000 hectares, in 2008: 16.000.000 hectares

In green: areas planted in 2003 in the different regions of the country. In red: new marginal lands to be added.

3. CONCLUSIONS

The model of intensification of Argentine agriculture, represented by the use of no-tillage and glyphosate, has resulted in the homogenization of production and landscapes based on transgenic soybeans as the dominant crop. The present export-oriented commodity production system is most likely to drive smaller farmers out of business that are not able to face the competition. For them, a diversification beyond global commodity markets with other crops for internal purposes might render an alternative development trajectory. The overwhelming dependence on transgenic soybeans makes farmers and the country especially vulnerable to changes in the global commodity markets. Argentina is going more efficient in terms of soybean production, but also it is also going fast to monoculture and dependence. Soybean intensification has produced social and economic consequences. Thousand of small- and medium-scale farmers have been forced out of the production system. In ten years, the country lost its food sovereignty.

Argentina concentrates agricultural efforts on a few commodities for exportation without an added value. Poor people can not afford any more a diverse diet. The protein basis of their meals was changed from high quality meat proteins to vegetable protein as soybean. Twenty percent of the argentine kids' (2.108.237) became undernourished. The nineties were characterized by a transition towards a more intensive model of agricultural production, both in terms of land use and technology application. Many farming systems in Argentina resemble some intensive models that are very common in the United States or Europe. Nutrient depletion is a new complex issue that must be

solved with holistic agro-ecological production policies but not with the current approach of increasing the application of chemical fertilizers. Overexploitation of natural resources and sub-utilization of alternative goods (by no incorporation of externalities in the cost production) are increasing the *ecological debt*.

Deforestation and expansion of agricultural borders must be analyzed fast and need policies decision to avoid an important loss of biodiversity and natural habitats, not only in Argentina but also in the neighbour countries. Indicators showing a negative trend are important keys to identify critical problems that will require a more attention by researchers and government. The increase of contamination risks, the increase agro-chemicals supplies, the biodiversity loss, and single-cultivation model must be discussed to assure the future sustainability of the Pampas and of the whole country. South American countries are using a very important "subsidy": their own environmental richness. There are some economic results, but intensification of the process has affected many people and different ecosystems. If we apply the tools of ecological economics incorporating the externalities to production costs, the results will be very different.

It is a reality that there is an increasing consensus that consumers want safe, local, organic fresh food and that they want the environment and wildlife to be protected. Assuring that these things happened in South American countries must allow an evaluation under a wider point of view and under the Precautionary Principle that ours government have forgotten. But changes of the current situation, do not depend only in definitions of new rules in the Agricultural and Environmental National Policy, they also depend on the existing demand of global customers and rich countries that must value and pay properly for chemical and ecological goods from developing countries. It is clear that this will require substantial changes in the Global Agricultural Policy.

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