Soybean Production in the Southern Cone of the Americas:
Update on Land and Pesticide Use

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Photo credits. *Front picture (left)*: Richard Doughman /Angélica Bermudez (2010). Wide cultivation of soybean monocrop in Alto Paraná, Paraguay. *Front picture (right)*: Richard Doughman (2010). Local road crossing extensive soybean fields, Alto Paraná, Paraguay. *Back picture*: Sarah Zanon Agapito-Tenfen (2010). Field of generically modified soybean tolerant to glyphosate infested with glyphosate tolerant weeds, Campos Novos, Santa Catarina, Brazil.

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Summary

The history of the soybean production in the Southern Cone of the Americas goes back for more than 100 years. However, it has been in the past 40 years, particularly in the last two decades, that it has experienced an accelerated transformation and expansion through a pattern of industrialized agriculture.

Soybean Production and Land Use

South America is the region with the fastest growth of soybean production globally. During the last 40 years the area under soybean cultivation has increased 30-fold, surpassing that in Asia in 1978, and that in North America in 2003. The introduction of genetically modified (GM) varieties in the region has marked a new phase of expansion in soybean production. In the first 14 years after the approval of GM varieties, soybean production grew by 25 million hectares (1996 to 2009), in comparison with the increase of 17 million hectares over the previous 25 years (1971-1995). In 2009, in the region approximately 43 million hectares of soybean was planted in total (44% of the 98.17 million cultivated globally). In 2010, this area reached almost 47 million hectares.

The vast majority of soybean production of South America takes place in the Southern Cone countries: Argentina, Bolivia, Brazil, Paraguay, and Uruguay. The largest area of soybean by far is located in Brazil accounting for 50% of the sub-regional total. Argentina and Brazil alone hold 90% of the sub-regional area planted with this crop.

South America´s share in the global soybean production by 2009 was 43% (94.91 million tons). In terms of volume, Brazil and Argentina have been the main soybean producers for the past 20 years in the Southern Cone. Worldwide, by 2009 Brazil held 26% of the soybean production and Argentina 24%.

The volume of soybean produced in the Southern Cone of the Americas is related to the planted area. As the area under soybean cultivation increases, so too does the volume harvested. Productivity has a limited influence on the increasing volumes of the regional soybean production since it has been highly variable in the cultivation of both conventional and GM varieties. Accordingly, the introduction of GM soybean has not resulted in the stabilization or increase in sub-regional productivity rates. On the contrary, based on the data analyzed, after the approval of GM soybean an accelerated rate of increase of the area cultivated with soybean has been recorded.

The expansion of the area planted with soybean has followed two patterns: i) occupying larger portions of arable land by substituting or displacing other crops or agricultural activities, and ii) through land use change, specifically from forest or other natural habitats to soybean monocrop. In relation to the first pattern, in the sub-region from 2005 to 2010, an average of 869 thousand hectares of arable land shifted to soybean cultivation every year. By 2009, Brazil, Argentina, and Paraguay had recorded the largest increases of soybean share in their national arable land equaling 36%, 59% and 66%, respectively. That year, 31% of the sub-regional arable land was occupied with soybean.

In relation to the second pattern of expansion of soybean cultivation (land use change), a significant portion of the soybean is being cropped on former forest lands. At both regional and national levels, as the area cultivated with soybean increases, forest areas decrease. In consequence, the ratio of forest area to that of soybean is shrinking rapidly. For example, in Argentina this ratio decreased from 7:1 in 1991 to barely 5:1 in 1996, the year of the introduction of GM soybean.

In terms of land management, the predominance of soybean in the Southern Cone agriculture is the result of two other processes. One process is the accelerated increase of the area cultivated with soybean in comparison to other crops. For instance, in Argentina from 2001 to 2010, the area planted with soybean grew by 63%, while sorghum only increased by 22%. The other process is the decrease in the area cultivated

with other crops than soybean. For example, in Paraguay from 2001 to 2010, the area planted with cassava reduced by 27% while soybean increased by 99%. These numbers confirm the dominance of soybean in the agriculture of the sub-region, which derives in greater competition for arable land between soybean and other agricultural activities, as well as an overall increase in the land dedicated to agriculture (through the expansion of the agricultural frontier into natural habitats such as forest).

Most of the soybean production in the Southern Cone is large-scale (i.e. on areas bigger than 500 hectares), which leads to land concentration. For instance in Brazil in 2006, 5% of the soybean producers managed 59% of the planted area. In Bolivia during the 2009/10 season, 2% of the producers managed 52% of the area cultivated with soybean. This process of land concentration into fewer producers has been increasing, meaning that a small number of people now manage larger areas (reaching even 2,500 to 5,000 hectares per plot in Argentina, Brazil, and Paraguay). In the smaller Southern Cone producing countries (e.g. Bolivia, Paraguay and Uruguay), the majority of the soybean and particularly large-scale soybean producers are foreigners. There are a considerable number of Brazilian producers and investors in both Bolivia and Paraguay.

The largest majority of soybean produced in the Southern Cone is GM for tolerance to the herbicide glyphosate. Since the approval of GM soybean in the sub-region (in 1996 in Argentina and Uruguay) it quickly spread until it took over most of the sub-regional area cultivated with this crop. Of the total area planted with soybean in Argentina, Bolivia, Brazil, and Uruguay, an average of 65% was GM in 2005. By 2010 GM soybean was on average 85% of the total produced in Argentina, Bolivia, and Brazil.

Soybean Production and Pesticides Use

The increase in the area planted with soybean in the Southern Cone has been accompanied by an increase in the use of pesticides, particularly herbicides and especially the herbicide glyphosate. For example, in Argentina the volumes of glyphosate applied nearly quadrupled (increasing by a factor of 3.8) in 2000 from the previous year, reaching a total of nearly 101 million liters applied. Since the approval of the glyphosate tolerant varieties, GM soybean have come to dominate the arable land of each soybean producing country in the Southern Cone. Because of this, a direct link between the area under GM soybean production and increased herbicide use can be established. Hence, it is not surprising that a significant rise in glyphosate use has been recorded in the few years since the approval of glyphosate tolerant GM soybean.

The main factors driving this increase in herbicide use in the Southern Cone are the high adoption of glyphosate tolerant GM soybean and the implementation of no tilling systems, which rely on glyphosate applications. Both factors result in the appearance of weeds resistant to this herbicide, which at the same time derives in the increasing use of more toxic pesticides (e.g. 2,4-D and paraquat according to the 2009 World Health Organization Recommended Classification of Pesticides by Hazard). The majority of the herbicides used in the sub-region come from China, Brazil, and Argentina.

Concluding Remarks

Soybean production in the Southern Cone of the Americas is widespread in terms of area occupied, which is in constant expansion particularly after the approval of GM soybean tolerant to the herbicide glyphosate. The growth in the volume of soybean harvested in the sub-region is the result of the increase in the cultivated area, not the improvement of productivity. Productivity of soybean has remained highly variable, even after the introduction of GM varieties. The data analyzed shows that together with the growing area of soybean cultivation - particularly after the approval of GM soybean - the substitution and displacement of other crops and agricultural activities have increased as well. Since the majority of the soybean produced in the sub-region is GM, the expansion of soybean cultivation is accompanied by increases in the volumes of glyphosate applied, and other more toxic herbicides used to control resistant weeds. The expansion of the soybean in the Southern Cone has also exacerbated deforestation and land concentration.

The massive production of soybean in the Southern Cone of South America is being largely driven by economic globalization, in which demand originating in a geographically distant places (e.g. Europe and China), impacts the organization of production and the socioeconomic dynamics of the producing places. A clear outcome is the externalization of the ecological, social and public health costs deriving from soybean production. A more comprehensive analysis of the implications of soybean cultivation is required to assess the real cost of its production in the Americas.

Preface

This report aims to contribute to a better understanding of the implications of soybean production. To that end, it compiles and analyzes data on land and pesticide use in the main soybean producing countries of the Southern Cone of South America. The Southern Cone is a sub-region that includes the following soybean producing countries: Argentina, Bolivia, Brazil, Paraguay, and Uruguay. In order to contextualize the information related to the Southern Cone, additional information on soybean production at the global and regional level (South America) is included.

This document is based on statistics that has been generated by national official bodies, specialized institutions, and organizations that produce first hand data on soybean cultivation. Statistics from the United Nations Program on Food and Agriculture (FAO) have also been included. Complementary information is presented in topic-specific text boxes, some of these containing official data and information reported in published literature.

As mentioned above, this report specifically focuses on land and pesticide use related to soybean production in the Southern Cone. Given the wide literature on these topics, together with the difficulty of accessing official information, this report is not exhaustive. Specific issues on land (e.g. impacts on soil fertility) and effects of pesticides (e.g. public health issues related to pesticides used in soybean production) have not been included. Moreover, while the importance of economic drivers in the current land use and pesticide management in soybean production in the Southern Cone is acknowledged by the authors, these aspects fall outside the scope of the report, accordingly they are not addressed.

Finally, this report is the joint effort of researchers from academic institutions and non-governmental organization (NGOs). The research synergies of these two sectors have greatly contributed to a more comprehensive analysis of the information compiled.

I Background

1.1 Introduction and Consolidation of Soybean Production in South America

Soybean *(Glycine max)* has a long history in South America going back nearly 130 years. Table 1 summarizes the phases of soybean introduction and expansion in South America. The first recorded introduction occurred in Brazil at the end of the 19th Century (1882), followed by further introductions in Argentina, Colombia, and Paraguay in the first third of the 20th Century. These initial introductions marked the first phase of soybean production in the region, which mostly aimed at experimentation and adaptation (Bonato and Bonato, 1987), as well as self-consumption particularly by Asian immigrants (Pérez, 2007).

During the first half of the 20th Century, soybean production in the Americas was concentrated in the United States of America (USA). The concentration of soybean production in the USA took place after World War II due to the almost exclusive rights to the global production and export of soybean – among other oleaginous crops, that the USA acquired through the Marshall Plan and the General Agreement on Tariffs and Trade (GATT) (Schlesinger, 2006).

Two factors shifted soybean production from the USA to South America: i) a moratorium on USA soybean production and by-products. This moratorium was established in the 1960s due to the shortage of production resulting from severe droughts in the country. ii) A decrease in sources of protein for animal production. Due to weather conditions in the 1970s, the sources of protein utilized to prepare animal feed formulations (typically anchovies) dropped dramatically resulting in the need for alternative sources of protein (Pérez, 2007). Accordingly, in the 1970s soybean production in South America, specifically in the Southern Cone experienced its first boom (Schlesinger, 2006; Pérez 2007), mainly in Brazil (Schlesinger, 2006). This marked the second phase of soybean expansion in South America.

The adoption of soybean production in Brazil was also facilitated by an important technical factor: the development of cultivars adapted to southern tropical areas (e.g. like Amazonia region). For the first time, in the 1970s cultivars insensitive to short daylight (in other words, short photoperiod) were developed in Brazil (Campelo et al. 1999). The practical implications of this have been the development of late-flowering varieties that facilitated mechanized harvesting and reduction of the soybean's growing season (Hartwig and Kiihl, 1979).

Besides this technological driver, the consolidation and expansion of soybean production in South America has been facilitated by several compounding factors, which according to Kreidler et al. (2004), Pérez (2007) and Suárez et al. (2010) are:

- Opening of market opportunities for soybean and by-products accompanied by high prices on the international market.
- Inclusion of soybean production and consumption in different agricultural and development programs.
- Strong economic incentives that benefited the production of oleaginous crops (e.g. exemption of taxes on the industrialization and trade of soybean, financial support to the private sector, and more credit facilities, among others).
- Construction of infrastructure mostly to facilitate the transport of soybean as harvested or processed products.
- Introduction of a technological package suitable for large-scale production. The introduction of genetically modified (GM) soybean varieties tolerant to herbicides and their related technological package (such as no-tilling system) marked the beginning of the third phase of soybean production in the region.

Table 1.
Phases of soybean introduction and consolidation in South America

Phase	Period of time	Characteristic
I Introduction	From late 19th Century to the first third of the 20th Century	Initial introduction for experimentation, adaptation and self-consumption purposes
II Steady growth	From the 1970s to the mid 1990s	Consolidation and expansion of commercial soybean production in the Southern Cone of South America
III Accelerated growth	From the mid 1990s onwards	Approval of GM varieties and accelerated increase of area planted with soybean

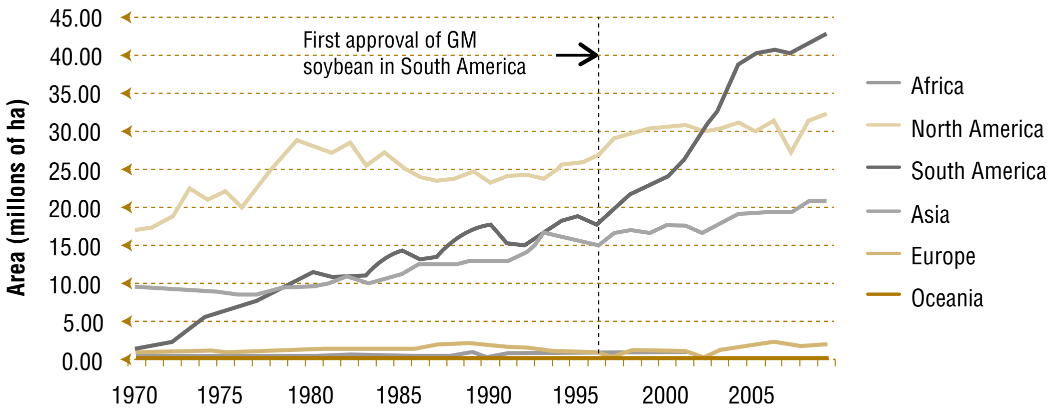
Source: Authors´work based on Bonato and Bonato (1987); Schlesinger (2006); Pérez (2007).

1.2 Overview of Soybean Production Worldwide and in South America

1.2.1 Growth of the Planted Area

South America is the region with the fastest growing area planted with soybean (Figure 1). During the last four decades, South America has increased its production area almost 30-fold (from 1.44 to 42.75 million hectares from 1970 to 2009). In 1978, South America surpassed Asia's soybean production area (the second largest at the time) when it reached 9.34 million hectares cultivated with soybean. In 2003, it surpassed North America (the largest producer for decades) when it reached 33.29 million hectares.

Figure 1.
Change in of the area planted with soybean in the different world regions during the last 40 years



Source: Authors´ work based on FAOSTAT (2011a).

The global area planted with soybean increased during the last 40 years following two different phases: steady and accelerated growth (refer to Table 2 for detailed data):

- The ***steady growth phase*** took place from the 1970s to the mid 1990s (approximately 25 years) during the period of commercial soybean production with conventional varieties, improved and adapted to the ecological conditions of the Southern Cone. In this period, the area planted with soybean increased 9-fold (from 1.87 to 18.91 million hectares), while in the other main producing regions, North America and Asia, it increased by about 48% and 69%, respectively. This growth in land surface planted with soybean in South America equaled more than 17 million hectares (from 1970 to 1995) with an average increase of 0.68 million hectares per year.

- The ***accelerated growth phase*** started in the period of approval of commercial production of GM soybean varieties. From 1996 to 2009, the area planted with soybean increased almost

140% (from 17.60 to 42.15 million hectares), in other words, it expanded over an area of 25 million hectares in 15 years, with an average increase of 1.80 million per year. North America and Asia experienced arise increase of approximately 22% and 40%, respectively, during the same years.

Although the percentage of increase in area planted with soybean is notably much higher in the steady growth phase (900% vs. 140%), in absolute terms the overall total and annual growth rate is much higher in the accelerated growth phase (17 million hectares vs. 25 million hectares; and 0.69 million hectares / year vs. 1.8 million hectares / year) (Table 2).

Table 2.
Comparison of the area planted with soybean among the main world production regions

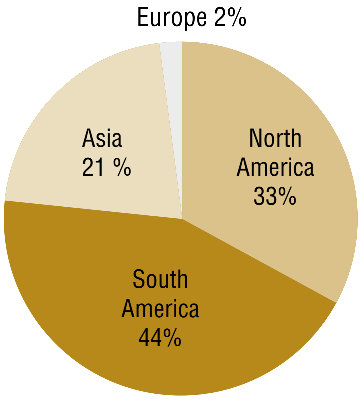
Steady growth phase				
From 1971 to 1995 of soybean production with conventional varieties				
		South America	**North America**	**Asia**
Area (10^6 ha) in:	1971	1.87	17.43	9.32
	1995	18.91	25.73	15.75
Increase:	On area (10^6 ha)	17.04	8.30	6.42
	Annual average (10^6 ha)	0.68	0.33	0.26
	% From 1971 to 1995	912.44	47.62	68.91
Accelerated growth phase				
From 1996 to 2009 of soybean production with conventional and GM varieties				
		South America	**North America**	**Asia**
Area (10^6 ha) in:	1996	17.60	26.49	15.05
	2009	42.75	32.29	20.99
Increase:	On area (10^6 ha)	25.15	5.80	5.94
	Annual average (10^6 ha)	1.80	0.41	0.42
	% From 1996 to 2009	142.90	21.89	39.47

Source: Authors´ work based on FAOSTAT (2011a).

1.2.2 Distribution of the Cultivated Area

Since 2003, South America has held the largest area planted with soybean (Figure 1), resulting from the constant and swift expansion of this crop in the region. In 2009, according to FAOSTAT (2011a), the total world area planted with soybean was 98.17 million hectares, out of which almost 44% were located in South America (Figure 2).

Figure 2.
Distribution of the global area planted with soybean in 2009



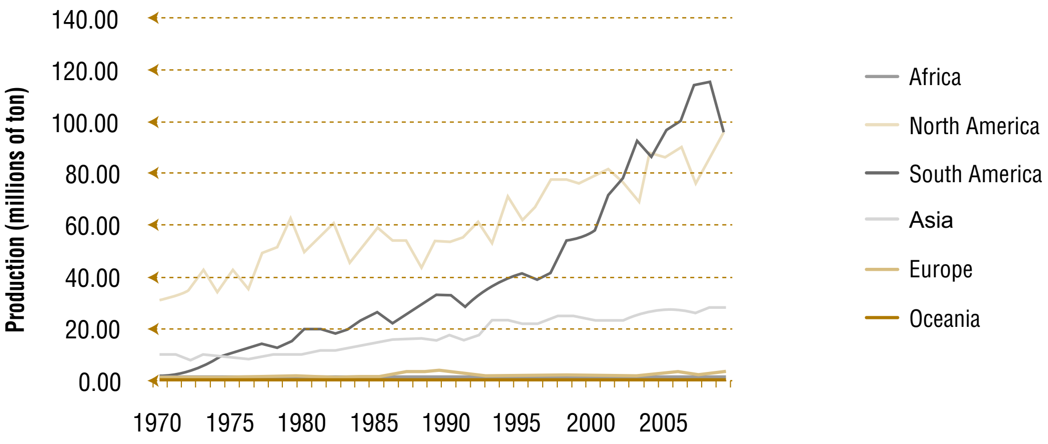
Source: Authors´ work based on FAOSTAT (2011a)

1.2.3 Production Volumes

The trajectory of global soybean production reveals a close relationship between the expansion of the area under production and the increase of the volumes harvested (compare Figure 1 and Figure 3). Later in this report (Figure 9 and Figure 10), this close relationship can also be seen in each of the major South American soybean producing countries and in South America as a whole.

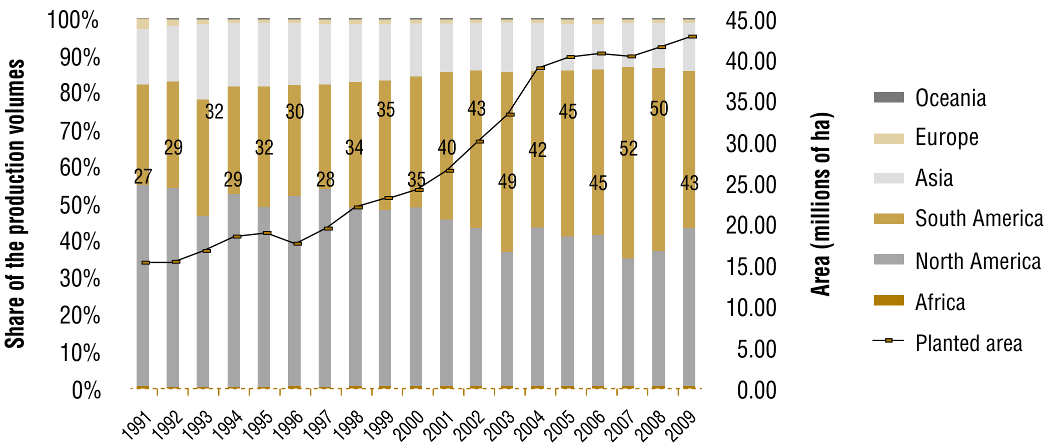
As South America holds the largest area planted with soybean (Figure 1), it also currently produces the largest volume of this crop (Figure 3). Accordingly, as the total area planted with soybean has increased, so too has the South American share of global soybean production (Figure 4), surpassing the volumes produced in North America in 2003 and from 2005 to 2008. In 2009, out of the 222.94 million tons of soybean harvested globally, 43% (equivalent to 94.91 million tons) was produced in the region.

Figure 3.
Change in the volumes of soybean production in the different world regions from 1991 to 2009



Source: Authors´ work based on FAOSTAT (2011b)

Figure 4.
Distribution of the global production of soybean from 1991 to 2009



Source: Authors´ work based on FAOSTAT (2011a; 2011b).

II Soybean Production and Land Use in the Southern Cone

2.1 *The Production Area*

2.1.1 Growth of the Planted Area

The increase in the area planted with soybean in the Southern Cone countries caused a boom in soybean production in the South American region and globally, in recent years (Figure 1).

For the last two decades, the area planted with soybean in the Southern Cone has experienced an increase of about 204%, 31.37 million hectares from 1991 to 2010 (Table 3). From this total, almost 45% of the increase took place in Argentina and 44% in Brazil, totaling 89% in these two countries alone. From 1991 to 2010, soybean plantations in the sub-region increased at an average rate of 1.57 million hectares per year.

Table 3.

Change in the area planted with soybean in the Southern Cone soybean producing countries from 1991 to 2010

Country	Year	Area (10^6 ha)	Period	Total increase in the period* (10^6 ha)	Average annual increase* (10^6 ha)	% Increase in the period*
Argentina	1991	5.00	1991-1995	1.00	0.20	20.00
	1995	6.00	1995-2000	4.66	0.78	77.67
	2000	10.66	2000-2005	4.73	0.79	44.37
	2005	15.39	2005-2010	3.61	0.60	23.46
	2010	19.00	1991-2010	14.00	0.70	280.00
Bolivia	1991	0.19	1991-1995	0.24	0.05	121.60
	1995	0.43	1995-2000	0.19	0.03	44.04
	2000	0.62	2000-2005	0.31	0.05	50.01
	2005	0.93	2005-2010	-0.01	0.00	-0.63
	2010	0.92	1991-2010	0.73	0.04	375.80
Brazil	1991	9.62	1991-1995	2.06	0.41	21.40
	1995	11.68	1995-2000	1.97	0.33	16.83
	2000	13.64	2000-2005	9.31	1.55	68.25
	2005	22.95	2005-2010	0.34	0.06	1.50
	2010	23.29	1991-2010	13.68	0.68	142.22
Paraguay	1991	0.55	1991-1995	0.18	0.04	33.08
	1995	0.74	1995-2000	0.46	0.08	63.15
	2000	1.20	2000-2005	0.80	0.13	66.67
	2005	2.00	2005-2010	0.68	0.11	34.01
	2010	2.68	1991-2010	2.13	0.11	384.96
Uruguay	1991	0.02	1991-1995	-0.01	0.00	-40.74
	1995	0.01	1995-2000	0.00	0.00	-19.09
	2000	0.01	2000-2005	0.27	0.04	3,023.16
	2005	0.28	2005-2010	0.59	0.10	210.53
	2010	0.86	1991-2010	0.84	0.04	4,550.13
Southern Cone	1991	15.38	1991-1995	3.47	0.69	22.55
	1995	18.85	1995-2000	7.28	1.21	38.60
	2000	26.13	2000-2005	15.42	2.57	59.01
	2005	41.54	2005-2010	5.21	0.87	12.55
	2010	46.76	1991-2010	31.37	1.57	203.98

* The data relates to the specified period only. Different time periods will result in different rates of change of soybean production in absolute (ha) or percentage terms. Accordingly, the negative figures relate to the difference between the specified years and do not reflect the constant trend in the given period.

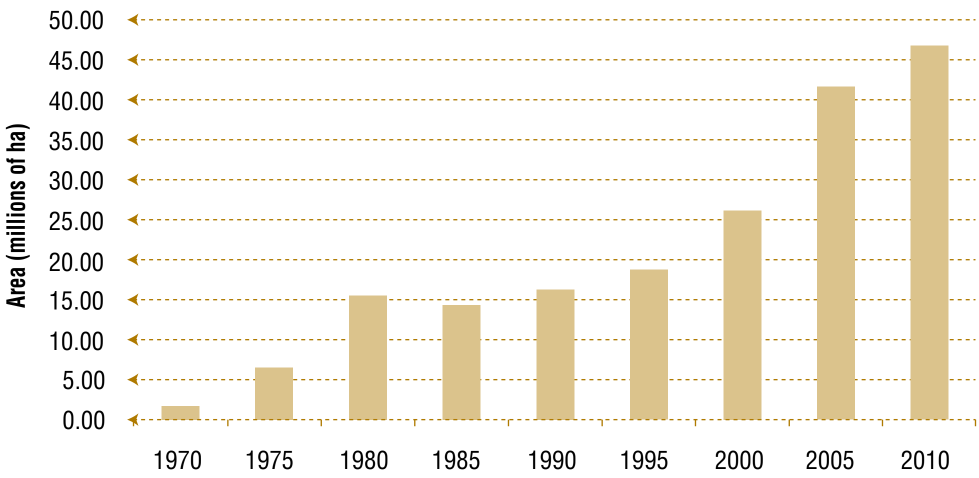
Source: Authors´ work based on data from Ministry of Agriculture of Argentina (2011); INE & MDRyT / SISPAM (2011); ABIOVE (2011); CAN (2008); MGAP-DIEA (2011a); FAOSTAT (2011b).

2.1.2 Distribution of the Planted Area

The Southern Cone countries hold the vast majority of the area cultivated with soybean in the South American region. In 2010 this area totaled 46.76 million hectares (Table 3 and Figure 5). Historically, Brazil and Argentina have been the largest soybean growers in the sub-region (Figure 6). In 2010, Brazil represented about 50% of the total sub-regional area cultivated with this crop (23.29 million hectares) and Argentina about 40% (19 million hectares) (Table 3). Accordingly, in this year Brazil and Argentina together accounted for 90% of the total sub-regional surface with soybean while the remaining 10% was distributed among Paraguay, Bolivia, and Uruguay (Figure 7). Until 1995, Brazil roughly doubled the area cultivated with this crop compared to Argentina; however, from 1996, this ratio has been continuously decreasing due to the rapid growth of the soybean area in the latter country since the approval of GM varieties (by 2007, the surface under soybean cultivation in Argentina was only 25%, approximately, smaller than in Brazil).

Figure 5.

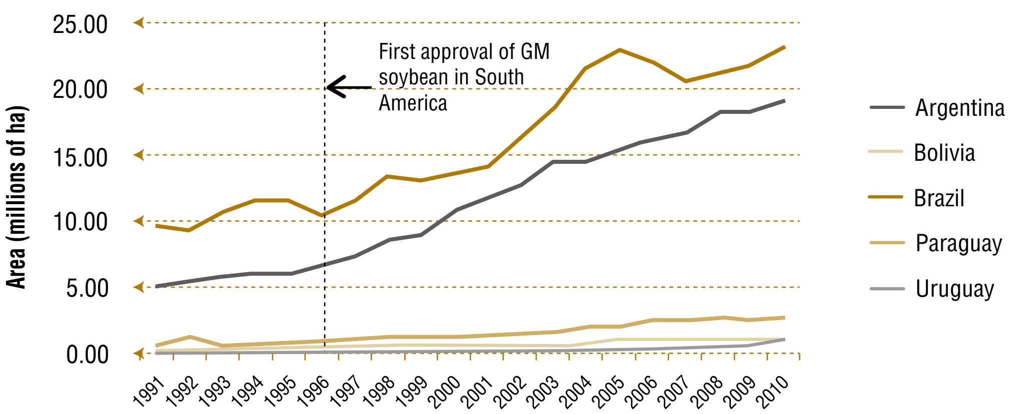
Total area planted with soybean in the Southern Cone from 1970 to 2010



Source: Ministry of Agriculture of Argentina (2011); INE & MDRyT / SISPAM (2011); MGAP-DIEA (2011a); FAOSTAT (2011b).

Figure 6.

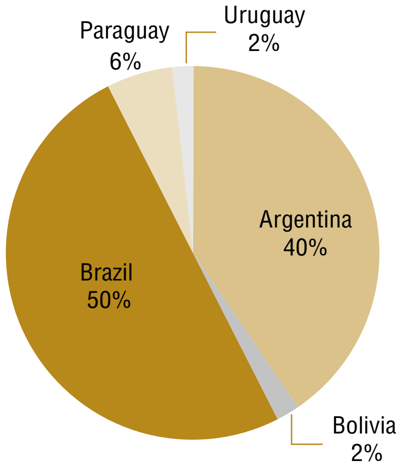
Area planted with soybean in the Southern Cone countries during the last 20 years (1991-2010)



Source: Authors´work based on data from Ministry of Agriculture of Argentina (2011); INE & MDRyT / SISPAM (2011); ABIOVE (2011); CAN (2008); MGAP-DIEA (2011a); FAOSTAT (2011b).

Figure 7.

Distribution of the area cultivated with soybean among the Southern Cone countries in 2010



Source: Authors´ work based on data from Ministry of Agriculture of Argentina (2011); INE & MDRyT / SISPAM (2011); ABIOVE (2011); CAN (2008); MGAP-DIEA (2011a); FAOSTAT (2011b).

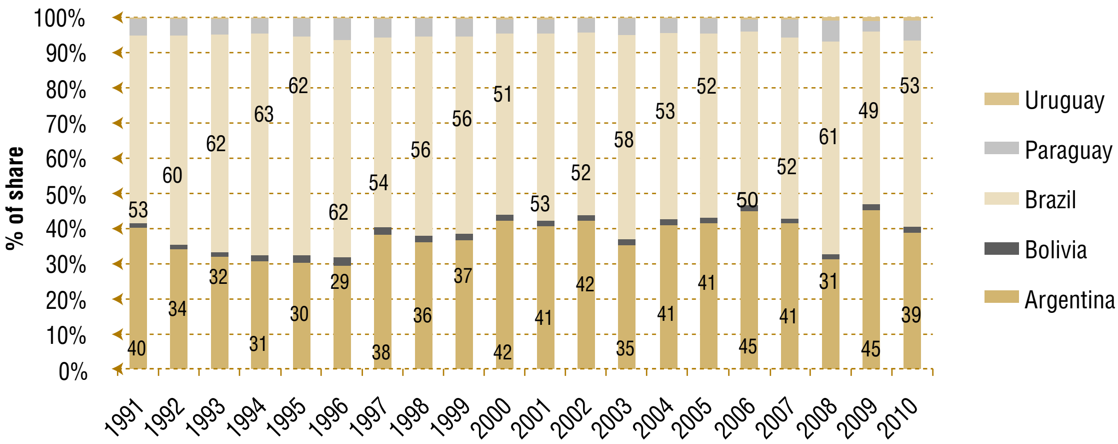
2.1.3 Production Volumes

As in the case of planted area, Brazil and Argentina are also the largest producers of soybean in terms of volume in the Southern Cone. Consequently, they hold the largest share of total sub-regional production (Figure 8). Over the past 20 years, Brazil has provided from 50 to 62% of the total sub-regional soybean harvest, while Argentina from 30 to 45%.

By 2009 the total sub-regional production was 116.36 million tons, out of which 57.35 and 52.67 million were produced by Brazil and Argentina, respectively. These volumes made Brazil the second largest world producer of soybean, holding 26% of the world total, and Argentina as the third with 24% of the global share (FAOSTAT, 2011b). In 2010, the volumes produced in the Southern Cone increased by nearly 11% reaching an approximate total of 130 million tons of soybean harvested (68.5 million produced by Brazil and 50 million by Argentina).

Figure 8.

Distribution of the soybean production among the Southern Cone countries from 1991 to 2010



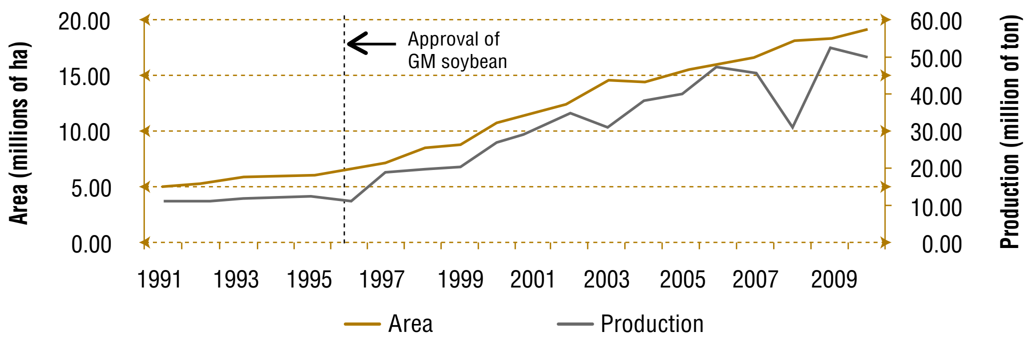
Source: Authors´ work based on data from the Ministry of Agriculture of Argentina (2011); INE and MDRyT / SISPAM (2011); ABIOVE (2011); CAN (2008); MGAP-DIEA (2011a); FAOSTAT (2011b).

The increase in the volume of soybean produced in the Southern Cone countries is directly related to the increase in area under soybean cultivation. Figure 9 shows that as the area used for soybean production rises, so too does the volume harvested. In other words, the larger the area of production, the larger the volumes of harvested soybean, regardless of the type of varieties sown (either conventional or GM varieties). Considering that during the last five years the largest proportion of soybean produced in the sub-region has been GM (see section 2.4), it can be said that the introduction of GM varieties did not result in a decrease or even maintenance of the area devoted to soybean production. On the contrary, an even faster expansion of the area under soybean cultivation has been recorded in the last years. An overall South American view shows more clearly the connection between increase in area and increase in soybean production (Figure 10). The next section further develops this in terms of the production / productivity relationship recorded in soybean production in the Southern Cone.

Figure 9.

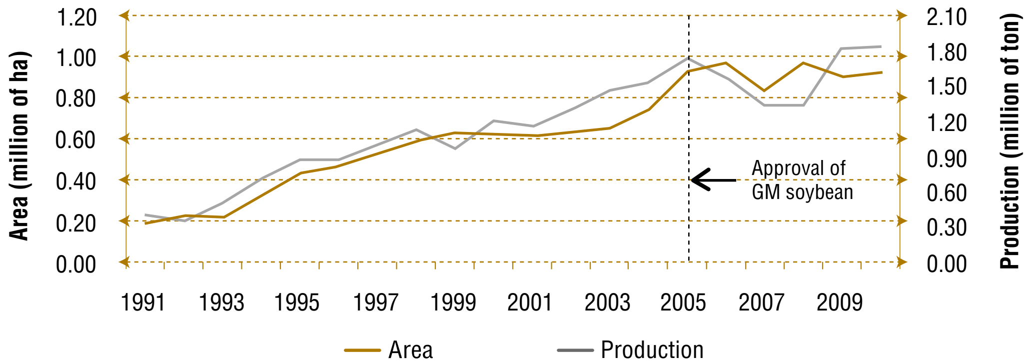
Variation of the area planted with soybean and volume harvested in the Southern Cone soybean producing countries during the last 20 years

a) Argentina



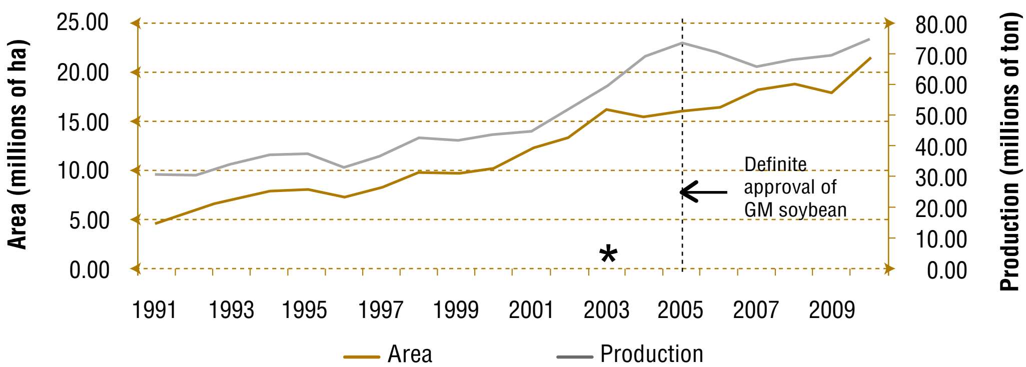
Source: Authors' work based on data from the Ministry of Agriculture (2011).

b) Bolivia



Source: Authors' work based on data from INE & MDRyT / SISPAM (2011).

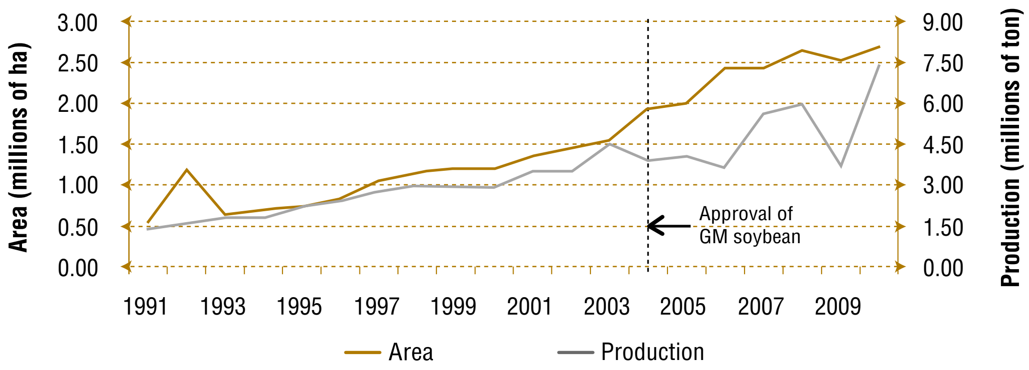
c) Brazil



* Provisional approval of GM soybean

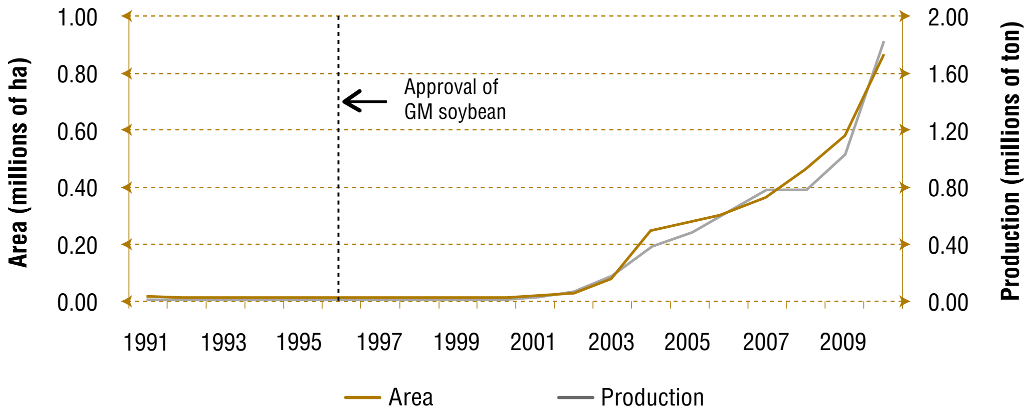
Source: Authors' work based on data from ABIOVE (2011); FAOSTAT (2011a; 2011b).

d) Paraguay



Source: Authors' work based on data from CAN (2008); FAOSTAT (2011a; 2011b).

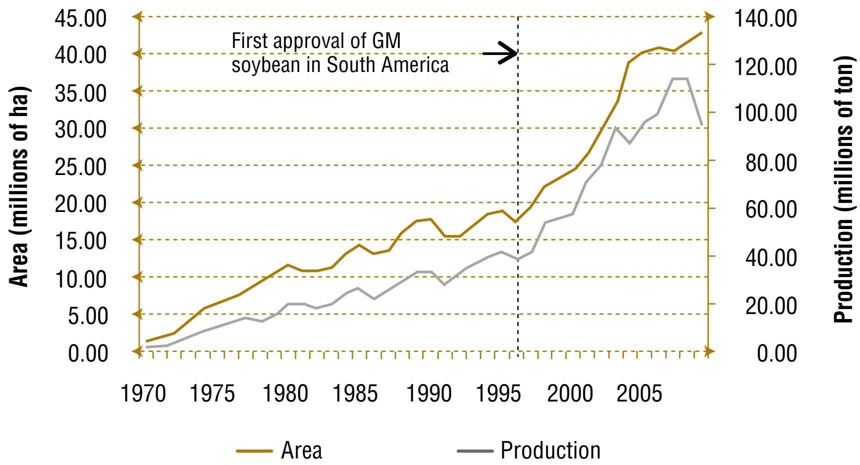
e) Uruguay



Source: Authors' work based on data from MGAP-DIEA (2011a).

Figure 10.

Increase of the area planted with soybean and volume harvested in South America from 1971 to 2009



Source: Authors´ work based on FAOSTAT (2011a; 2011b).

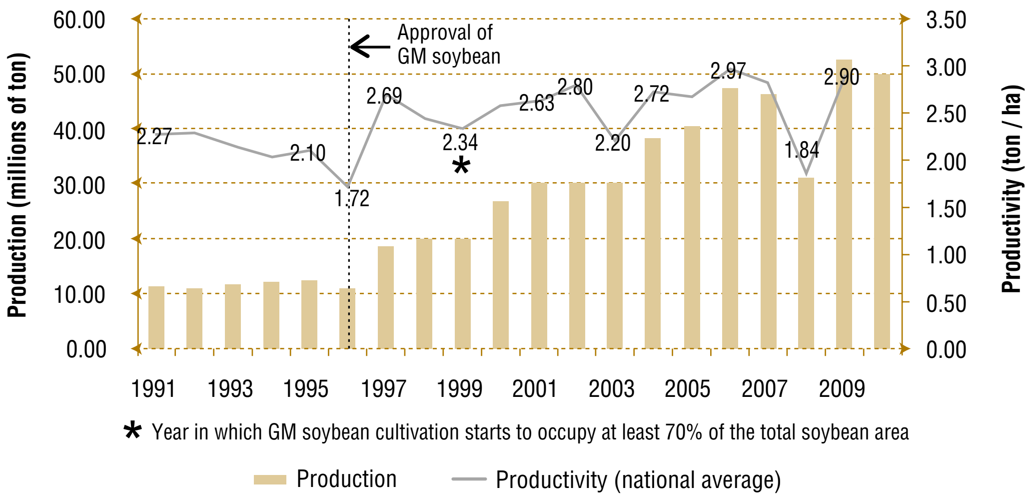
2.1.4 Productivity

Contrary to the trend of continuously increasing the area cultivated and volume harvested, the productivity of soybean in the Southern Cone has been remarkably varied. The data from the last 20 years, in both periods of production with conventional as well as GM varieties, indicate that productivity in the sub-region has experienced significant ups and downs in short periods of time, even between consecutive years in some cases (Figure 11).

Figure 11.

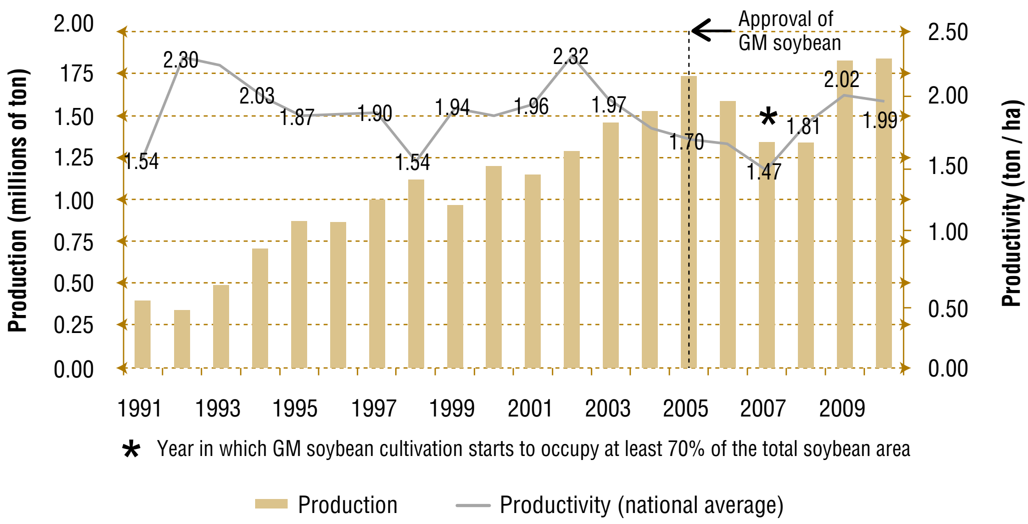
Production and productivity of soybean in the Southern Cone soybean producing countries from 1991 to 2010

a) Argentina



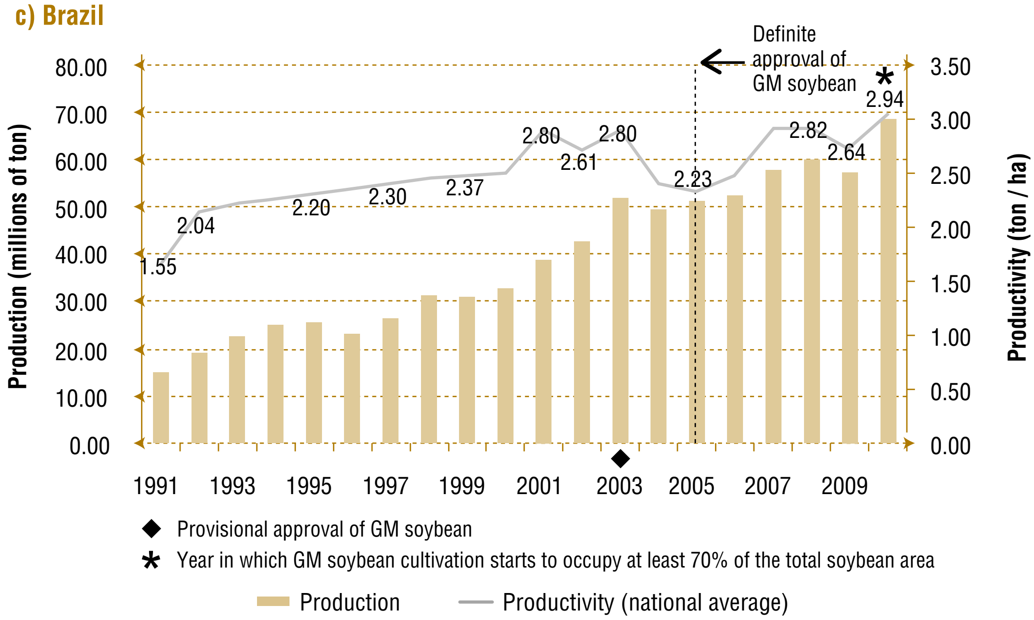
Source: Authors' work based on data from the Ministry of Agriculture (2011).

b) Bolivia



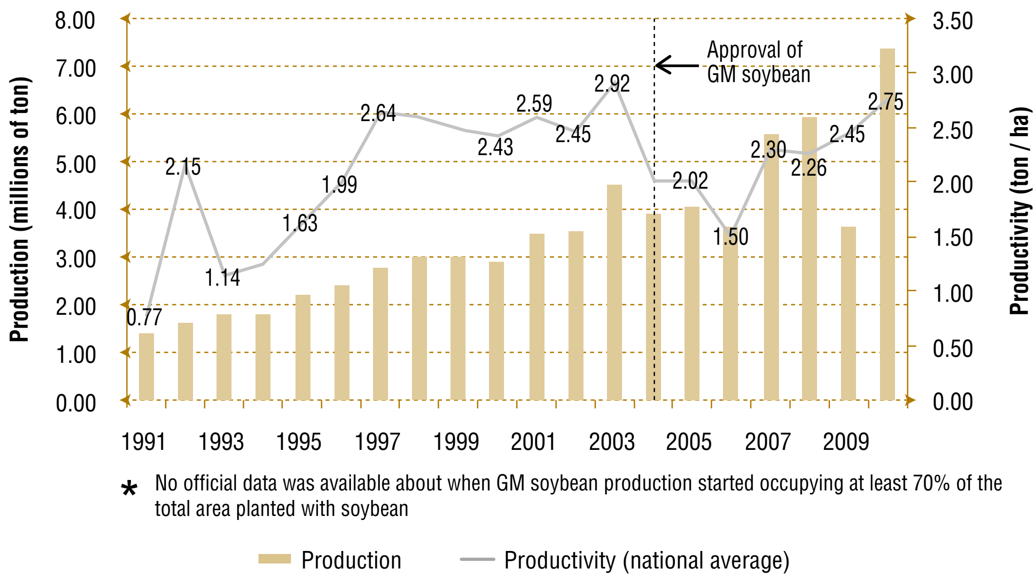
Source: Authors' work based on data from INE and MDRyT / SISPAM (2011).

c) Brazil



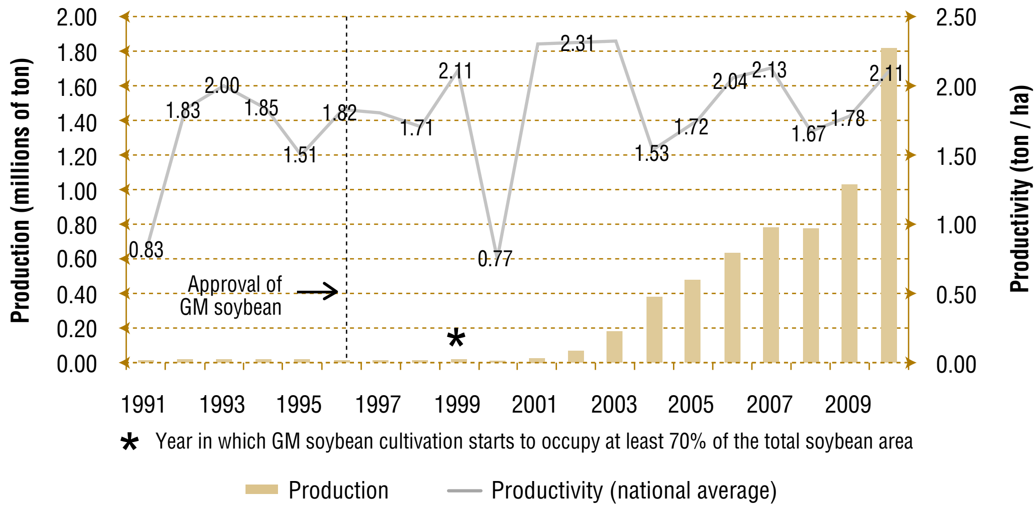
Source: Authors' work based on data from ABIOVE (2011); FAOSTAT (2011a).

d) Paraguay



Source: Authors' work based on data from CAN (2008); FAOSTAT (2011a).

e) Uruguay



Source: Authors' work based on data from MGAP-DIEA (2011a).

Based on the data available, it can be stated that the introduction of GM soybean varieties in Southern Cone agriculture did not contribute to the improvement or stabilization of national soybean productivity rates. When comparing the annual productivity average from the periods of cultivation of conventional and GM varieties (Table 4), similar productivity can be noted after the approval of GM soybean. Moreover, in Bolivia and Paraguay, the highest productivity levels have decreased; and in general terms, the lowest rates have become even lower (with exception of Brazil and Paraguay).

It is important to mention that productivity is the result of multiple factors beyond the genetic makeup of the agricultural varieties used (GM or non-GM) (Heinemann, 2009; IAASTD ed., 2009). One factor, for instance, is the improvement of the conventional parental varieties used for developing GM varieties. For example, in the case of Brazil (Figure 11c), the trend towards an increase in productivity of soybean is seen before the introduction of GM varieties. Accordingly, it is probable that this tendency resulted from more productive conventional varieties (either for direct cultivation or for development of GM soybean), or other factors, such as intensification of land management, fertilization schemes and pest management, may have also influenced the productivity rates registered in this country.

Table 4.

Average, highest and lowest productivity levels recorded before (from 1991) and after (to 2010) the approval of GM soybean in the Southern Cone countries

		Productivity (tons / year)				
		Argentina	**Bolivia**	**Brazil**	**Paraguay**	**Uruguay**
Period of production with conventional varieties	**Period**	1991-1995	1991-2004	1991-2004	1991-2003	1991-1995
	Average	2.17	1.94	2.30	2.08	1.61
	Max.	2.29	2.32	2.80	2.92	2.00
	Min.	2.04	1.54	1.55	0.77	0.83
Period of production with GM varieties	**Period**	1996-2009*	2005-2010	2005-2010	2004-2010	1996-2010
	Average	2.52	1.77	2.64	2.18	1.87
	Max.	2.97	2.02	2.94	2.75	2.32
	Min.	1.72	1.47	2.23	1.50	0.77

* Official data on the productivity level in Argentina for 2010 was not available.

Source: Authors´ work based on data from Ministry of Agriculture of Argentina (2011); INE & MDRyT / SISPAM (2011); ABIOVE (2011); CAN (2008); MGAP-DIEA (2011a); FAOSTAT (2011b).

In absolute terms, the recorded changes in productivity are small; however they become significant in percentage values, and may have considerable impacts on large-scale production areas, either positively or negatively. This adds pressure for further expansion of the area of soybean production in order to maximize beneficial or minimize adverse effects on production volumes.

Considering that GM varieties have occupied at least 70% of the area of soybean production during most of the period after their approval, the numbers in Figure 11 and Table 4 mostly refer to the performance of GM varieties. Accordingly, the data shows that the national productivity of soybean has remained unstable after the approval of GM soybean. As mentioned previously, this can be the result of several factors beyond the fitness of the GM varieties to perform well in agronomic terms. However, the data reveals that GM varieties have not been able to maintain a stable performance in the local production environments whatever they may be.

Since the volumes of soybean production in the sub-region have been steadily increasing while the productivity rates have been highly variable – and in some years even dropping considerably, again it can be concluded that the most influential factor in the overall production of soybean in the Southern Cone is the area planted. Hence, the increase in the Southern Cone’s share of the global soybean market is the result of expanding the area under soybean cultivation. The next section deals with the question of where this expansion takes place.

2.2 Land Use

The expansion of area planted with soybean has followed two patterns: i) occupying larger portions of the arable land[1] while substituting or displacing other crops or agricultural activities; and ii) increasing the overall amount of agricultural land[2] through land use change (from natural habitats to crop plantations).

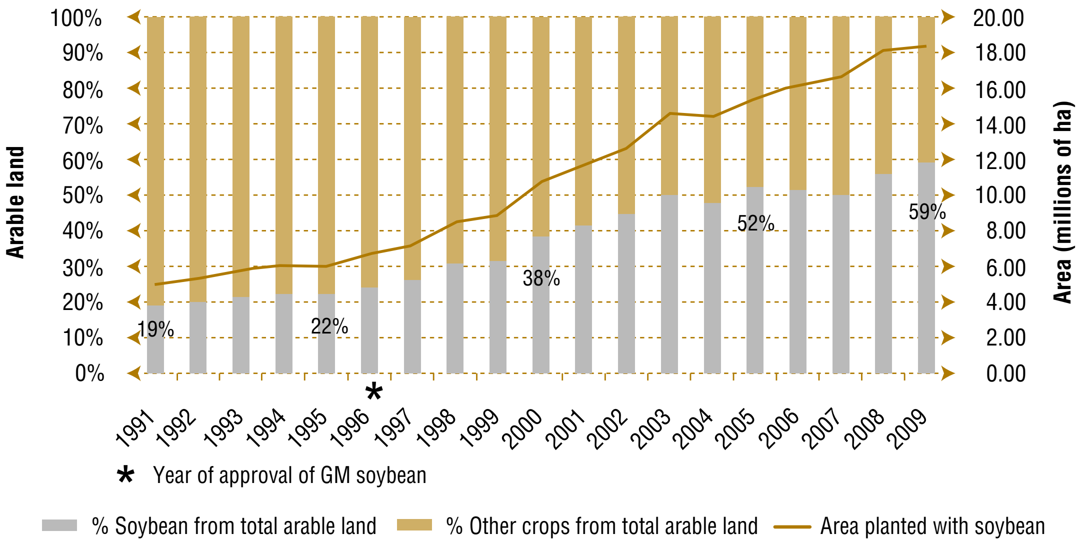
2.2.1 Increasing Area, Increasing Shares of Arable Land and Crop Replacement

As the area cultivated with soybean increases, soybean fields occupy larger portions of the total arable land available nationally (Figure 12). This is the case for each soybean producing country in the Southern Cone sub-region. At the national level, the increase in soybean´s share of arable land has been most dramatic in Argentina and Paraguay. In Argentina, the arable land occupied by soybean increased from 19% in 1991 to 38% in 2000 and 59% in 2009. In Paraguay, the increase amounted to 26%, 40% and 66%, respectively. By 2009, 31% (44.76 million hectares) of the total arable land in the Southern Cone was occupied by soybean cultivation (Table 5).

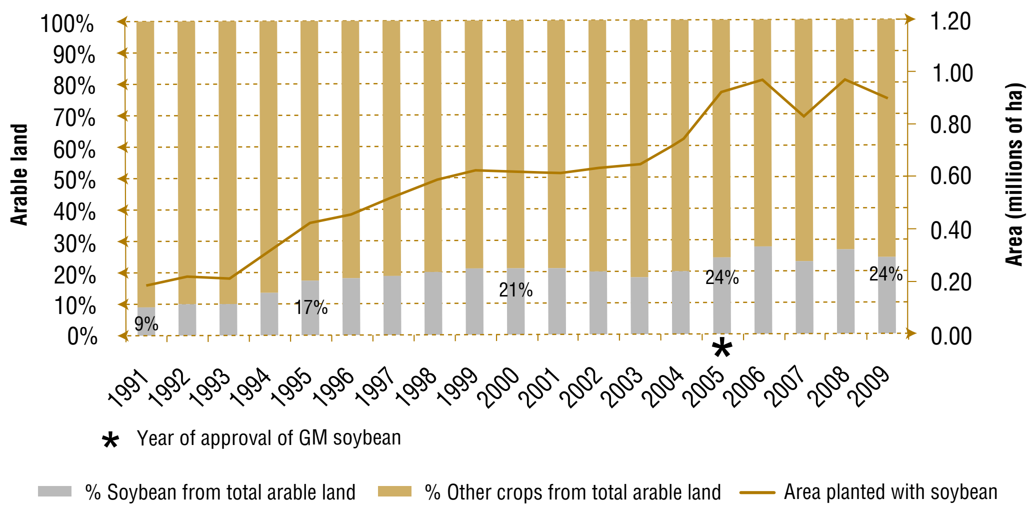
Figure 12.

Percentage of the area planted with soybean in relation to the total arable land in the Southern Cone soybean producing countries from 1991 to 2009

a) Argentina



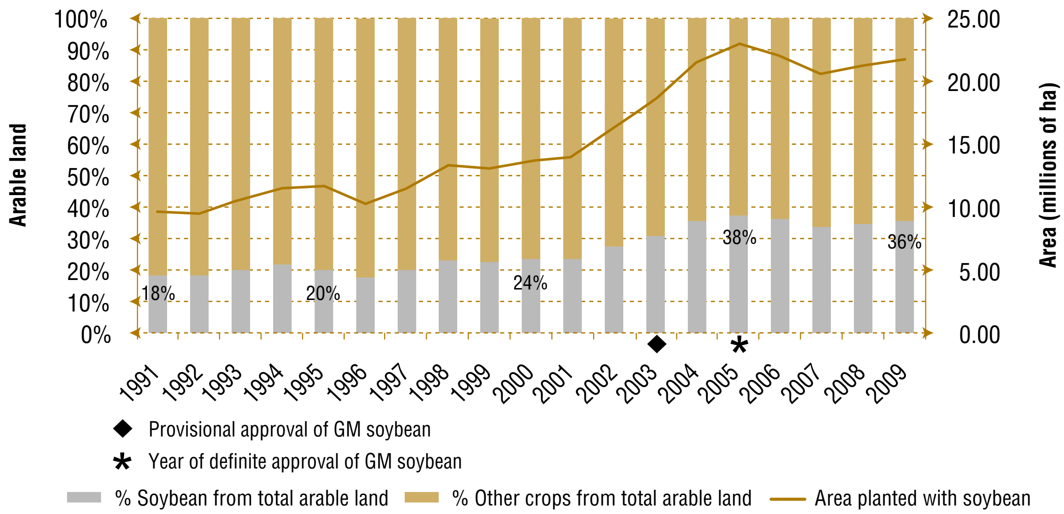
b) Bolivia



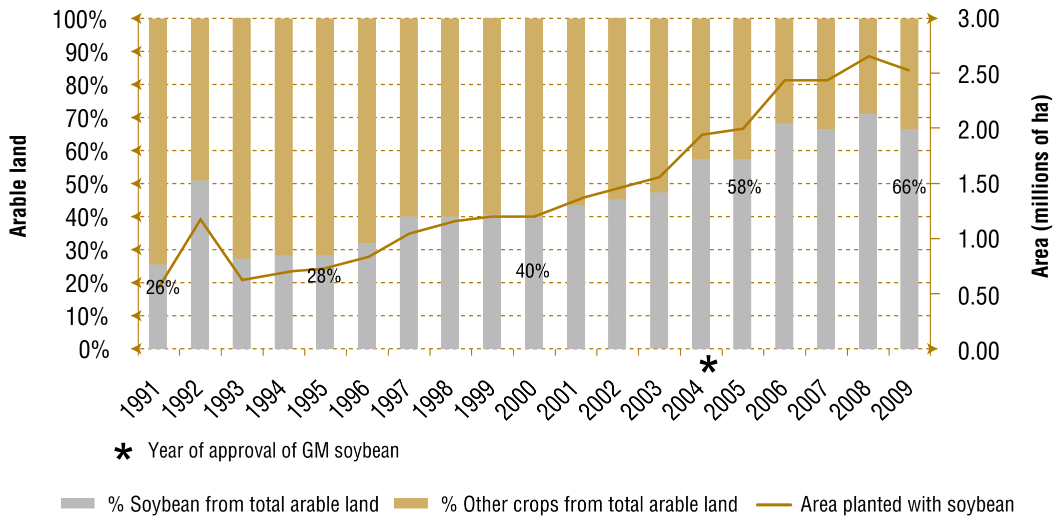
[1] According to FAOSTAT (2011c), "Arable land is the land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily in fallow (less than five years)".

[2] According to FAOSTAT (2011c), agricultural land is the sum of arable land and permanent pastures.

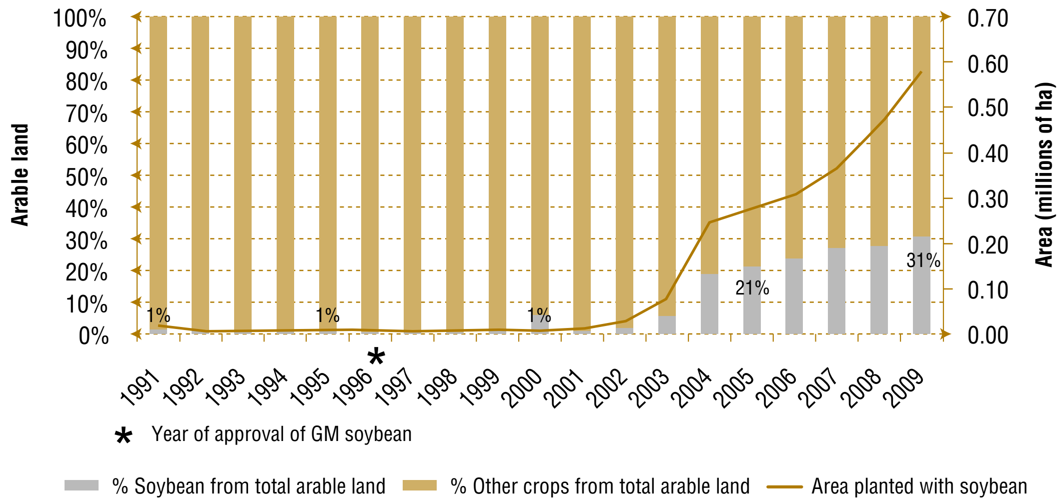
c) Brazil



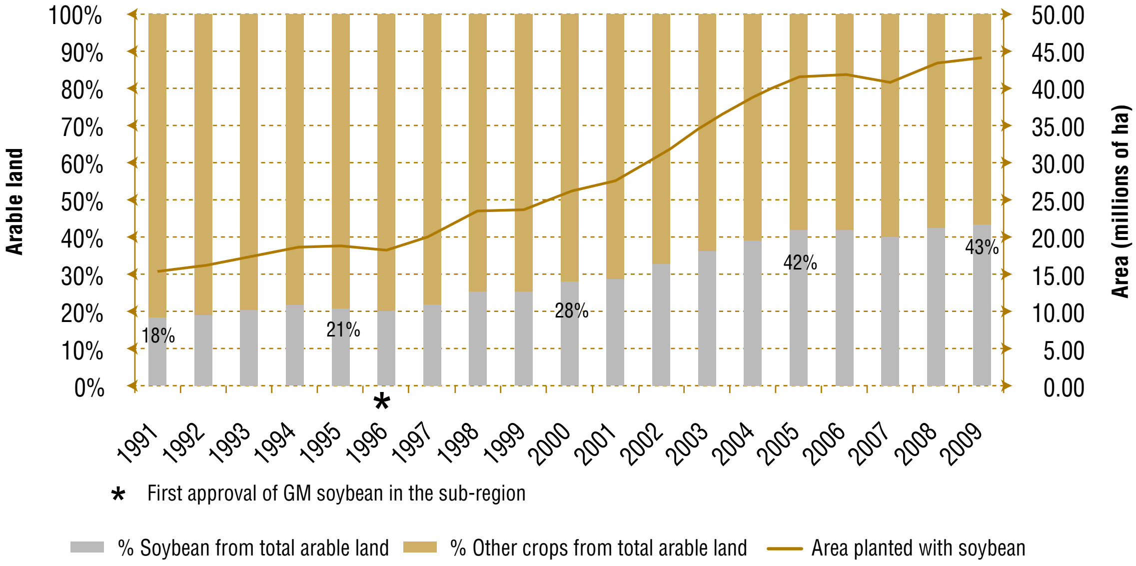
d) Paraguay



e) Uruguay



f) Southern Cone



Source: Authors´ work based on FAOSTAT (2011a).

Although the largest percentage increases in soybean's share of total national arable land are recorded in Argentina and Paraguay, the largest increase in absolute terms (hectares) has occurred in Brazil. Out of the 61.20 million hectares of total arable land in Brazil in 2009, approximately 36% (21.75 millions) was occupied by soybean, while in Argentina out of the 31.00 million hectares of arable land, 59% (18.34 millions) was used for soybean production in the same year (Table 5).

In the whole Southern Cone, soybean has expanded at an average rate of 869 thousand hectares per year from 2005 to 2010. The major increases have been recorded in Argentina (with an average of 602 thousand hectares per year) and Paraguay (113 thousand hectares per year). Brazil recorded an increase of 57 thousand hectares per year on average over the same period of time.

The large and ever increasing proportion of soybean's share of the arable land at national and sub-regional levels not only confirms the expansion of this crop, but also reveals its dominance over others. In 2009, 64%, 41% and 34%, of the total arable land in Brazil, Argentina and Paraguay, respectively, was available for a wide portfolio of crops cultivated in these countries, while only one (soybean) occupied a corresponding percentage of 36%, 59% and 66% of their arable land. The predominance of soybean is also clear in Bolivia and Uruguay, where in 2009 soybean was cultivated in 24% and 31%, respectively, of the nations' available arable land.

Table 6 details how prevalent soybean cultivation is in the Southern Cone soybean producing countries in terms of the ratio of soybean area to other crops. The most severe cases are in Argentina in relation to sorghum and in Bolivia and Paraguay in relation to beans. In Argentina, for instance, in the year 2000, the area planted with soybean was almost 19 times larger than sorghum, meaning that for every hectare cultivated with sorghum, there were 19 hectares with soybean (19:1). This ratio increased to almost 28:1 in 2005, and due to an increase in the area planted with sorghum in 2009 the ratio was 25:1.

Table 5.

Changes in the area planted with soybean, arable land, and agricultural land in the Southern Cone countries from 1991 to 2009

Country	Years of assessment	Soybean-planted area	Arable land	Agricultural land
		(10^6 ha)		
Argentina	1991	5.00	26.40	127.38
	1995	6.00	27.00	127.94
	2000	10.66	27.90	128.77
	2005	15.39	29.50	134.40
	2009	18.34	31.00	140.50
	2010	19.00	nda	nda
	Increase (ha) 91-09	13.34	4.60	13.12
	Increase (%) 91-09	266.80	17.42	10.30
Bolivia	1991	0.19	2.11	35.80
	1995	0.43	2.50	36.50
	2000	0.62	3.00	37.00
	2005	0.93	3.81	36.96
	2009	0.90	3.74	36.95
	2010	0.92	nda	nda
	Increase (ha) 91-09	0.71	1.63	1.16
	Increase (%) 91-09	365.53	77.25	3.23
Brazil	1991	9.62	52.00	244.94
	1995	11.68	58.06	258.47
	2000	13.64	57.70	261.41
	2005	22.95	61.00	264.50
	2009	21.75	61.20	264.50
	2010	23.29	nda	nda
	Increase (ha) 91-09	12.13	9.20	19.56
	Increase (%) 91-09	126.18	17.70	7.99
Paraguay	1991	0.55	2.15	17.20
	1995	0.74	2.60	16.46
	2000	1.20	3.02	20.33
	2005	2.00	3.46	19.94
	2009	2.52	3.80	20.90
	2010	2.68	nda	nda
	Increase (ha) 91-09	1.97	1.65	3.71
	Increase (%) 91-09	356.82	76.74	21.55
Uruguay	1991	0.02	1.26	14.83
	1995	0.01	1.29	14.86
	2000	0.01	1.37	14.96
	2005	0.28	1.30	14.74
	2009	0.58	1.88	14.81
	2010	0.86	nda	nda
	Increase (ha) 91-09	0.56	0.62	-0.02
	Increase (%) 91-09	3,012.81	49.21	-0.12
Southern Cone	1991	15.38	83.92	440.14
	1995	18.85	91.45	454.23
	2000	26.13	92.99	462.46
	2005	41.54	99.07	470.54
	2009	44.09	101.62	477.66
	2010	46.76	nda	nda
	Increase (ha) 91-09	28.71	17.70	37.52
	Increase (%) 91-09	186.67	21.09	8.53

nda = No official data available by January 31, 2012

Source: Authors´ work based on data from Ministry of Agriculture of Argentina (2011); INE & MDRyT / SISPAM (2011); ABIOVE (2011); CAN (2008); MGAP-DIEA (2011a); FAOSTAT (2011a; 2011b).

Table 6.

Ratio between the area planted with soybean and the area harvested with other economically important crops in the Southern Cone countries in 2001, 2005, and 2010

Country / Crop	2001		2005		2010		% Increase 2001-2010
	Area (10^6 ha)	Soybean: Other crops ratio	Area (10^6 ha)	Soybean: Other crops ratio	Area (10^6 ha)	Soybean: Other crops ratio	
Argentina							
Soybean	11.63	--	15.39	--	19.00	--	63.37
Maize	2.82	4.13	2.78	5.53	2.90	6.55	3.10
Sorghum	0.61	18.96	0.56	27.58	0.75	25.31	22.40
Sunflower	1.90	6.11	1.92	8.00	1.49	12.76	-21.79
Bolivia							
Soybean	0.62	--	0.93	--	0.92	--	49.47
Maize	0.31	2.01	0.34	2.74	0.30	3.10	-2.98
Rice	0.15	4.21	0.19	4.91	0.17	5.35	17.65
Beans	0.01	45.58	0.03	33.90	0.04	22.65	200.74
Brazil							
Soybean	13.97	--	22.95	--	23.29	--	66.69
Maize	12.33	1.13	11.55	1.99	12.81	1.82	3.93
Beans	3.45	4.05	3.75	6.12	3.46	6.73	0.34
Wheat	1.73	8.09	2.36	9.72	2.18	10.70	26.03
Paraguay							
Soybean	1.35	--	2.00	--	2.68	--	98.53
Maize	0.41	3.32	0.40	5.00	0.79	3.38	95.40
Cassava	0.24	5.55	0.29	6.90	0.18	15.10	-26.99
Beans	0.06	21.60	0.08	26.67	0.06	47.22	-9.18
Uruguay							
Soybean	0.01	--	0.28	--	0.86	--	7,092.98
Maize	0.06	0.21	0.06	4.59	0.10	8.99	67.83
Sorghum	0.04	0.34	0.02	14.63	0.04	24.66	-0.28
Sunflower	0.04	0.34	0.12	2.36	0.01	86.32	-71.51

Source: Authors´ work based on FAOSTAT (2011b).

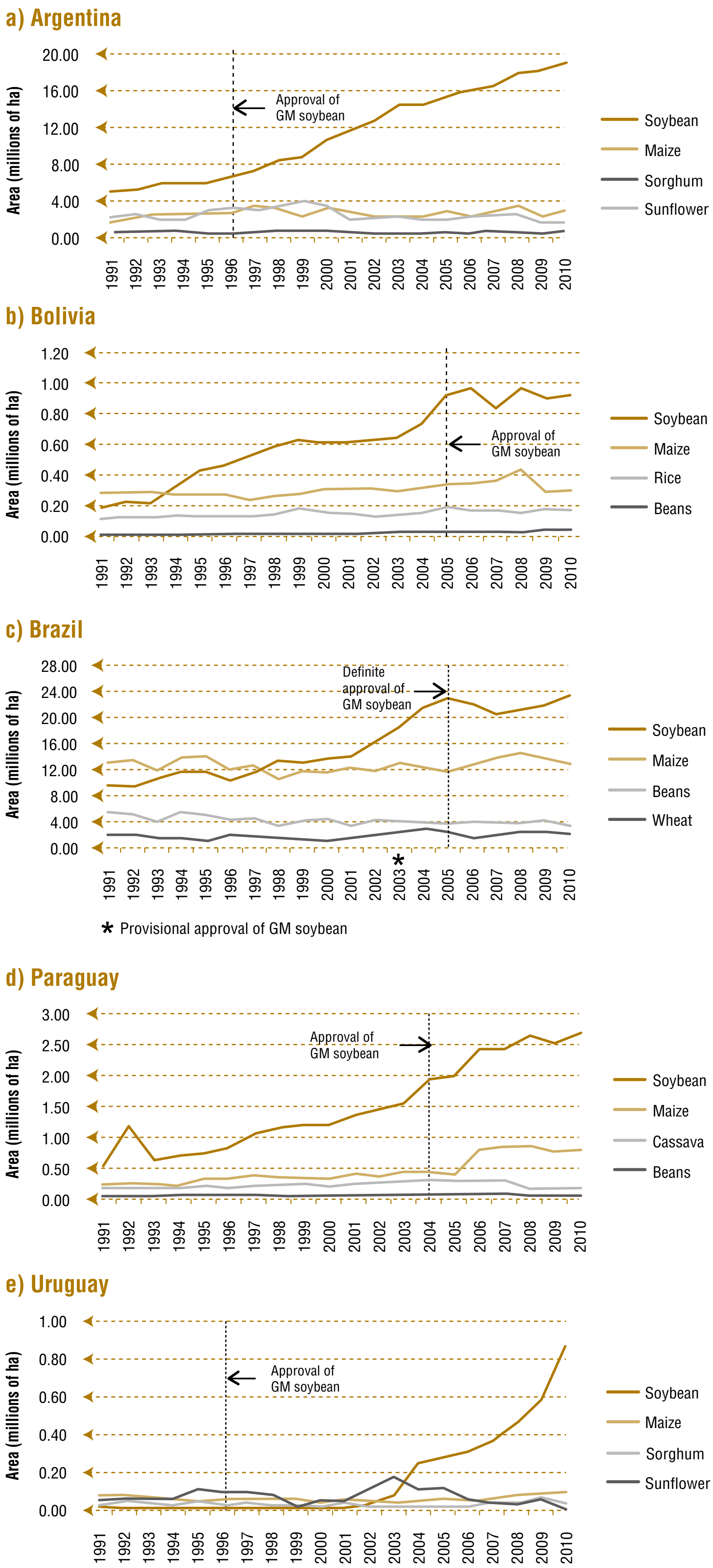
From a land management point of view, the increase in the ratio of soybean to other crops results from two simultaneous processes, based on the data shown in Table 6:

- *The area planted with soybean increases faster than for that planted with other crops.* For instance, while the area planted with soybean in Argentina increased by 63% from 2001 to 2010, the area planted with sorghum raised by 22%. In Brazil, during the same period, soybean increased in area by 67%, and maize by 4%. Figure 13 shows graphically how the area occupied by soybean expands at much higher rates than other commercially important crops in the Southern Cone countries. In Argentina (Figure 13a), after the approval of GM soybean the expansion of the area cultivated with soybean sped up considerably in comparison to other crops.

- *The area cultivated with important agricultural crops decreases while the area cultivated with soybean continuously increases.* From 2001 to 2010, in Bolivia the total area planted with maize decreased by 3% while that of soybean increased by 50%. In Paraguay, during the same period, the area planted with cassava reduced by 27% while that of soybean raised by 99%. The most dramatic changes in percentage terms are seen in Uruguay, where the area planted with sunflower decreased by 72% and that of soybean increased more than 70-fold from 2001 to 2010.

Figure 13.

Changes in the area planted with different economically important crops in the Southern Cone countries from 1991 to 2010



Source: Authors' work based on data from FAOSTAT (2011a).

The land management patterns that bring about the predominance of soybean on arable land at the same time result in two other parallel processes:

- *Soybean cultivation competes with other agricultural activities, resulting in a decrease in area dedicated to the latter.* A significant portion of the expansion in the area planted with soybean takes place on already existing arable land occupied by other agricultural crops or dedicated to animal husbandry. This can be seen in the increase in absolute values and in the percentage of the area cultivated with soybean, which from 1991 to 2009 has grown much more than the arable land (Table 5). In Argentina, in these years, the area planted with soybean has expanded by 13.34 million hectares (equivalent to an increase of 267%), while the arable land by 4.60 million hectares (17%). In other words, in Argentina from 1991 to 2009, the area planted with soybean increased three times more than the arable land. In Brazil, during the same time period, the area cultivated with soybean increased by 12.13 million hectares (126%) while arable land grew by 9.20 million (18%). In the whole Southern Cone sub-region, soybean has expanded by 28.71 million hectares (187%) and the arable land by 17.70 million (21%) from 1991 to 2009. Accordingly, in the sub-region the area of soybean has increased much more and much faster than the arable land. As mentioned previously, the expansion in the area of soybean has been taking place on land previously cultivated with other crops or dedicated to other agricultural activities (e.g. cattle production). This is at the root of crop replacement and animal husbandry displacement by soybean in the Southern Cone. Some specific examples of crop replacement by soybean cultivation are described in Box 1.

Box 1. Displaced agricultural activities due to the increase in soybean area

The increase in area cultivated with soybean results in land use change. For instance in Uruguay, pastures dedicated to animal husbandry are shifting to soybean cultivation. In this country, during the last decade, grasslands used for dairy cattle production have been reduced by 15% (approximately 150 thousand hectares), while beef cattle production pastures by 30% (MGAP-DIEA, 2011a; MGAP-DGSG, 2011). Moreover, the increase in the area planted with soybean also results in a change in agricultural production systems, such as crop replacement. In Argentina, from the 1996/97 season (the year of approval of GM soybean) to 2002/03, rice, corn, sunflower and wheat have reduced in terms of the area devoted to their cultivation by 44.1%, 26.2%, 34.2% and 3.5%, respectively (Pengue, 2004). From 2000 to 2005 GM soybean in Argentina took over 4.6 million hectares previously dedicated to other crops (Pengue, 2005). In Uruguay, soybean production has resulted in a decrease of area planted with sunflower, from 50 thousand hectares in the 2000/01 season to an intended area of 4 thousand in 2010/11 (MGAP-DIEA, 2011b). One of the concerns with crop replacement is the resulting reduction in the quantity and variety of the food base, which leads to a narrowing of diets, the source of malnutrition (Scialabba, 2007; Johns and Eyzaguirre, 2006). Unsurprisingly, the major soybean-producing countries in the Southern Cone have seen a decrease in their local food supply since 1996, particularly Argentina and Paraguay (according to FAO statistics analyzed by Heinemann, 2009).

- *The increase in the area planted with soybean contributes to the expansion of agricultural land.* The growth in area cultivated with soybean, results in the expansion of agricultural land. This expansion has been taking place in forests and other natural habitats, particularly during the last decade. The next section develops this point further.

2.2.2 Expansion of Agricultural Land and Deforestation

There are no comprehensive official data on how much the expansion of agricultural lands results from the increase in area planted with soybean in the Southern Cone. However, given that in the sub-region the area cultivated with soybean has been growing at high rates, that soybean is becoming by far the most predominant crop on arable lands, and that simultaneously arable lands have been increasing continuously, it can be inferred that soybean contributes to the expansion of agricultural land. Table 5 details the extent to which agricultural land has been increasing in the Southern Cone, and Table 7 provides data on the change of forest area.

Table 7.
Change in the forest area in the main soybean producing countries of the Southern Cone from 1991 to 2009

Country	Year	Area (10^6 ha)	Period	Area decreased (10^6 ha)	Average annual reduction (10^6 ha)	% Reduction in the period
Argentina	1991	34.50	1991-1995	1.17	0.23	3.40
	1995	33.33	1995-2000	1.47	0.24	4.40
	2000	31.86	2000-2005	1.26	0.21	3.96
	2005	30.60	2005-2009	0.96	0.19	3.13
	2009	29.64	1991-2009	4.86	0.26	14.09
Bolivia	1991	62.52	1991-1995	1.08	0.22	1.73
	1995	61.44	1996-2000	1.35	0.23	2.20
	2000	60.09	2001-2005	1.36	0.23	2.26
	2005	58.73	2006-2009	1.23	0.25	0.42
	2009	57.50	1991-2009	5.02	0.26	8.03
Brazil	1991	571.95	1991-1995	11.56	2.31	2.02
	1995	560.39	1996-2000	14.45	2.41	2.58
	2000	545.94	2001-2005	15.45	2.57	2.83
	2005	530.49	2006-2009	8.78	1.76	1.65
	2009	521.72	1991-2009	50.23	2.64	8.78
Paraguay	1991	20.98	1991-1995	0.72	0.14	3.41
	1995	20.26	1996-2000	0.89	0.15	4.41
	2000	19.37	2001-2005	0.89	0.15	4.61
	2005	18.48	2006-2009	0.71	0.14	3.87
	2009	17.76	1991-2009	3.22	0.17	15.34
Uruguay	1991	0.97	1991-1995	-0.20	-0.04	-20.31
	1995	1.17	1996-2000	-0.25	-0.04	-21.10
	2000	1.41	2001-2005	-0.11	-0.02	-7.65
	2005	1.52	2006-2009	-0.18	-0.04	-11.79
	2009	1.70	1991-2009	-0.73	-0.04	-75.32
Southern Cone	1991	690.92	1991-1995	15.80	3.16	2.29
	1995	675.12	1996-2000	17.71	2.95	2.62
	2000	657.41	2001-2005	17.59	2.93	2.68
	2005	639.82	2005-2009	11.50	2.30	1.80
	2009	628.32	1991-2009	62.60	3.29	9.06

Source: Authors´ work based on data from FAOSTAT (2011a).

The expansion of agricultural land takes place on forest land and other habitats (e.g. natural pastures). Soybean drives this process both directly and indirectly:

- *Indirect influence: The growth in soybean area replaces other crops or agricultural activities.* Crop replacement is one of the ways in which soybean increases its production area. The replaced crops or other agricultural activities either decrease in area (mostly subsistence or locally relevant crops) or are displaced or expanded onto other lands, commonly natural habitats (this is case for the relevant commercial crops). Accordingly, the increasing dominance of soybean on arable lands and the pressure that this creates to move other crops or other agricultural activities beyond the agricultural frontier is the indirect way in which soybean area growth contributes to the expansion of agricultural land.

- *Direct influence: The growth in soybean area expands into natural habitats.* The saturation of arable land with soybean cultivation pushes the soybean fields into non-agricultural ecosystems. This is the case in some countries and regions where the increased area planted with soybean overlaps with areas with high rates of deforestation (Box 2, Box 3 and Box 4).

Box 2. Conversion of native and fragmented forests to soybean cultivation in Argentina

Soybean production in Argentina has been increasing at the expense of forest land in the main soybean growing provinces. Based on data from the Directorate of Native Forest (an entity under the Secretary of Environment and Sustainable Development of Argentina), Benbrook (2005) calculated that from 2003 to 2004, almost 550 thousand hectares of forest in the provinces of Chaco, Formosa, Salta, Santiago del Estero and Tucumán (five out of the six major soybean producing provinces, according to Pengue, 2005), were cut down to plant soybean. This area of deforestation was equal to 75% of the deforestation recorded in the same provinces in the period from 1993 to 2002 (see table below). The deforestation from 2003 to 2004 represented 34% of the area in which soybean expanded that year.

Native or fragmented forest area converted to soybean production in Argentina

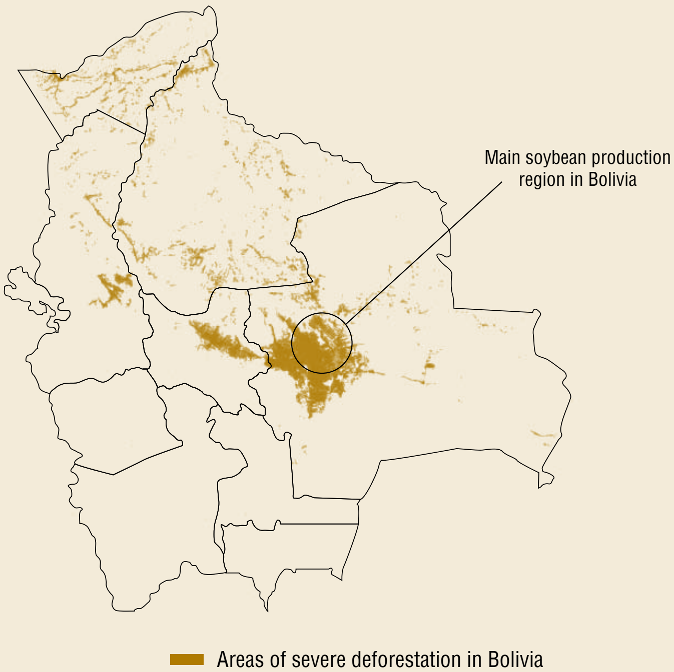
Province	Converted area (10^6 ha)	
	1998-2002	2003-2004
Chaco	0.12	0.09
Formosa	0.02	0.02
Salta	0.21	0.15
Santiago del Estero	0.36	0.27
Tucumán	0.03	0.02
Total	**0.73**	**0.55**

Source: Benbrook (2005) based on data from the Directorate of Native Forest of Argentina.

Box 3. Soybean frontier expansion onto forest lands in Bolivia

The major soybean producing zones in Bolivia are located in four eco-regions of Santa Cruz: Flood Amazon rainforest, pre Andean Amazonian forest, floodplain, and Chiquitano dry forest (Suárez et al. 2010; Ibisch and Mérida, 2003). These major soybean-producing zones overlap with the areas where the largest deforestation in the country is recorded (see map below), and are responsible for 50% of the nation's total forest cutting. The majority of deforestation in the Bolivian soybean zone takes place through the clearance of forest patches larger than 500 hectares; to establish large-scale soybean production properties (Suárez et al. 2010). This is consistent with the United Nations Development Programme (UNDP) findings, based on the data from the former Ministry of Sustainable Development, which established that the main activity causing deforestation is industrial agriculture (UNDP-Bolivia, 2008). UNDP-Bolivia also reported that 65% of the area occupied by large-scale soybean growers is the result of forest clearing (based on the data from 1993 to 2002). Suárez et al. (2010) adds that small-scale soybean production also contributes to deforestation; however, at much reduced rates.

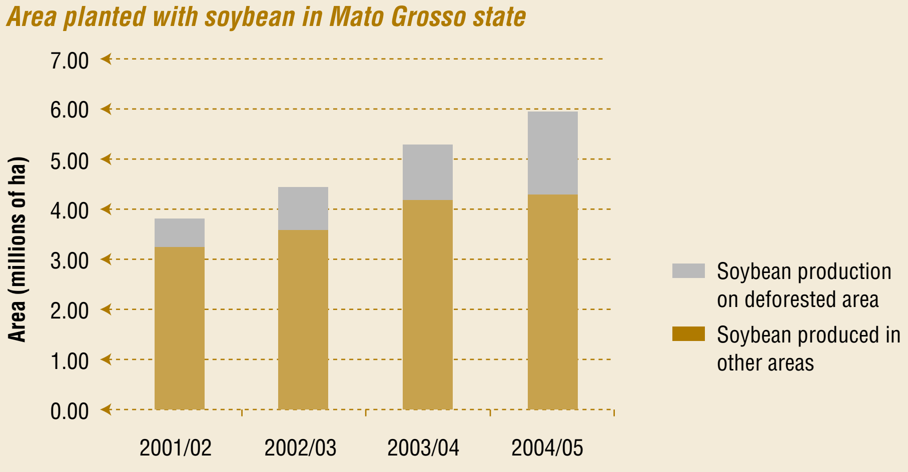
Overview of the areas with severe deforestation in Bolivia



Source: Adapted from UNDP-Bolivia (2008, p. 119).

Box 4. Soybean expansion and Amazon deforestation in Brazil

In 2006, 84% of all illegal Amazon deforestation in Brazil took place in Mato Grosso, Rondônia and Pará states to establish pastures and soybean fields. However, in Mato Grosso, the increase rate of area planted with soybean has been higher than that of pastures. This is seen by the fact that beef cattle production was reduced in its main municipalities and a significant portion of soybean is produced on cleared forest (Barona et al., 2010). For instance, in the 2001/02 season, 15% of soybean was planted on deforested land. By 2006, this percentage increased to 27% (see figure below) corresponding to 1.02 million hectares that were previously covered with forest (Risso et al., 2009).



Source: Risso et al. (2009).

Based on the analysis of satellite images, Rudorff et al. (2011) reports that since the establishment of the Soy Moratorium in Brazil in July 2006 (an agreement made by the largest soybean companies to not trade soybean from deforested Brazilian Amazon) the overall deforestation in the Amazon soybean producing States decreased from 2007 to 2009 (see table). However, the deforestation of the Amazon still reaches significant levels (more than 500 thousand hectares in the soybean producing states in 2009); and in the country, forest clearing and the area planted with soybean continue to growth. Another satellite image analysis done by Fernández (2009) indicates that the new expansion region for soybean production in Brazil is the Cerrado. At the Uruçuí-Una Ecological Station (intended to preserve the Cerrado area) from 2003 to 2008 an increase of deforestation was recorded, 61% of it taking place in the Ecological Station and 73% in its buffer zone. The aim of this deforestation is to adapt forest land to agricultural activities (e.g. production of soybean and pastures). According to Kreidler et al. (2004), the goal of the expansion of soybean in the Brazilian Cerrado is to maintain Brazil's competitiveness in the global soybean production.

Total annual deforestation in the Brazilian Amazon states since the Soybean Moratorium

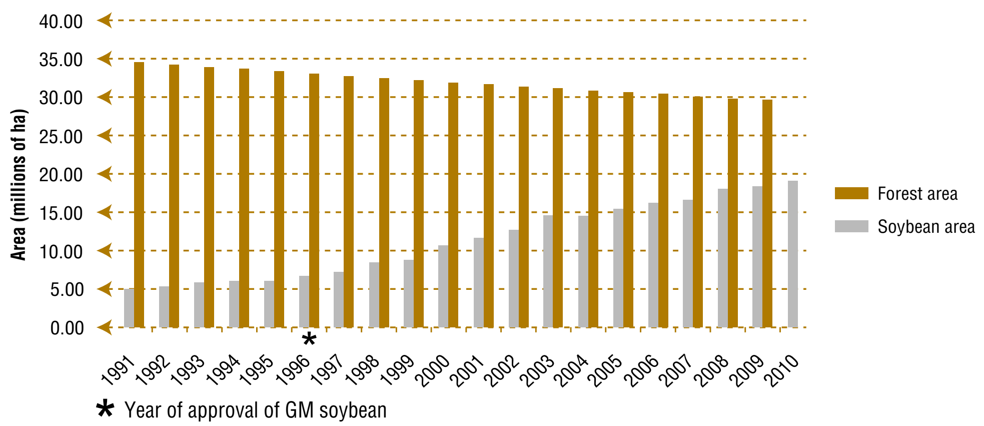
	Deforested area (10^6 ha)		
State	2007	2008	2009
Mato Grosso	0.24	0.32	0.07
Pará	0.55	0.56	0.43
Rondonia	0.16	0.11	0.05
Total	**0.95**	**0.99**	**0.54**

Source: Rudorff et al. (2011).

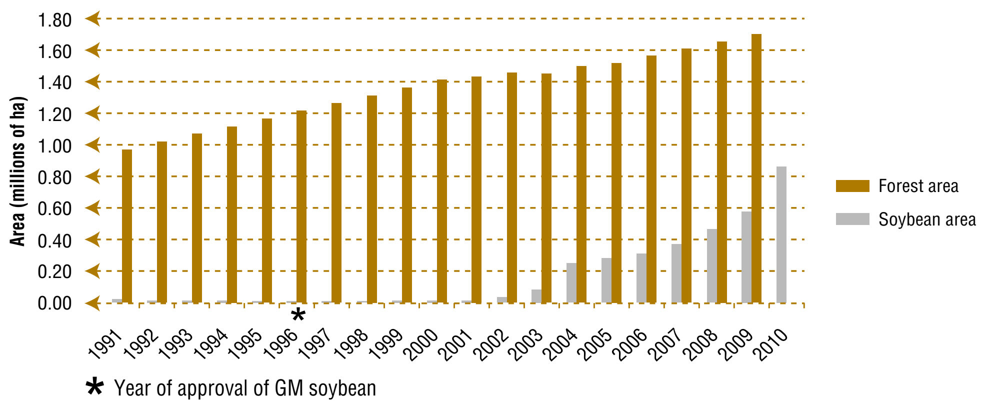
As mentioned, there are no official data that could help to define how much of the decrease in forest area is related to the growth in area under soybean cultivation. However, based on the currently available information, it can be seen that as the area planted with soybean rapidly increases (Table 5) the forest area decreases (Table 7). As a result, the ratio of forest to soybean area reduces as well. Figure 14 shows the most severe cases in which the forest to soybean ratio is dropping. In Argentina, in 1991 the forest area was almost 7 times larger than the area under soybean production (this means that for every hectare cultivated with soybean, there were almost seven hectares of forest). In 1996 (the year of approval of GM soybean varieties) the ratio decreased to 4.96 and in 2009 to 1.62. In Uruguay, in 1991 forest occupied a 52.21 times larger area than soybean, by 2009 it was only 2.94. However, the case of Uruguay is different from the rest of the Southern Cone soybean producing countries. In Uruguay, soybean is expanding into areas used for other agricultural activities and natural pastures; not into forest areas. According to MGAP-DGF (2011), in Uruguay the area of tree plantations for industrial purposes has been increasing instead (e.g. eucalyptus plantations for cellulose production).

Figure 14.
Change in the area planted with soybean and forest area in Argentina and Uruguay

a) Argentina



b) Uruguay



Source: Authors´ work based on FAOSTAT (2011a).

2.3 The Land Users

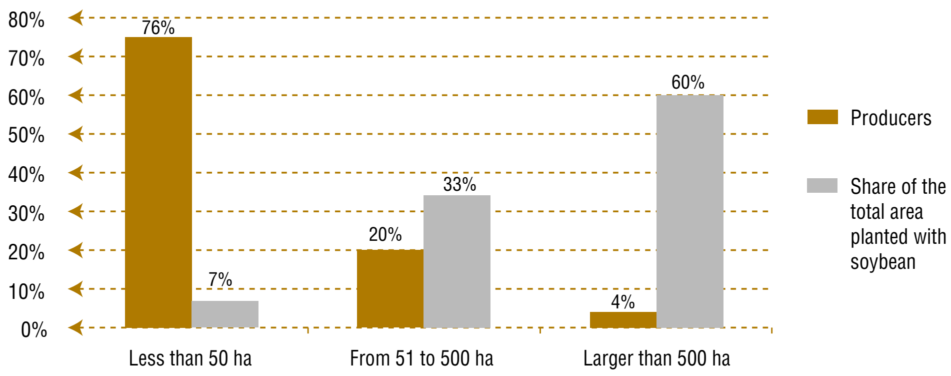
In the Southern Cone, soybean production is carried out mostly by large-scale producers who manage fields bigger than 500 hectares. This means that most of the soybean produced in the Southern Cone comes from highly industrialized agricultural systems, which due to intensification of soybean production, leads to land concentration. For instance, in Paraguay in 2005, 4% of the soybean producers held 60% of the total area planted with soybean, while the remaining 76% of the producers held only 7% of the total area cultivated with this crop. In Brazil in 2006, 5% of the soybean growers managed 59% of the soybean area, while in Bolivia during the 2009/10 season, 2% of the farmers held 52% of the soybean production (Figure 15). These numbers show that a high proportion of the area under soybean cultivation is held and managed by a very small proportion of the producers.

In soybean production, land concentration reaches extreme levels within each of the Southern Cone soybean producing countries. For instance, in Paraguay in 2005, 0.2% of the soybean producers managed 12% of the soybean area in plots equal to or larger than 5,000 hectares (CAN, 2008). In Brazil in 2006, less than 1% of the soybean producers held 27% of the production area in plots larger than 2,500 hectares (IBGE, n.d.). In Argentina, in 2010 more than 50% of soybean production was carried out by 2.6% of the total producers (1,600 growers approximately), who held a total area of 9.34 million hectares through plots larger than 5,000 hectares. The rest of the area cultivated with soybean in Argentina in 2010 was distributed among 54,400 growers through plots of 100 to 500 hectares each (FAA, 2011).

Figure 15.

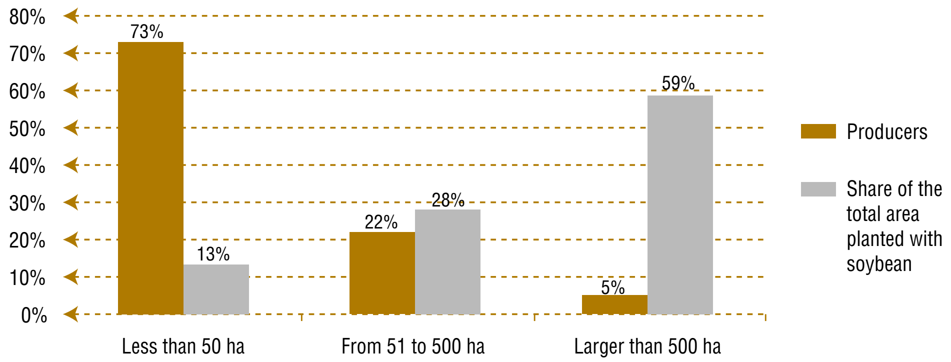
Distribution of the land planted with soybean among producers of different scales in Paraguay (2005), Brazil (2006) and Bolivia (2009/10)

a) Paraguay



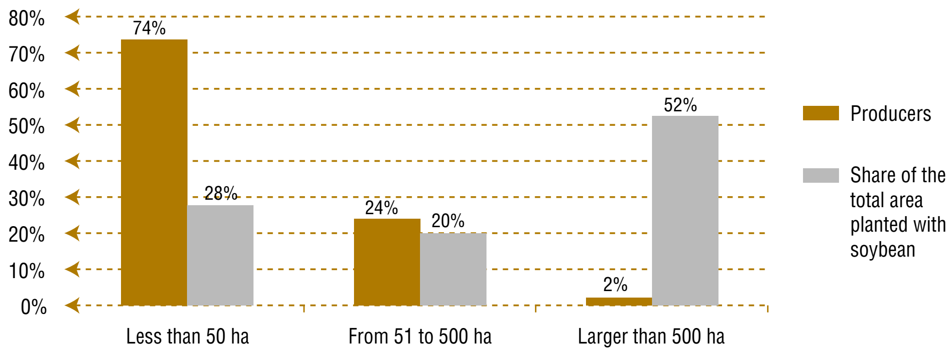
Source: Authors´ work based on data from CAN (2008).

b) Brazil



Source: Authors´ work based on data from IBGE (2006).

c) Bolivia

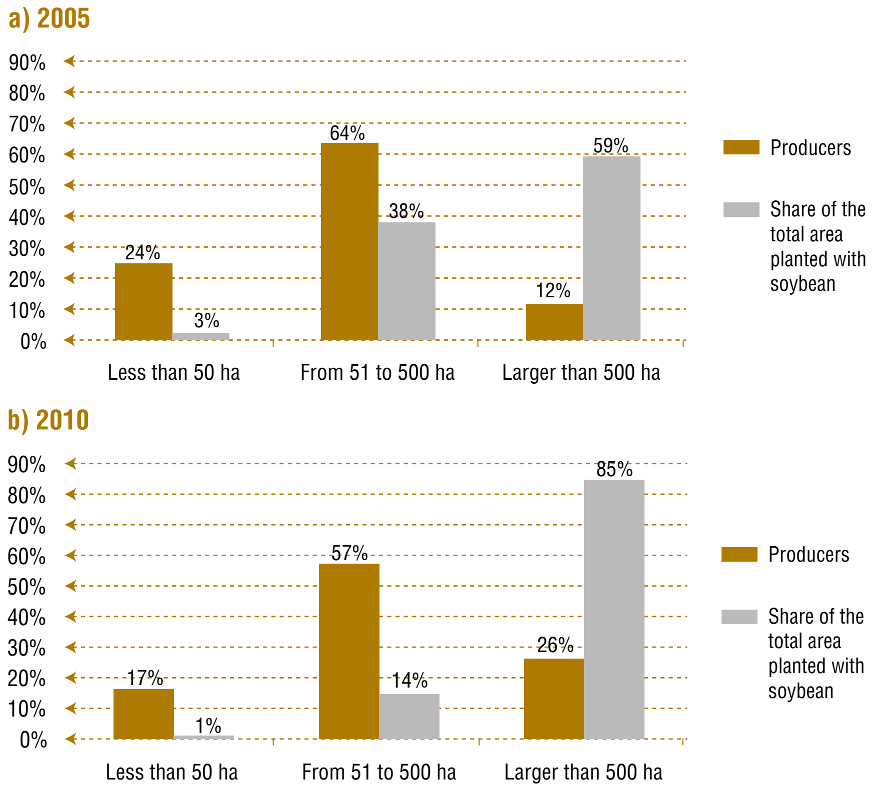


Source: Authors´ work based on data from ANAPO (2010).

As the area planted with soybean expands, the process of land concentration also increases. For example, Figure 16 shows the intensification of land concentration in Uruguay. In this country in 2005, 12% of the soybean producers held almost 60% of the area cultivated with this crop. By 2010, 26% of the growers held 85% of the soybean production land. That same year, 12 companies (1% of the total producers) managed 35% of the total area under soybean production (Arbeletche and Gutiérrez, 2010). The land concentration in Uruguay becomes even more evident when considering that small-scale producers (with plots smaller than 50 hectares) decreased from 24% (2005) to 17% (2010) of the total land users, and the area that they managed decreased from 3% (2005) to 1% (2010).

Figure 16.

Distribution of the land planted with soybean among producers of different scales in Uruguay in 2005 and 2010



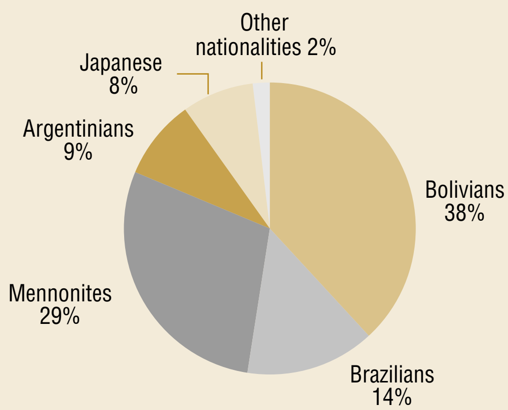
Source: Authors´ work based on date from MGAP-DIEA (2005; 2011b).

Another important feature of soybean production in the Southern Cone is that in the small producing countries (Bolivia, Paraguay, and Uruguay), the majority of the soybean growers are foreigners (Box 5).

Box 5. Foreign soybean growers in the small Southern Cone soybean producing countries

Bolivia: The majority of the soybean producers in Bolivia are foreigners. In the 2009/10 season, for instance, 62% of the soybean producers were from different nationalities (mostly Mennonites and Brazilians) while 38% were Bolivians (see graph below). According to UNDP-Bolivia (2008), among the large-scale soybean producers, the participation of Brazilian producers and investors is quite considerable.

Distribution of soybean growers in Bolivia according to their nationality (2009/10)



Source: Authors' work based on data from ANAPO (2010).

Paraguay: Brazilian producers control the production and commercialization of soybean in Paraguay (Foguel and Riquelme, 2005). The migration of Brazilian soybean producers to Paraguay started in the 1970s and really took off in the 1990s. There are several factors accounting for Brazilian migration to Paraguay according to Foguel and Riquelme (2005) and Palau (n.d.): i) cheap and fertile lands in Paraguay attracted Brazilian investors who found – in the face of climbing inflation and weakening of the financial system in Brazil in the 1970s and 1980s – a safe investment in land both inside and outside the country; ii) Brazilian macroeconomic policy strengthened its agroindustries on international raw materials markets; ii) the process of land concentration in Brazil resulted in rural unemployment and a demand for land, which pushed displaced rural labor to peripheral lands in Brazil and neighboring countries, such as Paraguay; iv) international policy in Paraguay favored Brazilian migration and land adquisition by foreigners. As a result, the majority of soybean investment, technology, and producers in Paraguay come from Brazil. Moreover, a significant percentage of large-scale soybean producers are Brazilians and to a lesser extent Mennonites and Paraguayans.

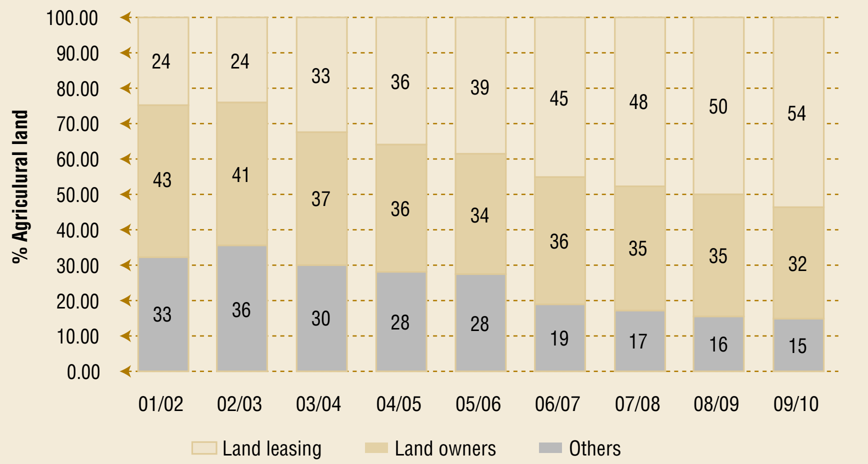
Uruguay: Soybean production in Uruguay takes place through "sowing pools", which are consortiums of investors – mainly from Argentina – who manage large production areas at the regional level (Oyhantcabal and Narbondo, 2011). In the 2009/10 season, 12 sowing pools managed 35% of the area planted with soybean and represented 1% of all producers (Arbelete and Gutiérrez, 2010).

The simultaneous patterns of saturation of arable land with soybean plantations, the expansion of agricultural land into more remote areas, and the concentration of land by a small proportion of land users results in: i) a greater industrialization of soybean production; ii) an increase in the price of land; and iii) changes in the access to and the tenure of land, as a result of the two previous ones. The case of Uruguay is a clear example (Box 6).

Box 6. Changes in land tenure and land prices in Uruguay

The expansion of agricultural land due to the increase in area planted with soybean, together with the process of land concentration, is resulting in increased tensions related to land access, tenure, and accordingly, land prices. The current trend in accessing land is through leasing, as shown in Figure a. From the 2001/02 to the 2009/10 season, the percentage of agricultural land used by owners decreased from 43% to 32%, while leasing has more than doubled since 2001 (from 24% to 54%). The increase in the price of land is remarkable, five-fold in the last 10 years (Figure b) as a result of a two-sided process: expansion, on the one hand, and concentration, on the other. As the area planted with soybean expands, the demand for land also increases. As the concentration of land intensifies and produce from industrialized agriculture monopolizes the markets, small-scale farmers find renting their land to large-scale producers a more feasible source of income than farming it themselves.

a) Distribution of land in Uruguay in relation to property and use management



Source: Authors´ work based on data from MGAP-DIEA (2010).

b) Changes in price of land in Uruguay during the last 10 years

Source: Authors´ work based on data from MGAP-DIEA, (2011c).

2.4 The Technology

The majority of soybean produced in the Southern Cone is genetically modified (GM) for tolerance to the herbicide glyphosate. For instance, in the sub-region´s largest soybean producing country (Brazil), by 2010, 71% of the soybean produced was GM. As for the second largest producing country (Argentina), from 2001 to 2010 the percentage of GM soybean in commercial cultivations ranged from 90% to 100% (Figure 17)[3] .

The approval of GM soybean in the sub-region occurred at two specific points in time. The first in 1996 when it was approved in Argentina (Resolution SAGPyA Nº167/96) and Uruguay (Resolution of the Department of Agricultural Protection of the Ministry of Animal Husbandry, Agriculture and Fisheries) (DINAMA-PNUMA-FMAM, 2007). The second, in 2004/05, when it was approved in Paraguay (Resolution Nº1691), Bolivia (Administrative Resolutions Nº16/2005 and Nº044/2005); and Brazil (Law Nº11.105, Art. 30, 35 and 36 of March 2005). It is worth noting however that in Brazil, a significant percentage of soybean cultivation was GM before its definite approval in 2005 (see Figure 17c).

Since the approval of GM soybean, it quickly spread until it took over a majority of the sub-regional area planted with this crop. Of the total area planted with soybean in the sub-region (with the exception of Paraguay,

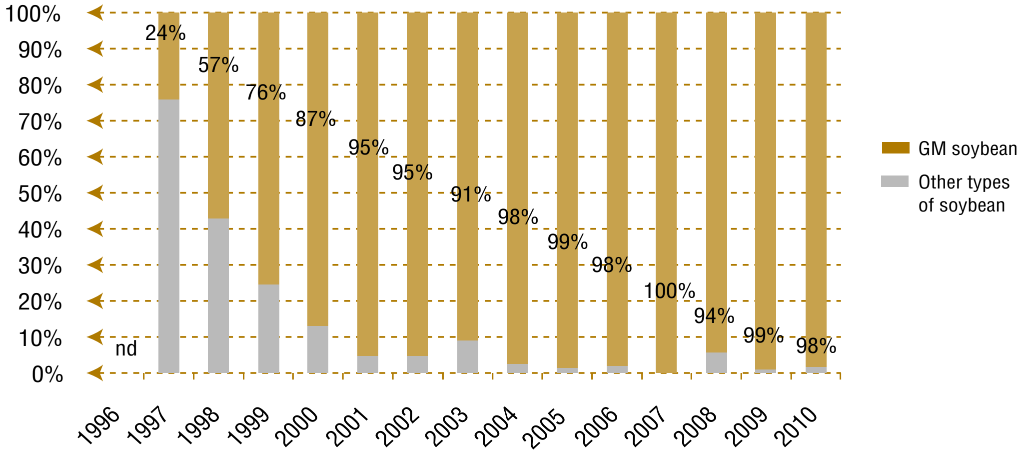
[3] Figure 17, as well as Figure 19 and Figure 20 do not include data from Paraguay since the authors did not have access to official information on the kinds of soybean varieties planted and pesticides or herbicides used in soybean production in this country.

which was not included in the analysis since no official information was available), approximately 65% was GM in 2005. By 2010, 85% of the total soybean crop planted in Argentina, Bolivia, and Brazil was GM.

Figure 17.

Percentage of GM soybean cultivation in the Southern Cone soybean producing countries

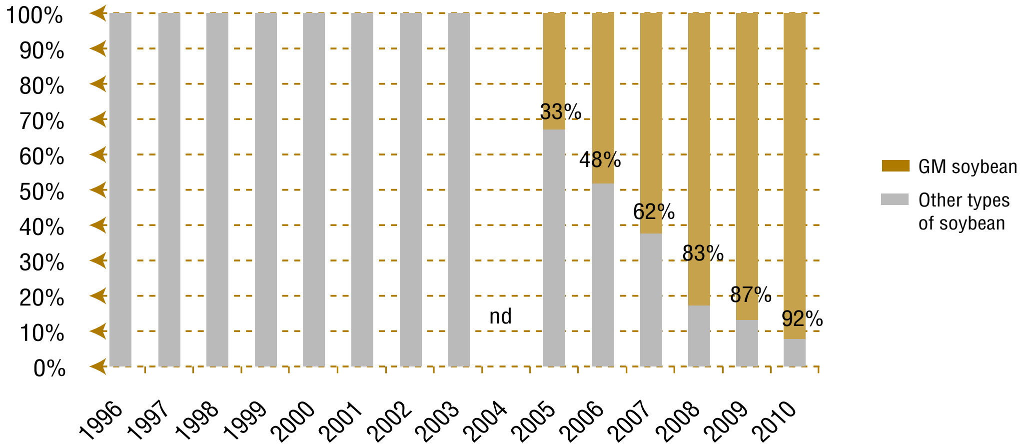
a) Argentina



nd = No data. Refers to the years when it was not possible to find information from official sources.

Source: Authors´ work based on data from Ministry of Agriculture of Argentina (2011).

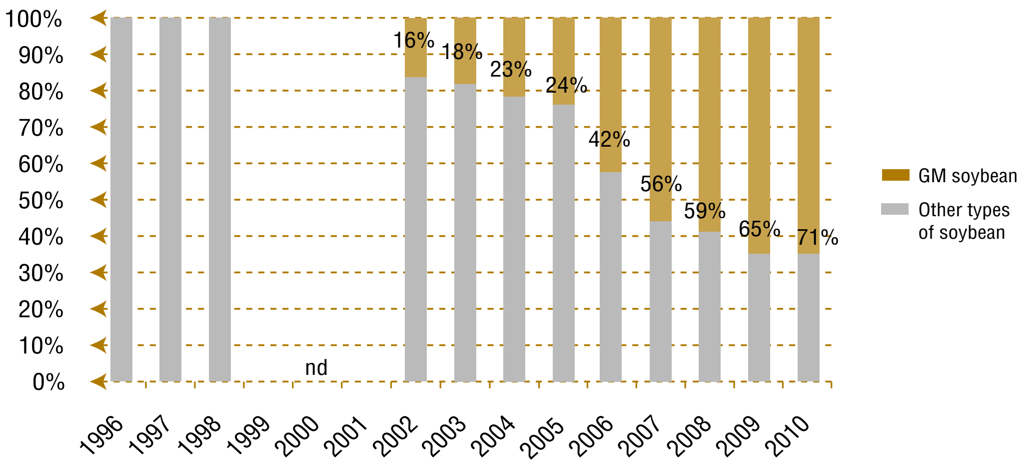
b) Bolivia



nd = No data. Refers to the years when it was not possible to find information from official sources.

Source: Authors´ work based on data from CRS-Santa Cruz (1996-2008); COSEM-Santa Cruz (2009; 2010).

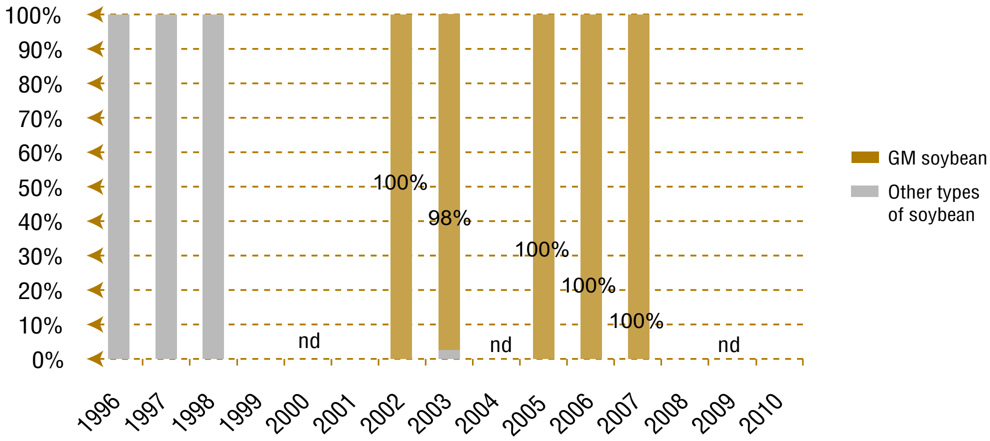
c) Brazil



nd = No data. Refers to the years when it was not possible to find information from official sources.

Source: Authors´ work based on data from FAEP (2011); Céleres (2011).

d) Uruguay



nd = No data. Refers to the years when it was not possible to find information from official sources.

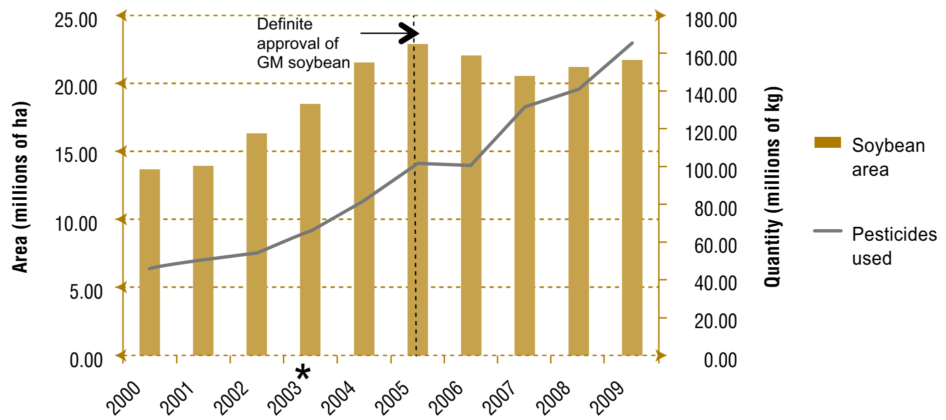
Source: Authors´ work based on data from CUS (2011).

III Soybean Production and Pesticide Use in the Southern Cone

The increase in area planted with soybean in the Southern Cone has been accompanied by an increase in the use of pesticides related to its production, particularly herbicides and specifically the herbicide glyphosate (Figure 18). Considering that the majority of the soybean planted in each Southern Cone country is genetically modified to tolerate the herbicide glyphosate and soybean is the predominant crop occupying the arable land of each country, a direct link between the area of GM soybean and increases in the use of herbicides can be established.

A few years after the approval of GM soybean, there was a noticeable increase in the volumes of pesticides used (Figure 18 and Box 7) and specifically the volumes of glyphosate applied (Figure 19 and Figure 20). In Brazil and Argentina, after the approval of GM soybean, the volumes of pesticides, in general, and glyphosate used, in specific, remained stable despite the increase in area planted with this crop. However, a few years later, the volumes increased significantly over short periods of time. In Brazil, the volumes of pesticide sold increased by 360% between 2000 to 2009 (in nine years), and by 160% from 2005 to 2009 (four years after the definite approval of GM soybean) (Box 7 contains further information on pesticide use in Brazil). In the case of Argentina, from 1996 to 1999, the volume of glyphosate used ranged from 20 to 26 million liters per year. In this country, in 2000 (four years after the approval of GM soybean), the volumes of glyphosate applied increased 380% in relation to the previous year reaching a volume of almost 101 million liters.

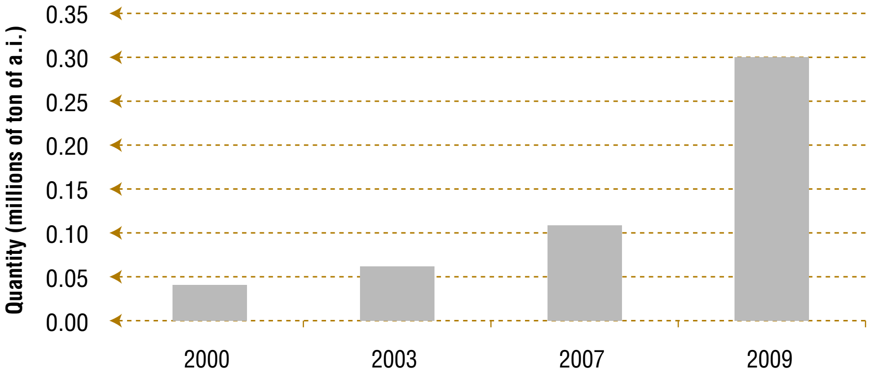
Figure 18.
Volumes of pesticides used in Brazil in relation to ther soybean production area



* Provisional approval of GM soybean

Source: Authors´ work based on data from SINDAG (2010); FAOSTAT (2011b).

Figure 19.
Volumes of glyphosate sales in Brazil

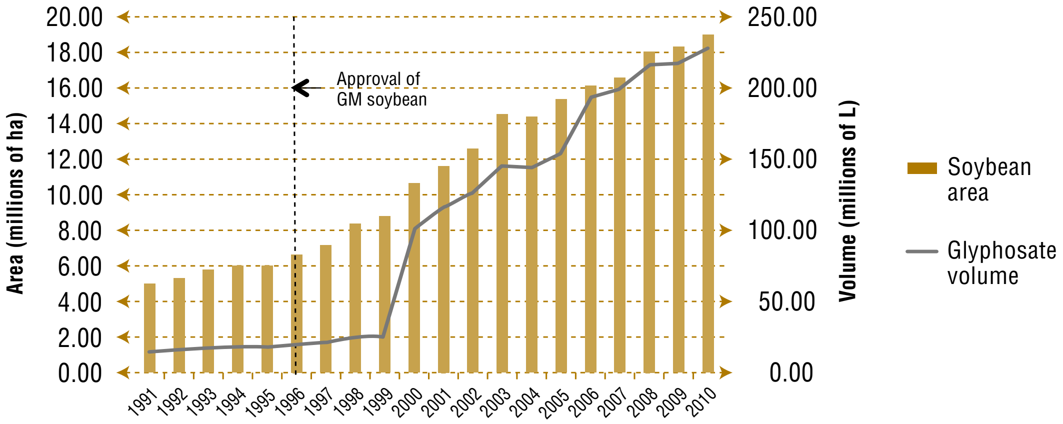


a.i.= active ingredient

Source: Meyer and Cederberg (2010) based on the National Health Surveillance Agency (ANVISA, according to its name in Portuguese).

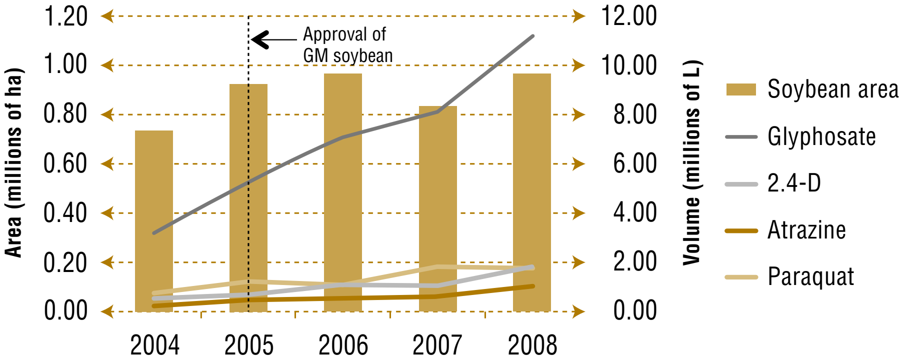
Figure 20.
Volumes of herbicides used in soybean production in Argentina, Bolivia and Uruguay in relation to the soybean planted area

a) Argentina



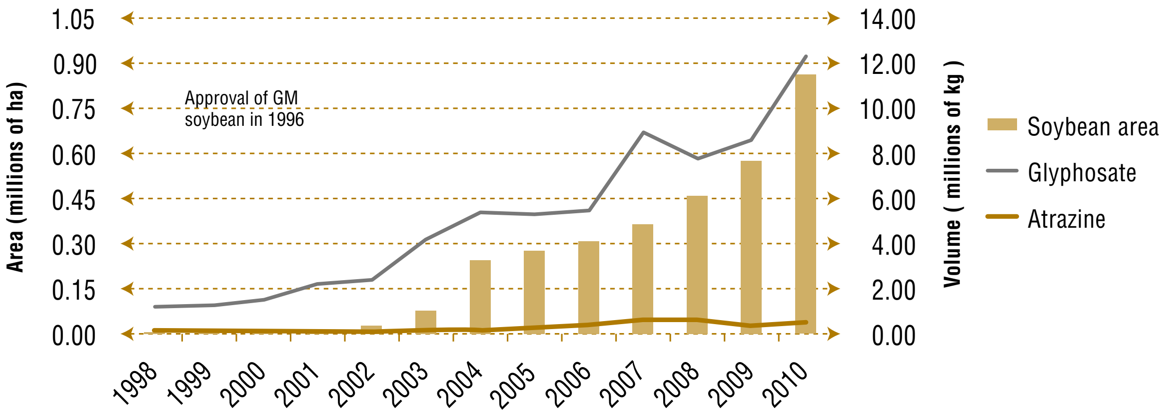
Source: Authors´ work based on data from CASAFE (2011).

b) Bolivia



Source: Authors´ work based on data from SENASAG (2009).

c) Uruguay



Source: Authors´ work based on data from MGAP-DGSA (2011).

Box 7. Pesticide use related to soybean production in Brazil

The increases in soybean production area and pesticide use are related. According to the Institute of Agricultural Economics of Brazil (IEA, 2011), soybean production is the largest user of pesticides in the country and increased its demand by 3.8% in 2010. Soybean accounted for 44.1% of total sales of pesticides that year. The major sales were recorded in the largest soybean producing states: Mato Grosso, Paraná and Río Grande do Sul, corresponding to the 20.4%, 12.1% and 10.2% of the total national (occupying the first, third and fourth places of national pesticide demand). Goias and Mato Grosso do Sul (the largest soybean producers in the Cerrado region) are the fifth and eighth major markets for pesticides in the Brazil, representing 10.2% and 4.7% of the total sales, respectively.

The increase in glyphosate use in the Southern Cone soybean producing countries results from the increase in the area planted with GM soybean tolerant to this herbicide and the implementation of the no-tillage system. No-tillage systems rely on herbicide applications and become very suitable to glyphosate tolerant soybean cultivation (Villa-Aiub et al., 2007; Powles, 2008).

The increased application of glyphosate results in another process that is the development of glyphosate resistant in weeds (Papa, 2000; Cerdeira et al, 2011). Based on a review of reported cases, Powles (2008, p. 361) concludes that "[r]emoval of the tillage by adoption of a no-till seeding system [...] allow[es] resistance to emerge […] [G]lyphosate-resistant weeds can evolve where there is insufficient diversity in weed management systems."

The appearance of weeds resistant to glyphosate in GM soybean production in the Southern Cone countries is resulting in greater applications of complementary herbicides (Table 8). These complementary herbicides (e.g. 2,4-D, atrazine, and paraquat) are currently more effective in controlling resistant weeds due to their higher levels of toxicity (WHO, 2010), which is why some of them are banned in other parts of the world (Box 8 and Box 9).

Table 8.
Volumes of herbicides used in Argentina, Bolivia, and Uruguay

Country	Herbicide	Year	Volume (10^6 L)	Period	Times of increase
Argentina	Glyphosate	1991	15.00	--	--
		1996	19.98	1991-1996	1.33
		2011	237.60	1996-2011	11.89
	Paraquat	2004	0.65	--	--
		2010	1.20	2004-2010	1.84
Country	**Herbicide**	**Year**	**Volume (10^6 L)**	**Period**	**Times of increase**
Bolivia	Glyphosate	2004	3.18	--	--
		2008	11.19	2004-2008	3.52
	2,4-D	2004	0.54	--	--
		2008	1.82	2004-2008	3.35
	Atrazine	2004	0.23	--	--
		2008	1.03	2004-2008	4.56
	Paraquat	2004	0.76	--	--
		2008	1.75	2004-2008	2.31
Country	**Herbicide**	**Year**	**Volume (10^6 kg)**	**Period**	**Times of increase**
Uruguay	Glyphosate	1998	1.22	--	--
		2003	4.20	1998-2003	3.44
		2010	12.29	2003-2010	2.92
	Atrazine	1998	0.18	--	--
		2003	0.20	1998-2003	1.16
		2010	0.52	2003-2010	2.58

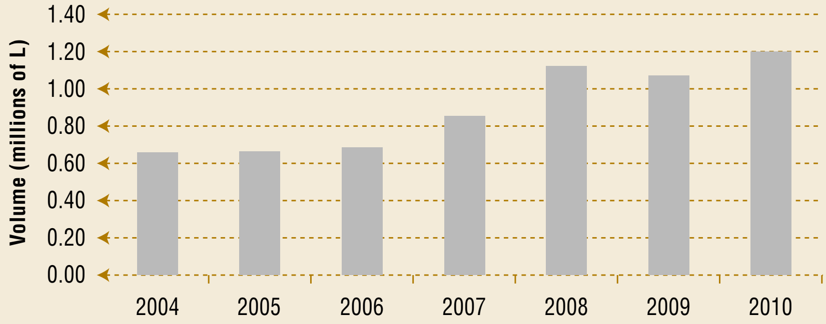
Source: CASAFE (2011); SENASAG (2009); MGAP-DGSA (2011).

Box 8. Paraquat use in Argentina, Bolivia and Brazil in recent years

Paraquat is the active ingredient in one of the most widely used herbicides: Gramoxome, developed by the Swiss Company, Syngenta. Toxicological studies have implicated paraquat in the development of neurological (e.g. Parkinson´s disease) and reproductive disorders (Wright, 2007; Frazier, 2007). For this reason in 2003, paraquat was banned in 13 European Union (EU) countries, including Sweden, Denmark, France and Austria; yet, the European Council authorized its use in the EU. In July 2007, based on the appeal presented by the Swedish government on the lack of compliance of paraquat with the EU safety standards, this herbicide was banned in the EU (Reuters, 2007). Despite this, paraquat use is not only still used in the main soybean producing countries of the Southern Cone of South America, but its volumes of importation and application are also continuously increasing (see Figure a) and Figure b). In Argentina, in 2010, 1.2 million liters of paraquat were used. In Bolivia, 1.75 million liters were imported in 2008, mostly to Santa Cruz, the largest Bolivian soybean-producing region. In Brazil's five major soybean producing states alone, 3.32 million liters of paraquat were used in 2009 (see Figure c).

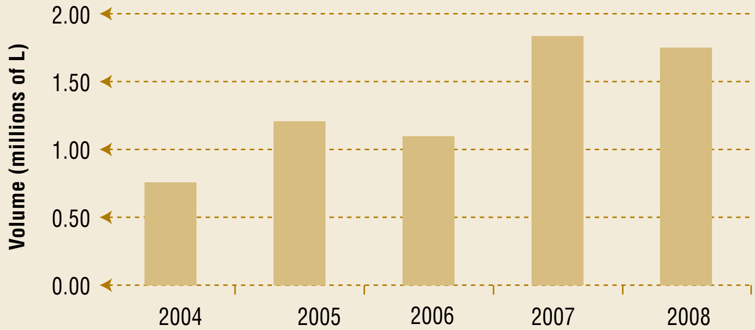
Volumes of paraquat use in Argentina, Bolivia, and Brazil

a) Argentina



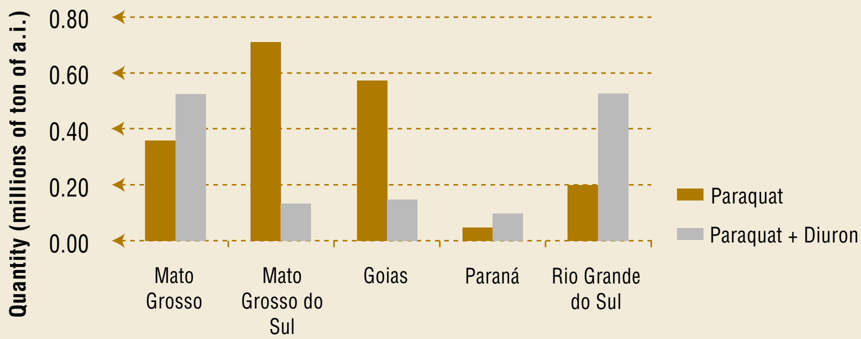
Source: Authors' work based on data from CASAFE (2011).

b) Bolivia



Source: Authors' work based on data from SENASAG (2009).

c) Brazil



a.i.= active ingredient

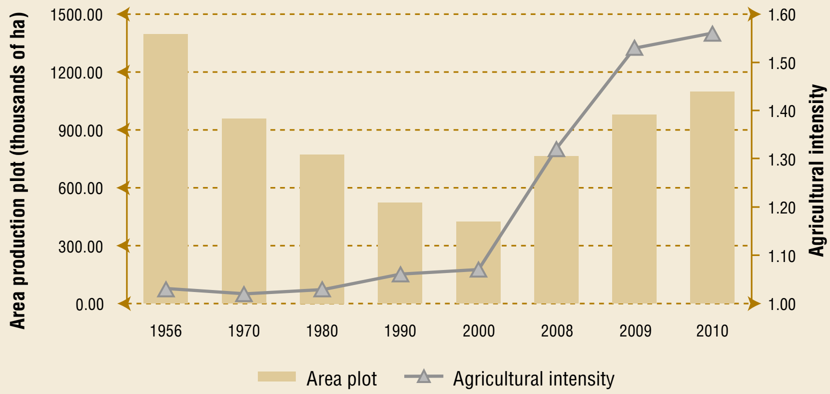
Source: Adapted from Meyer and Cerdeberg (2010) based on data from the Ministry of Agriculture, Livestock and Food Supply.

Box 9. Which pesticides are used in the production of conventional and GM soybean in Uruguay?

As in the rest of the Southern Cone countries, in Uruguay the increase in agricultural area has been accompanied by an intensification of agricultural production (see Figure a). Part of this intensification involves the increasing use of pesticides, which is also directly related to the increase in production area (see Figure b). In the case of soybean in Uruguay (almost all GM), there are several pesticides used in terms of variety and volumes (see Figure c). By far, the main pesticides imported and used in the country are herbicides. The main herbicide used is glyphosate (Figure d, shows the direct relationship between the area cultivated with soybean and glyphosate application in Uruguay), followed by atrazine, used for long fallow periods to combat weeds less susceptible to glyphosate. However, herbicides are not the only pesticides used in soybean production. The insecticides commonly used have been endosulfan to control soybean stink bug (*Piezodorus guildinni*) (Figure e). Endosulfan is used alone or in mixtures with cypermethrin. Since 2007 the Ministry of Livestock, Agriculture, and Fisheries (MGAP in Spanish) restricted the use of endosulfan and began to replace it with neonicotinoids and pyrethroids such as thiametoxan and lambda cyhalothrin. For control of the bean shoot borer (*Epinotia aporema*) and caterpillars in soybean (*Anticarsia gemattalis*), chlorpyrifos is primarily used (Figure f). Since 2006 this non-selective insecticide has been replaced by growth regulators (e.g. triflumuron, methoxyfenozide, diflubenzuron, etc.), which are more effective at controlling caterpillars. However since 2007/08, the use of chlorpyrifos increased again due to the presence of new pests in soybeans, such as spiders and swarming locusts. Although fungal diseases in soybeans are not a problem in Uruguay, seeds are commonly treated with fungicides (e.g. thiram and carbendazim) before planting to avoid problems with *damping* off. Diseases at the end of the growing season are commonly treated with fungicide mixtures of trifloxystrobin – cyproconazole (Oyhantcabal and Narbondo, 2011; Blum et al., 2008).

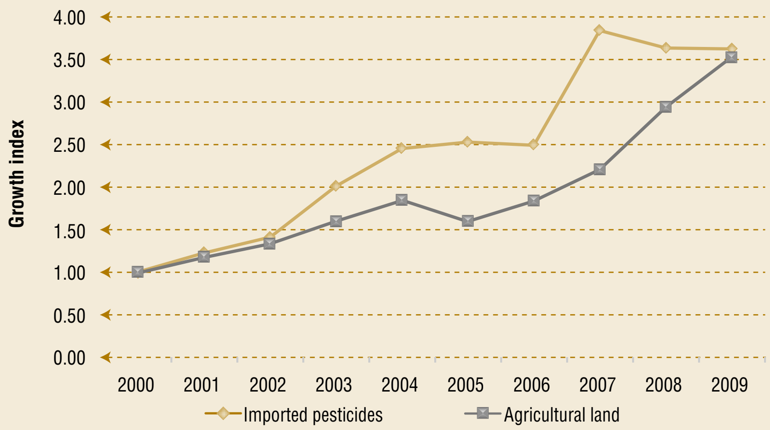
Intensification of soybean production and pesticides used in Uruguay

a) Intensification of agricultural production



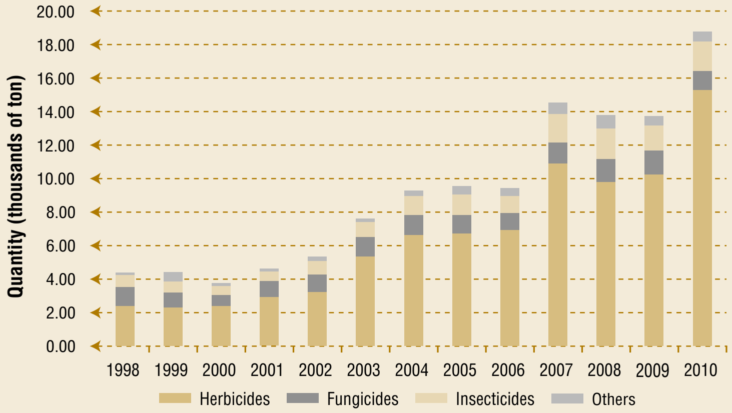
Source: Authors´work based on data from MGAP-DIEA (2008; 2010).

b) Relationship of pesticides imported vs. agricultural land



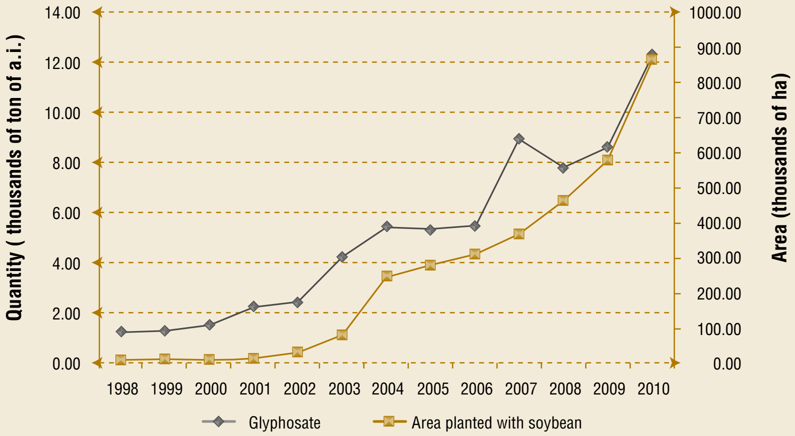
Source: Authors´work based on data from MGAP-DIEA (2011a); MGAP-DGSA (2011)

c) Quantity of imported pesticides



Source: Authors´work based on data from MGAP-DIEA (2011); MGAP-DGSA (2011).

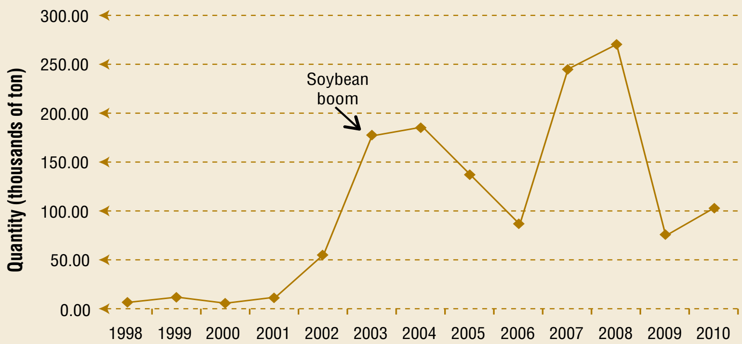
d) Relationship of soybean-planted area vs. glyphosate use



a.i.= active ingredient

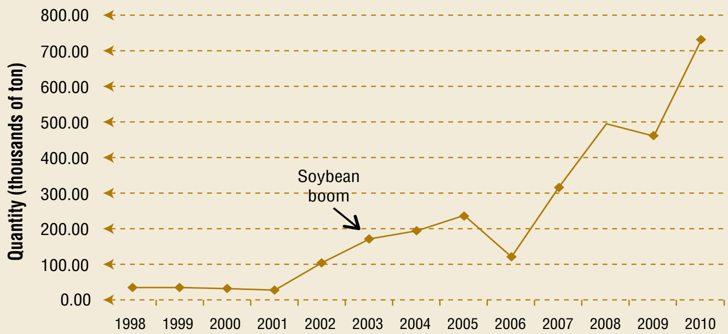
Source: Authors´work based on data from MGAP-DIEA (2011a); MGAP-DGSA (2011).

e) Quantity of endosulfan used



Source: Authors´work based on data from MGAP-DGSA (2011).

f) Quantity of chlorpyrifos used



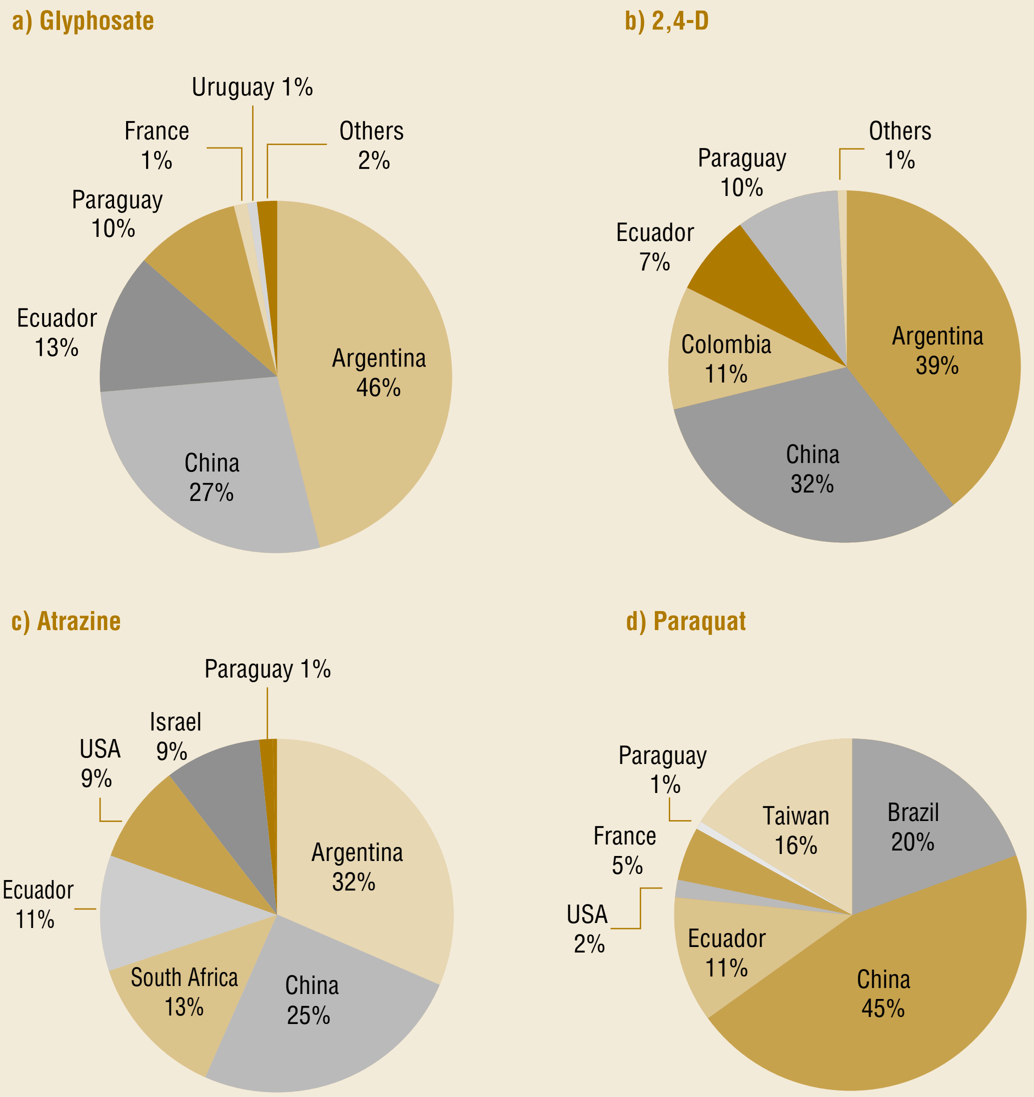
Source: Authors´work based on data from MGAP-DGSA (2011).

The majority of the herbicides used in the Southern Cone are imported, either from China or the sub-regional producing countries (Argentina, Brazil and Paraguay). There is no accurate information on the origin of the herbicides used; however, the information in Box 10 provides a glimpse.

Box 10. The origin of pesticides in the Southern Cone: Examples from Bolivia, Brazil, and Uruguay

Bolivia: Based on data from the National Service of Agricultural Health and Food Safety (SENASAG in Spanish) from 2004 to 2008 a total of 50 million liters of the four main herbicides used in soybean production (glyphosate, 2,4-D, atrazine and paraquat) were imported into the country. Out of this total, 35 million liters (70% of the total for the period) was glyphosate, 7 million (13%) paraquat, 5 million (11%) 2,4-D, and 3 million (6%) atrazine. The majority of the herbicides used in soybean production in Bolivia come from Argentina and China. This is the case for glyphosate, 2,4-D and atrazine. In the case of paraquat, most of this herbicide comes from Argentina and Brazil (see figure below).

Origin of the main herbicides used in soybean production in Bolivia from 2004 to 2008



Source: Authors' work based on data from SENASAG (2009).

Brazil: A significant portion of the paraquat used in Brazil comes from Europe. According to the data from the Ministry of Development, Industry, and Foreign Trade of Brazil reported by Meyer and Cederberg (2010), European exports of paraquat to Brazil have increased 235% since the banning of this herbicide in Europe. Paraquat imports in Brazil have increased from 2.8 million kilograms in 2008 to 6.6 million in 2009.

Uruguay: This country depends on imports of pesticides and a portion of them are imported as basic ingredients that are mixed to produce specific formulations. Currently, 50% of all imports originate from China, while 35% come from Argentina. 40% of insecticides come from China and 32% from Argentina. As for fungicides, 42% and 32% come from Brazil and China, respectively (Blum et al., 2008; MGAP-DGSA, 2011).

IV Concluding Remarks

The data analyzed in this report on land and pesticides used in the America´s Southern Cone (Argentina, Bolivia, Brazil, Paraguay and Uruguay), points out the following:

- The area devoted to soybean production is increasing rapidly, particularly after the approval of GM varieties.

- The process of increasing the area planted with soybean is accompanied by a simultaneous process of substitution and displacement of other crops and agricultural activities. From this, the overall outcome is the prevalence of soybean on arable lands at the expense of other crops with local and economic importance.

- The growing volumes of soybean production in the Southern Cone are the direct result of the increased production area, rather than the national productivity rates, as these have been remarkably variable before and after the introduction of GM soybean. Therefore, the introduction of GM varieties in the sub-region did not result in the improvement or stabilization of the national productivity rates of soybean.

- The expansion of the area cultivated with soybean adds to deforestation in indirect (crop displacement) and direct ways (soybean cropping on natural habitats). Both processes derive in the widening of the agricultural frontier in the different producing countries.

- The current dynamics of soybean production in the Southern Cone is leading to a massive concentration of land in large-scale producers. A significant proportion of them are foreigners.

- The commercial production of soybean results in the increased use of pesticides, especially herbicides. That is because the vast majority of the area cultivated with this crop is GM tolerant to glyphosate, resulting in the high use of this herbicide in the no-tillage and weed control practices.

- The agricultural management inherent to GM soybean leads to the emergence of glyphosate resistant weeds, a process that in turn causes an increased use of toxic herbicides to control them. In some cases these herbicides are banned in other parts of the world.

The massive expansion of the area under soybean cultivation in the Southern Cone of South America, and its related implications (such as the impacts on land and pesticides use analyzed in this report) are related to a key cause: the global demand for soybean as a source of animal protein and as a raw material for agrofuel production (Tomei and Upham, 2009; Yu et al., 2010).

Based on the data reported, it is possible to conclude that the high demand for soybeans in the international market and the mass production to supply it, require the implementation of highly industrialized technological packages, as well as changes in the organization of land use. Both result in significant ecological and social changes at the local level. Najam et al. (2007) and Reenberg and Fenger (2011) call this process as economic globalization through which "local land use changes are increasingly driven by demands for products that are part of commodity chains with a large spatial span" (Reenberg and Fenger, 2011, p. 86). In other words, a relationship between processes occurring in distant geographic locations that are apparently different in nature can be established. For example, the demand for soybeans in Europe impacts the dynamics of land and pesticide use in South America.

In producing countries of the Southern Cone, the economic globalization of soybean has two direct socioeconomic implications:

i. Local needs (for example, demand for products that are not intended for export) lose their relevance in the production dynamics, including the selection of the agricultural technologies applied (Reenberg and Fenger, 2011).

ii. The geographical separation between the source of the soybean demand and its production sites generates the externalization of environmental and social costs related to its massive cultivation (Meyer and Cedeberg, 2010). A clear example of this is the use of hazardous inputs (such as paraquat) or risky technologies (like GM soybean) in the producing countries of the Southern Cone, when the same inputs and technologies are simultaneously prohibited in areas where the demand originates (e.g. Europe). The latter raises important ethical questions about the application of different standards of environmental and public health protection among the places where the demand arises and the commodities are produced.

A more holistic analysis of the complex ecological, social, economic and even ethical implications related to the production and export of soybean is necessary. This requires the consideration of the whole production cycle and the eco-social system related to it. Only then it will be possible to understand the real causes and consequences of soybean production in the Americas.

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