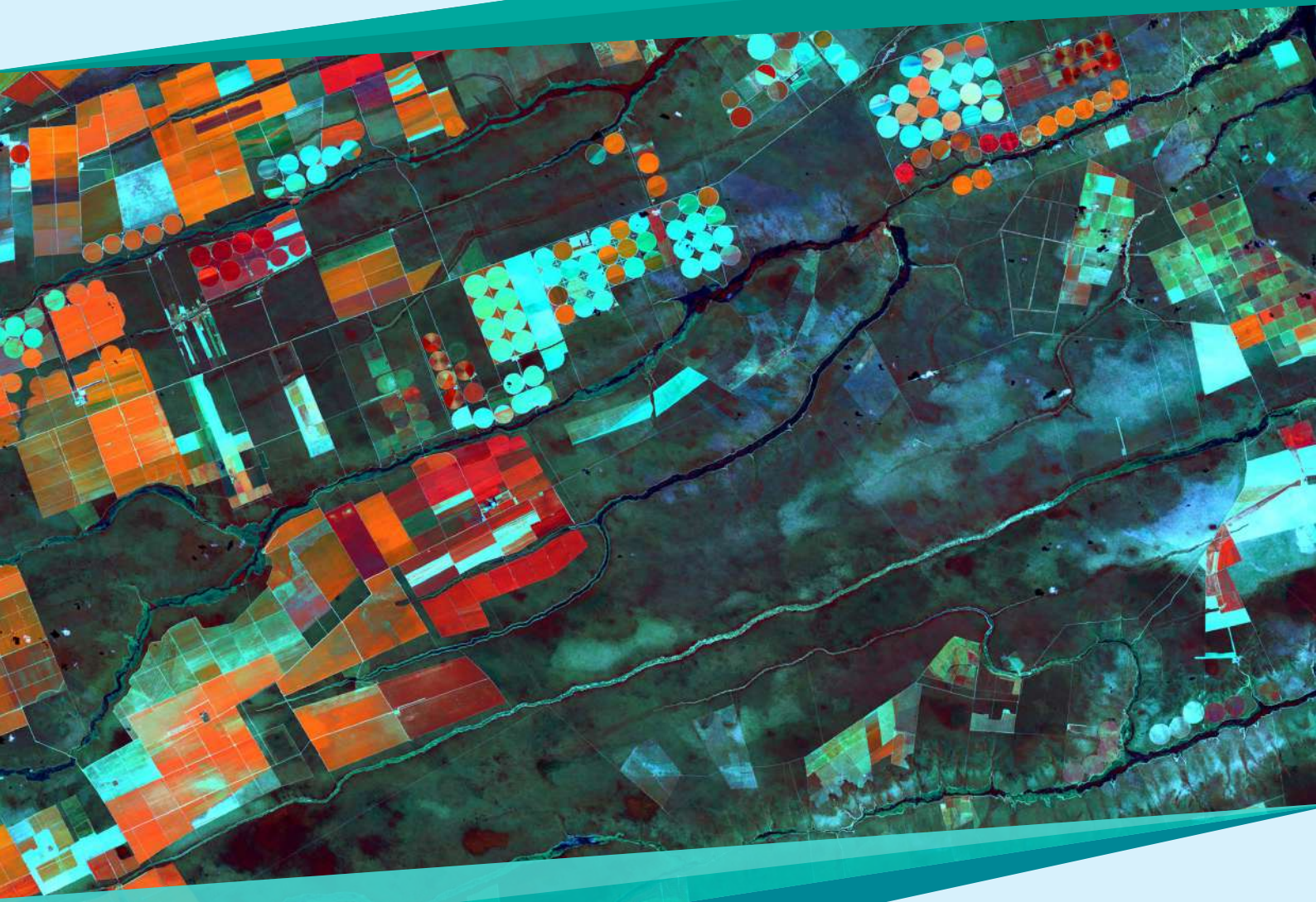

GEOSPATIAL ANALYSIS OF THE SOY DYNAMIC IN THE CERRADO BIOME 2014 TO 2017

GTC

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CONTENTS

EXECUTIVE SUMMARY

In 2015, Agrosatélite made a geospatial analysis of the dynamics of soy production in the Cerrado Biome for the period 2000 to 2014. This study updates that analysis for the period 2014 to 2017. The main reason for updating this analysis is to provide the GTC (Cerrado Task Force) with objective information about the dynamics of soy expansion in this period and about the contribution of soy production to the Cerrado's deforestation.

Soy expanded into 1.41 million hectares between 2014 and 2016, bringing soy area to 17.07 million hectares in this Biome, representing 50% of Brazil's soy area. The recent publication of deforestation maps by the PRODES-Cerrado project made it possible to cross these maps with Agrosatélite's soy map for the year 2016/17, which indicated that 201,000 hectares of native vegetation were converted into soy crops between 2014 and 2017. The dynamics of this conversion were more intense in the MATOPIBA region (the states in the Biome's northern sector), than in the states in the southern part of the Cerrado. Nevertheless, in both regions, conversion of native vegetation into soy was significantly lower when compared to the conversions seen between 2000 and 2014. In MATOPIBA, this reduction was mostly due to losses in four consecutive crops (2011/12 to 2014/15) from droughts that limited the producers' investment capacity. In the Cerrado's southern states, the reduction in the rate of opening up new areas for soy expansion was due to a continuing process of intensifying production through better use of land stocks suitable for soy production and to the continued search for higher yields.

The result of this study's analysis showed, once again, the relevance that satellite images have in supplying objective and up-to-date information on the processes that impact the changes in the earth's land use and occupation. This result is expected to help formulate measures related to sustainable soy production in the Cerrado Biome.

1. INTRODUCTION

Recognised as one of the world's 34 biodiversity hotspots, the Cerrado is South America's second largest biome. It has approximately 50% of its native vegetation preserved and occupies 23.9% of Brazil's territory, covering parts of eleven states, as well as the entire Federal District. The Cerrado Biome is also known for its relevance in the hydrologic system as it contains the springs of important rivers that supply part of Brazil's main hydrographic basins, for example the São Francisco River basin.

At the same time, the Cerrado Biome is one of Brazil's main agricultural regions, responsible for over half of Brazil's production of soy and for a large part of its production of sugarcane, coffee and beef, among other agricultural and livestock activities of major relevance to Brazil. Given soy's economic and strategic importance for the country, its dynamics of territorial occupation in the Cerrado Biome and the frequent association of soy with the Biome's deforestation, it is imperative that the soy crop is monitored and mapped each crop year. Only in this way is it possible to identify and measure soy's contribution as a vector in new deforestation, leaving the field of speculation for a transparent discussion based on objective information which can orient the sustainable expansion of soy production in the Biome.

It was in this respect that the GTS (Soy Task Force), responsible for the Soy Moratorium agreement in the Amazon Biome, decided to create the GTC (Cerrado Task Force) with the objective of erradicating, in the shortest timeframe possible, deforestation in the Cerrado Biome, reconciling the production of soy with environmental, economic and social interests, where deforestation is defined by the GTC as the conversion of native vegetation. One of the GTC's actions was to obtain an updated soy map for the 2016/17 crop, using as reference the soy map for the 2013/14 crop prepared by Agrosatélite for the study: "Geospatial Analysis of the Dynamics of Annual Crops in the Cerrado Biome from 2000 to 2014", available on biomas. agrosatelite.com.br. In addition to the soy map, part of this study was an evaluation of the soy areas that expanded into native vegetation, based on deforestation mapped by PRODES-Cerrado for the period 2014-2016.

2. MATERIALS AND METHODS

2.1 Mapping soy in the 2016/17 crop

The mapping of soy area for the 2016/17 crop year was based on the images obtained by the satellites Landsat-7, Landsat-8 and Sentinel-2A, supported by a temporal series of images obtained by the MODIS sensor. Approximately 2,000 images were used, 930 from Landsat-8 (OLI sensor), 670 from Landsat-7 (ETM+ sensor) and 400 from Sentinel-2A (MSI sensor). These images were submitted to a thorough visual interpretation to identify and map soy areas in the 2016/17 crop year. A temporal series of images from the MODIS sensor, transformed into EVI (Enhanced Vegetation Index), was used in the form of 16-day temporal compositions through consultations of the web application for EMBRAPA's SatVeg project (www.satveg.cnptia.embrapa.br).

The mapping of soy area in the 2016/17 crop year had, as its starting point, the 2013/14 soy map prepared by Agrosatélite in 2015 for the project "Geospatial Analysis of the Dynamics of Annual Crops in the Cerrado Biome from 2000 to 2014", available at biomas.agrosatelite.com.br. Using this map, the expansions and retractions of soy crops were identified in accordance with the images acquired throughout the 2016/17 crop year.

Figure 1a shows an area of soy expansion (red line) and one of soy retraction (black line) in 2016/17, related to the 2013/14 crop year, both identified in an image acquired on 7th January 2017 by the Landsat-8 satellite. Figure 1b shows the temporal series from the MODIS images for the soy expansion area, highlighting the deforestation that occurred in the first semester of 2014. Figure 1c illustrates the temporal series from the MODIS images for a sugarcane crop that was made over to soy for the 2013/14 and 2014/15 crops and replanted with sugarcane in 2015, characterised as an area of soy retraction.

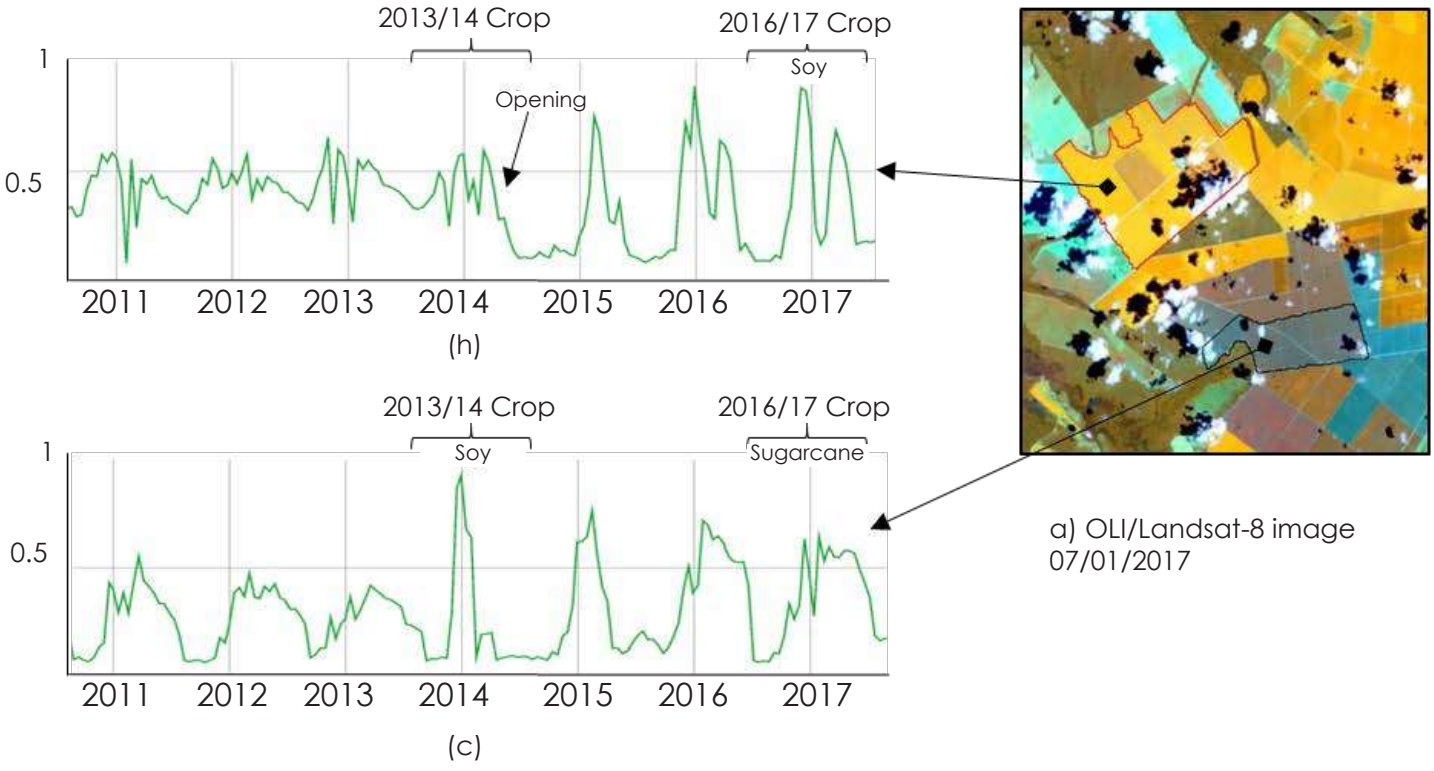


Figure 1 – Examples of soy crop expansion and retraction: a) detail of the image from 7th January 2017 from Landsat-8, identified as an area of soy expansion (red line) and retraction (black line); b) MODIS temporal series of expansion area; c) MODIS temporal series of retraction area.

2.2 Analysis of soy expansion into native vegetation

The analysis of the soy area which expanded into native vegetation in the period 2014- 2016 was based on the deforestation maps for the years 2014, 2015 and 2016 from PRODES-Cerrado, available at http://www.dpi.inpe.br/fipcerrado/#. This methodological procedure differed from that adopted by Agrosatélite for the study "Geospatial Analysis of the Dynamics of Annual Crops in the Cerrado Biome from 2000 to 2014", in that the areas of soy expansion in the study period were analysed one by one, directly on the satellite images of the year prior to the soy expansion, to identify which class of land use and land cover change was converted to soy. This method is more precise in terms of identifying and quantifying land use and land cover changes, when compared to a simple crossing with the PRODES-Cerrado maps that could generate inconsistencies as a function of the geometric adjustment and the difference in the scale of the analysis of the data. These inconsistencies were observed with greater frequency in small areas along the borders between soy fields and native vegetation, especially in the southern states of the Cerrado Biome, as can be seen in the detail shown in Figure 2c. However, with the adoption of a cut-off threshold of five hectares to eliminate these small areas called "false positives", the result is more consistent and very similar to that which would be obtained from an individual analysis of each soy area that expanded into deforested areas (Figure 2d). The five-hectare threshold is very conservative, neither eliminating all the undesirable intersections, as illustrated in Figure 2d, nor excluding all the smaller deforested areas that were effectively associated with a conversion to soy. In MATOPIBA, the method of crossing the PRODES map with the soy expansion map gave a good result because of the larger deforested areas in this region, compared to the southern states of the Cerrado Biome.

The Cerrado Biome has two distinct regions in terms of the dynamics of soy expansion: the MATOPIBA region, which encompasses the states of Maranhão, Tocantins, Piauí and Bahia and is considered the current frontier of agricultural expansion in Brazil, and the southern states, which are the Federal District and those parts of the states of Goiás, Minas Gerais, Mato Grosso do Sul, Mato Grosso, Paraná and São Paulo which are within the Cerrado Biome and where agricultural and livestock activities are more consolidated.

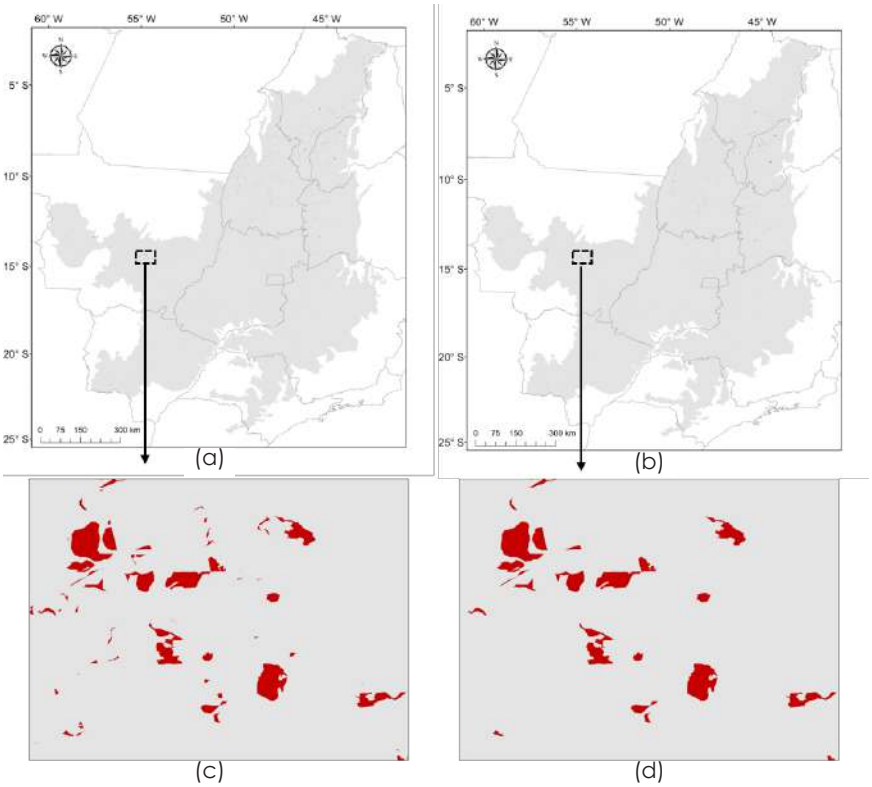


Figure 2 – Intersection of the soy map for the 2016/17 crop year, with the PRODES-Cerrado deforestation map for the period 2014-2016: a) Map of areas where soy expanded into deforested areas; b) Map of areas where soy expanded into deforested areas, eliminating areas with less than five hectares; c) Detail of a region of soy expansion into deforested areas; d) Detail of a region of soy expansion into deforested areas, eliminating areas with less than five hectares, which are mostly "false positives" on the borders of deforested areas with soy expansion areas.

2.3 Analysis of soy expansion into suitable areas

The analysis of soy expansion into areas that are adequate or inadequate for soy was made through crossing soy expansion areas for the crop years from 2013/14 through 2016/17 with the 2014 map of agricultural capacity in the Cerrado Biome, prepared by Agrosatélite in the context of the project: "Geospatial Analysis of the Dynamics of Annual Crops in the Cerrado Biome from 2000 to 2014" (available at biomas.agrosatelite.com.br).

In this study, edaphoclimatic potential was divided into four classes: 1) high potential – H; 2) medium potential – M; 3) low potential – L; and 4) inadequate – I, based on a methodology similar to that adopted for ZARC (Agricultural Zoning for Climatic Risk) for soy production. ZARC is established by taking into consideration the historical climate, soil water holding capacity, and the evapotranspiration demands during critical growth stages throughout the crop season. In addition to the edaphoclimatic potential, the Agrosatélite study considered the slope and altitude data in INPE's SRTM/TOPODATA digital elevation model (dsr.inpe.br/topodata). Areas considered restricted were those with a slope of more than 12%. In the case of altitude, the restriction criterion considered the spatial distribution for the minimum altitude of soy, corn and cotton crops grown in the 2013/14 crop year.

The agricultural fields at lowest altimetry were connected, creating a surface of the lowest agricultural altimetry in 2014. After comparing the surface of the lowest agricultural altimetry with the surface of the digital elevation model, the surface that stayed below the surface of the lowest agricultural altimetry were considered restricted as regards altitude. This assumption takes into consideration that, regionally, areas of lower altitudes are peripheral and more restricted as regards agricultural expansion. This is a very restrictive criterion but one which is consistent with the current local agricultural production, up to the moment when the best areas became depleted. So, from the above data, 13 classes of agricultural capacity were defined:

1. High edaphoclimatic potential without slope and altitude restrictions (H, NR);
2. High edaphoclimatic potential with slope restrictions (H, SR);
3. High edaphoclimatic potential with altitude restrictions (H, AR);
4. High edaphoclimatic potential with slope and altitude restrictions (H, SRA);
5. Average edaphoclimatic potential without slope and altitude restrictions (M, NR);
6. Average edaphoclimatic potential with slope restrictions (M, SR);
7. Average edaphoclimatic potential with altitude restrictions (M, AR);
8. Average edaphoclimatic potential with slope and altitude restrictions (M, SRA);
9. Low edaphoclimatic potential without slope and altitude restrictions (L, NR);
10. Low edaphoclimatic potential with slope restrictions (L, SR);
11. Low edaphoclimatic potential with altitude restrictions (L, AR);
12. Low edaphoclimatic potential with slope and altitude restrictions (L, SRA);
13. Inadequate due to edaphoclimatic deficiencies, independent of slope and/or altitude restrictions (I).

3. RESULTS AND DISCUSSION

3.1 Soy dynamics 2000/01-2016/17

Figures 3 to 5 illustrate soy dynamics in the Cerrado Biome for the period 2000/01-2013/14, taken from the study "Geospatial Analysis of the Dynamics of Annual Crops in the Cerrado Biome from 2000 to 2014" (biomas.agrosatelite.com.br). Although the analysis of these data is not part of the scope of the present study, it has been added to this report for the purpose of improving the understanding of the dynamics of soy expansion during the period 2000-2017. Figure 6 shows the soy map for the 2016/17 crop, the main result of this study.

Figure 7 shows that, in the period 2000/01-2016/17, soy area in the Cerrado Biome went from 7.53 million hectares to 17.07 million hectares, an increase of 128% (9.54 million hectares). In MATOPIBA, soy area increased fourfold (2.97 million hectares), going from 0.97 million hectares to 3.94 million hectares. In the Cerrado's southern states, soy area doubled, going from 6.56 million hectares to 13.12 million hectares. Furthermore, the annual rate of soy expansion in the period 2000/01-2006/07 was much lower (0.43 million hectares per year) than the period 2006/07-2013/14 (0.78 million hectares per year). However, in the more recent period 2013/14-2016/17, there was a significant reduction in the expansion rate (0.49 million hectares per year), both in the MATOPIBA region and in the southern states, due to a less favourable market environment than that in the prior period and to recurring droughts in the period 2012-2015, especially in MATOPIBA, which slowed investments.

The increase in Cerrado soy area in the period 2013/14-2016/17 was 1.41 million hectares (9.0%), going from 15.66 million hectares to 17.07 million hectares. In the MATOPIBA region, the increase was 0.52 million hectares (35%), with Tocantins state expanding its soy area by 0.23 million hectares (16%), from 0.68 million hectares to 0.91 million hectares (Figure 8). This confirms MATOPIBA's position as a very relevant region in the recent expansion of soy area in the Cerrado Biome. In the Cerrado's southern states, the expansion was 0.89 million hectares (61%).

The soy map for the 2016/17 crop revealed that over half (50.4%) of Brazil's soy area (33.9 million hectares) is concentrated in the Cerrado Biome. The states of Goiás and Mato Grosso have the largest soy area and, together, represent 54% (9.28 million hectares) of soy in the Cerrado Biome (Table 1).

Table 1 – Soy area by state, in those areas within the Cerrado Biome, for the 2016/17 crop

	Soy Area in Hectares – 2016/17 Crop Year											
	DF	GO	MG	MS	MT	PR	SP	MA	TO	PI	BA	Total
Soy	88,572	3,644,519	1,531,541	1,652,907	5,630,601	79,499	496,431	748,482	914,009	653,375	1,627,368	**17,067,304**

DF-Federal District; GO-Goiás; MG-Minas Gerais; MS-Mato Grosso do Sul; MT-Mato Grosso; PR-Paraná; SP-São Paulo; MA-Maranhão; TO-Tocantins; PI-Piauí; BA-Bahia.

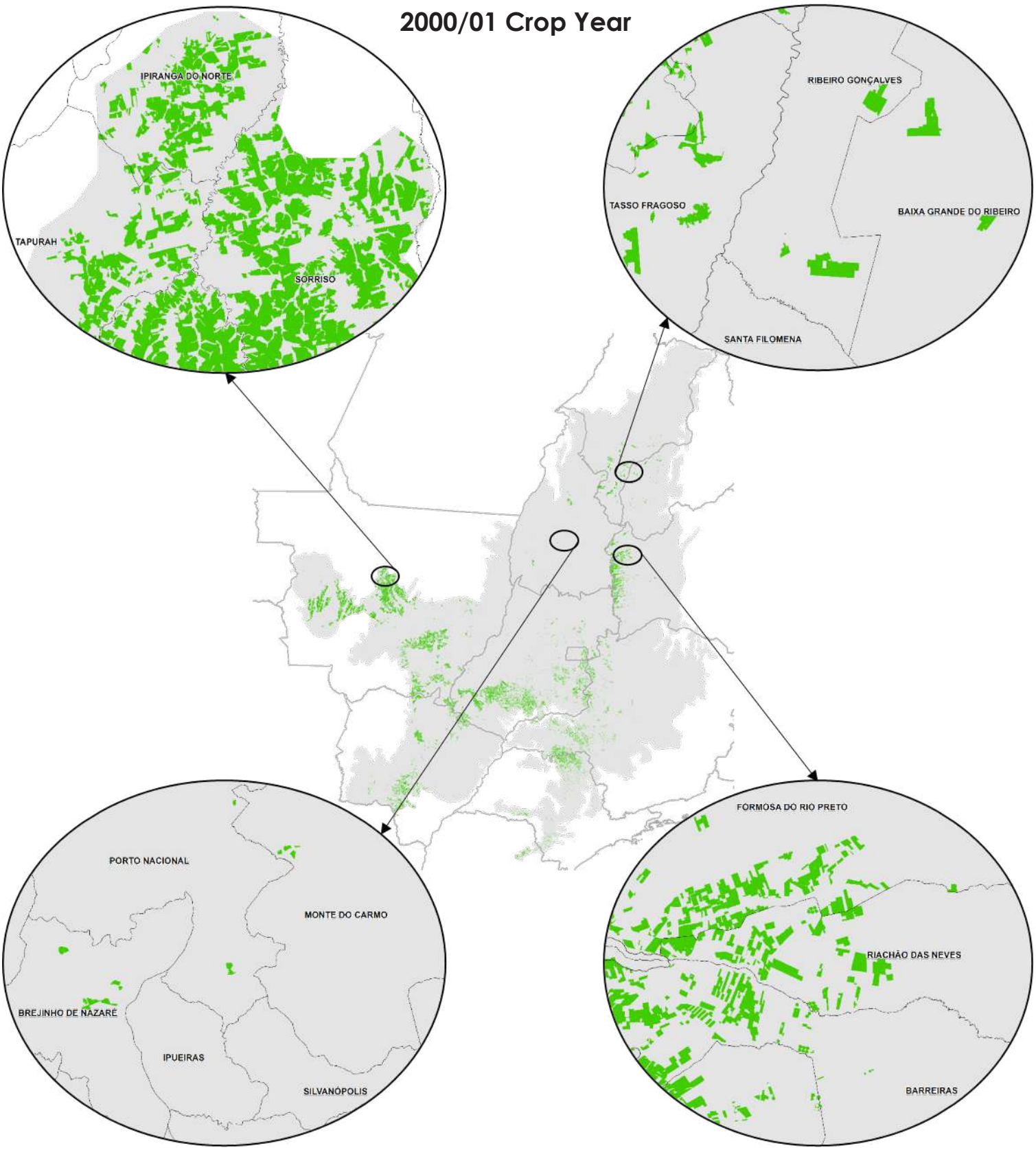


Figure 3 – Map of soy area in the Cerrado Biome for the 2000/01 crop year.

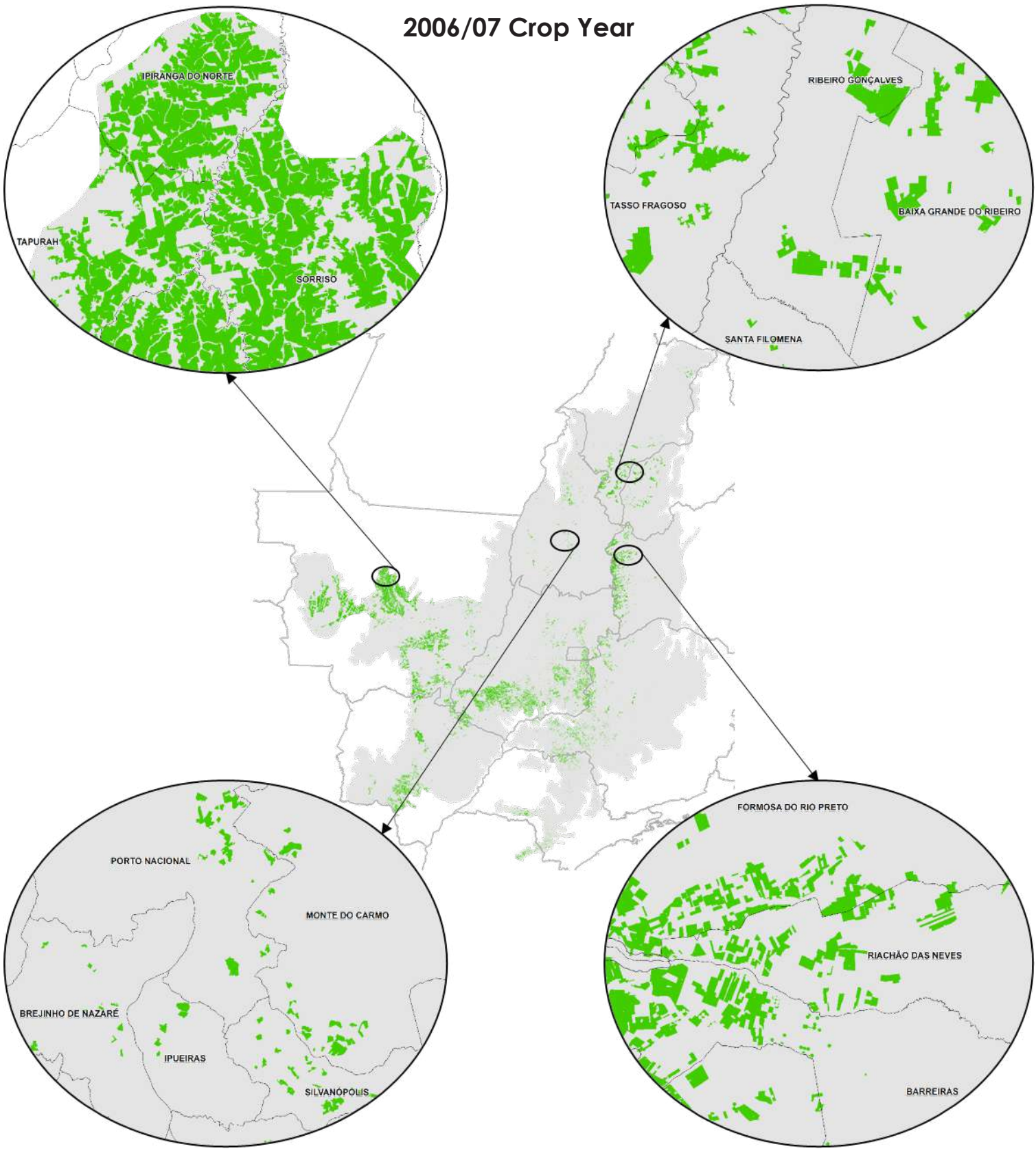


Figure 4 – Map of soy area in the Cerrado Biome for the 2006/07 crop year.

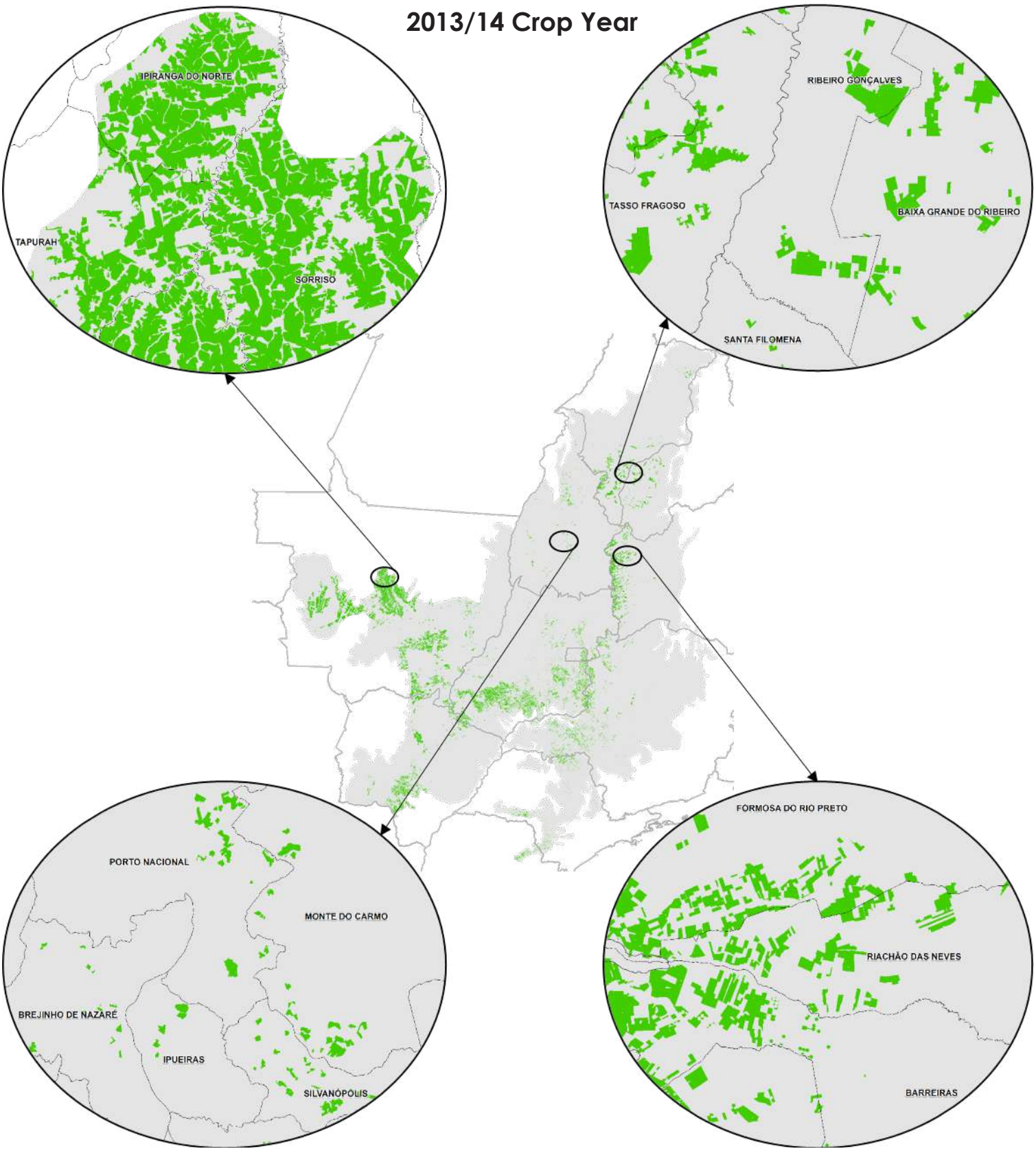


Figure 5 – Map of soy area in the Cerrado Biome for the 2013/14 crop year.

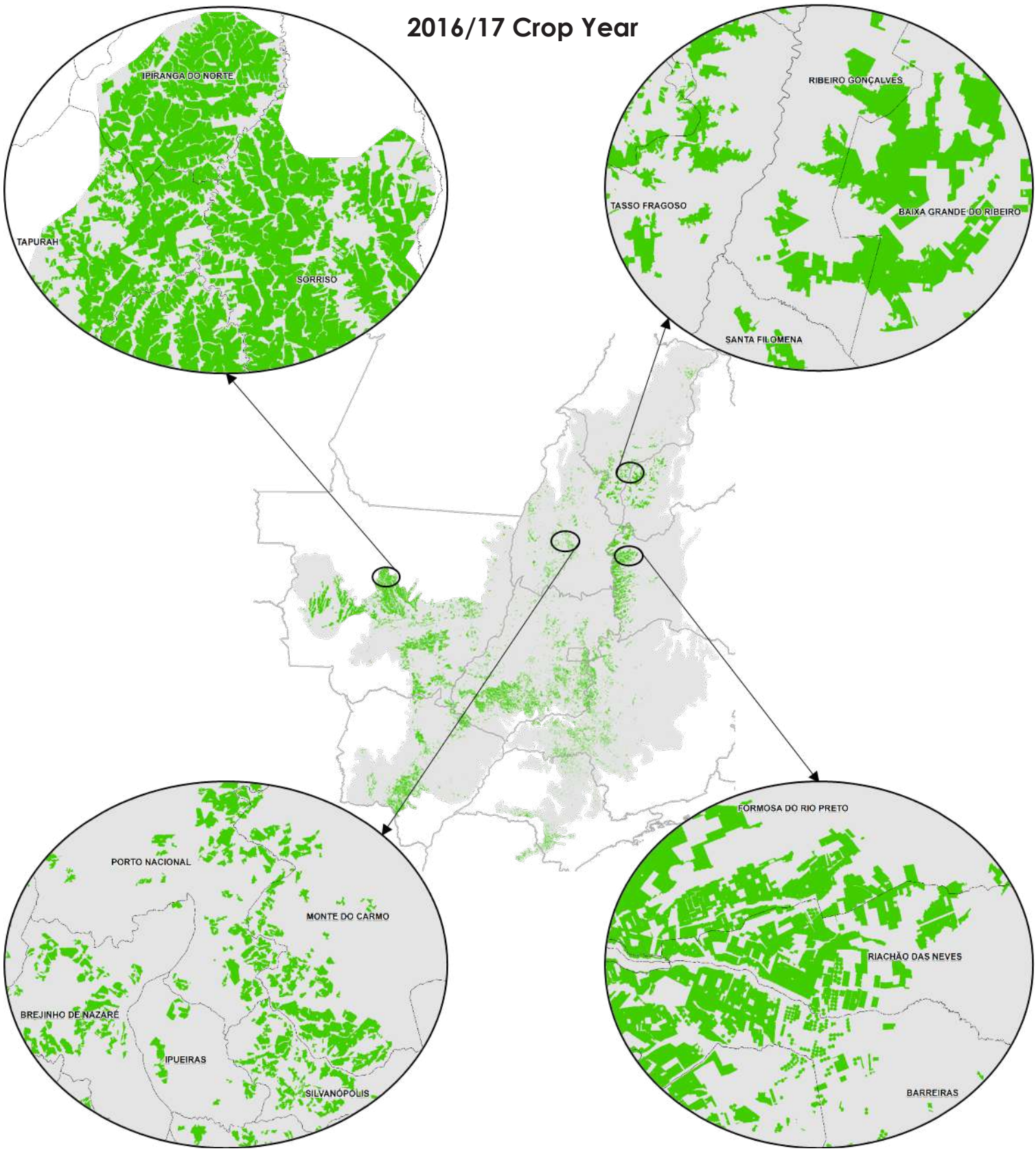


Figure 6 – Map of soy area in the Cerrado Biome for the 2016/17 crop year.

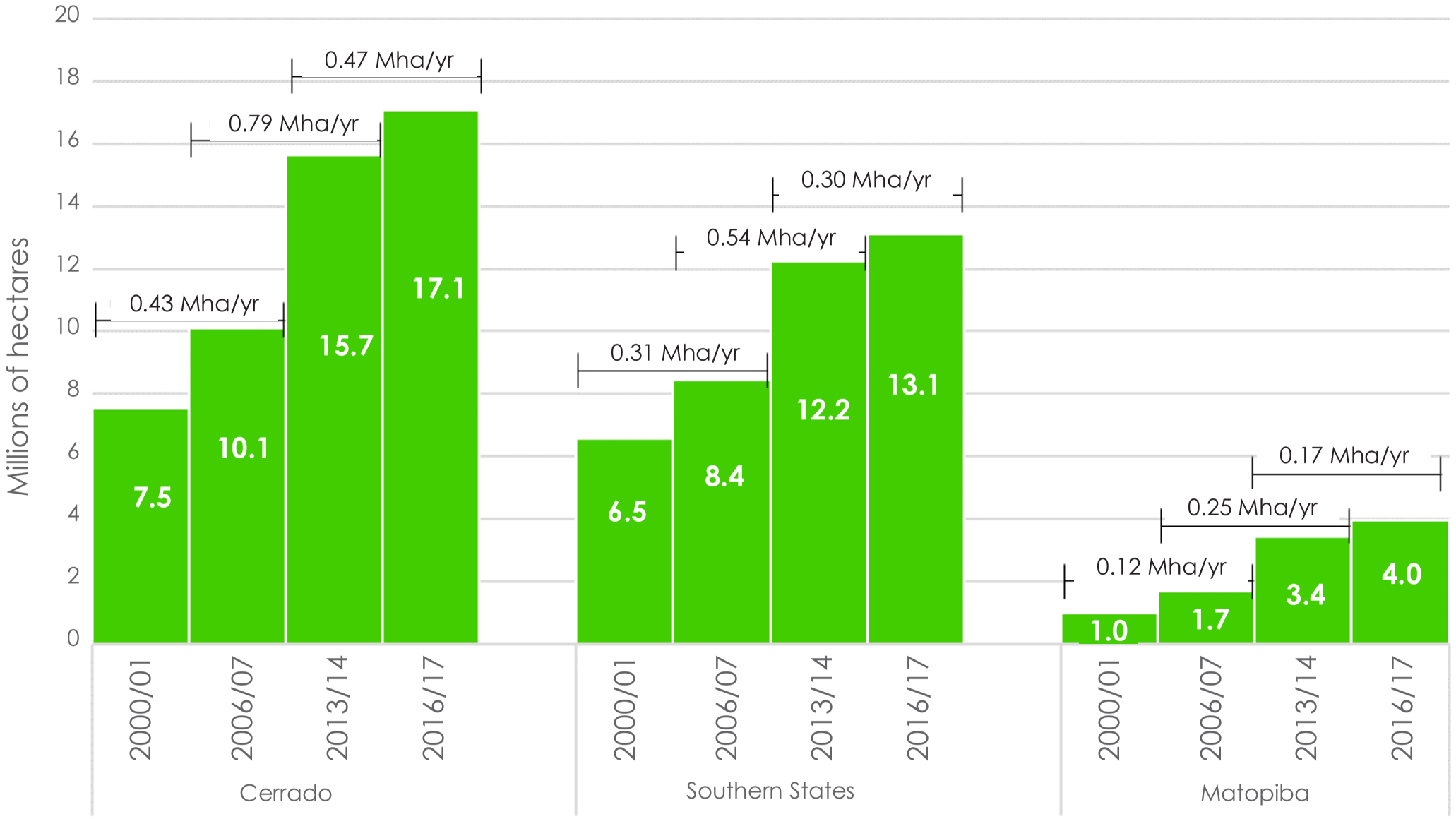
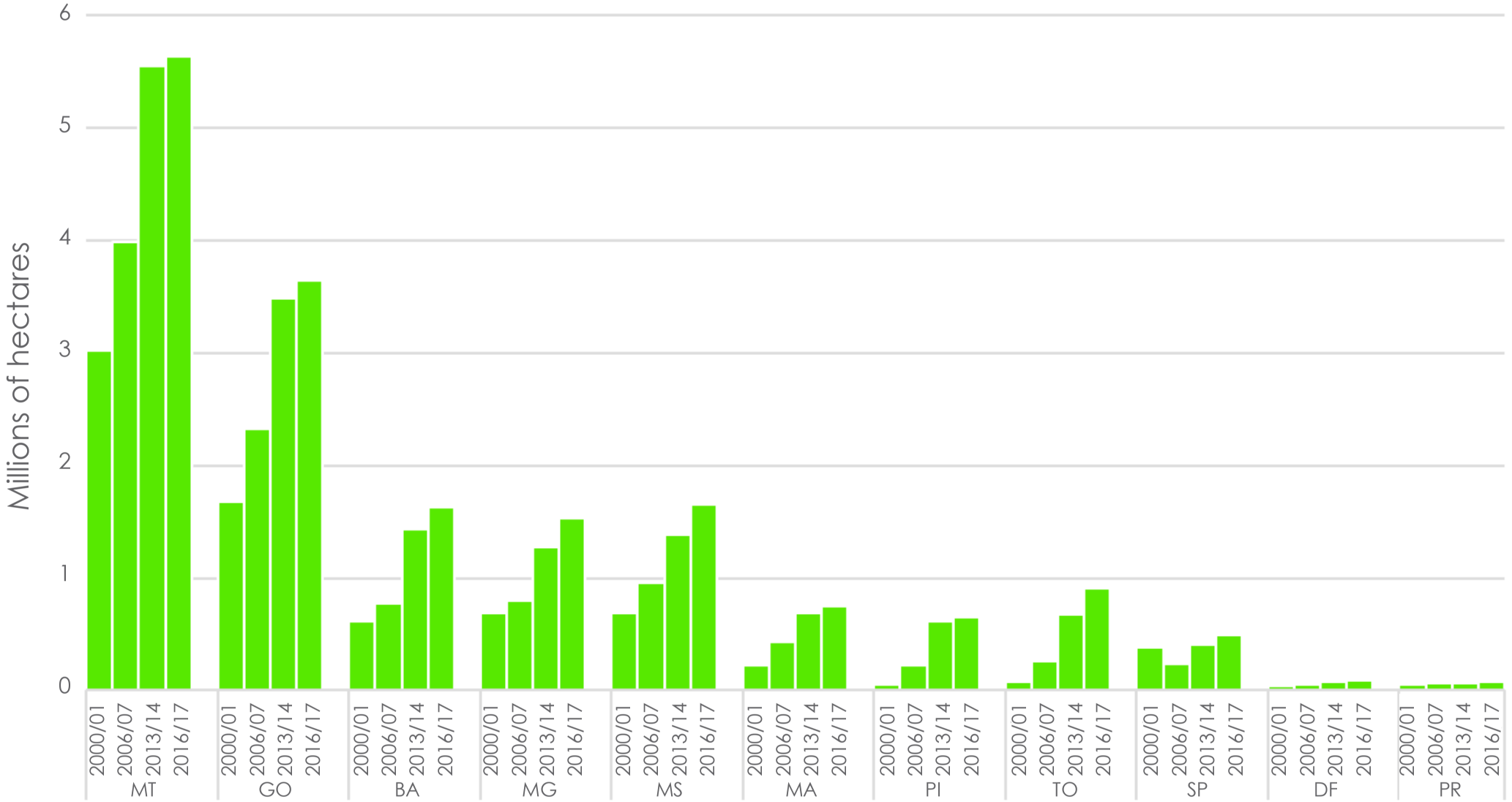


Figure 7 – Evolution of soy area in the Cerrado, divided between the southern states and MATOPIBA for crop years 2000/01 to 2016/17.



MT-Mato Grosso; GO-Goiás; BA-Bahia; MG-Minas Gerais; MS-Mato Grosso do Sul; MA-Maranhão; PI-Piauí; TO-Tocantins; SP-São Paulo; DF-Federal District; PR-Paraná

Figure 8 – Soy area by Federal District and States, in that part of their territory within the Cerrado Biome, in crop years 2000/01, 2006/07, 2013/14 and 2016/17.

3.2 Analysis of soy expansion into native vegetation

3.2.1 Soy into native vegetation – 2000-2017

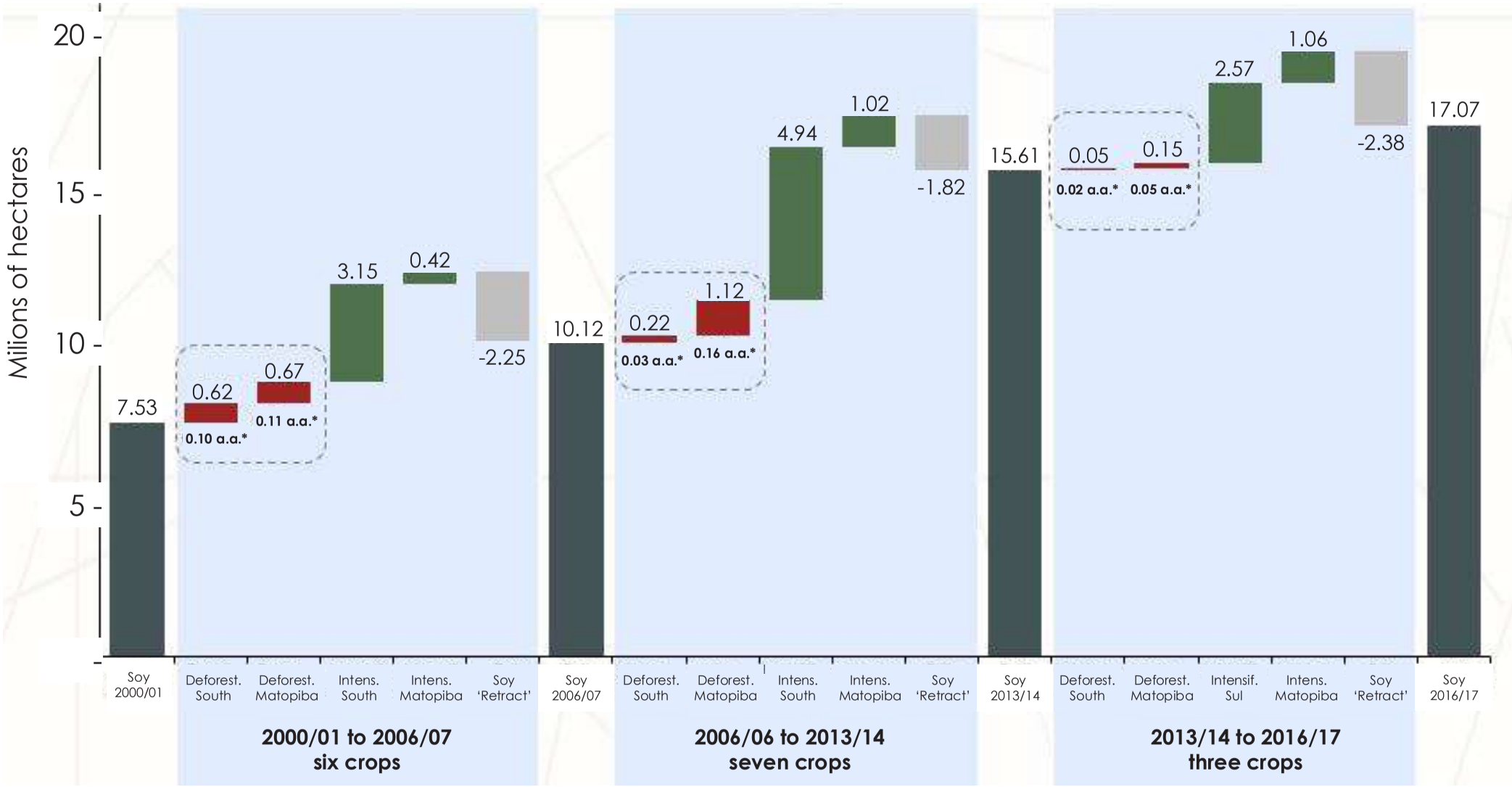
As seen in Item 3.1, soy area in the Cerrado Biome expanded by 9.54 million hectares in the period 2000/01-2016/17. In this period, 2.83 million hectares (30%) of the soy expansion was into deforested areas, with about 1.94 million hectares (69%) of this deforestation in the MATOPIBA region and 0.89 million hectares (31%) in the Cerrado's southern states.

Figures 9 and 10 show the results of soy expansion, with and without deforestation, in the three periods analysed: 1) 2000/01-2006/07 (six crop years); 2) 2006/07-2013/14 (seven crop year); and 3) 2013/14-2016/17 (three crop years). Even though the three periods do not have the same duration, they show the gradual reduction in soy expansion with deforestation, in relation to soy expansion without deforestation, both in the Cerrado's southern states and in the MATOPIBA region.

In MATOPIBA, deforestation associated with soy in the first period analysed (2000/01-2006/07) was 0.11 million hectares per year, increasing in the second period (2006/07-2013/14) to 0.16 million hectares per year. However, the third period (2013/14-2016/17) saw a significant reduction (0.05 million hectares per year), shown in Figure 9. One of the main reasons for the reduction in deforestation in the most recent period is the losses that occurred in four consecutive crop years (2011/12-2014/15) as a result of the drought in several areas of the MATOPIBA region, which limited the investment capacity of producers to open new areas. It should be noted that the period and the analysis from 2014 to 2017 (three crop years) is shorter than the prior periods (six or seven crop years). This means that part of the deforested areas, which are not yet planted with soy, could be used for this crop in the next three or four years and that, therefore, this rate of 0.05 million hectares per year could suffer an increase. Nevertheless, it would certainly not increase enough to reach the prior period's rate of 0.16 million hectares per year. In the Cerrado's southern states, deforestation associated with soy fell significantly from the first period analysed to the second, going from 0.10 million hectares per year to 0.03 million hectares per year. A less expressive reduction, but still significant, was seen in the most recent period, with a rate of 0.02 million hectares per year (Figure 9). It is possible that this conversion rate of native vegetation into soy is slightly lower between 2013/14 and 2016/17 because, in this period, the evaluation of deforestation due to soy expansion was made by crossing the PRODES-Cerrado map with the soy expansion map. This slightly overestimates the deforested areas converted into soy because of the occurrence of "false positives", especially in the Cerrado's southern states, as discussed in Item 2.2. "False positives" do not occur in the prior periods (2000/01-2006/07 and 2006/07-2013/14) because those evaluations were made individually for each area of soy expansion (see Item 2.2).

Figure 9 also shows the areas of soy retraction, which have remained stable throughout the periods analysed. Areas of retraction are an expected phenomenon within the dynamics of soy production and do not mean the area was abandoned. Rather, it is a floating stock of areas available for soy crops. For the most part, retractions occur in three situations: i) areas temporarily fallow, especially peripheral areas or those not yet consolidated; ii) crop rotation, with cotton and corn crops planted first, a common practice in MATOPIBA; and iii) renewal of sugarcane crops, rotating with soy for one or two years.

It should be emphasised that, in the period 2014-2017, the conversion rates of native vegetation into soy were the lowest of the last 16 years, both in the MATOPIBA region and in the Cerrado's southern states. Continued expansion of soy production through intensification, seeking for crop yield increases and better use of the already opened areas, is the main reason that soy is decreasingly a vector of deforestation, both in MATOPIBA and in the southern states.



*represents the average annual rate for the period, expressed in ha / year.

Note: For the periods 2000/01-2006/07 and 2006/07-2013/14, the data comes from the study "Geospatial Analysis of the Dynamics of Annual Crops in the Cerrado Biome from 2000 to 2014" (biomas.agrosatelite.com.br). For the period 2013/14-2016/17, the data was obtained by crossing the 2016/17 soy map with the deforestation mapped by PRODES-Cerrado for the years 2014, 2015 and 2016.

Figure 9 – Soy expansion, with and without deforestation, in the Cerrado Biome in 2000/01 to 2016/17 crop years.

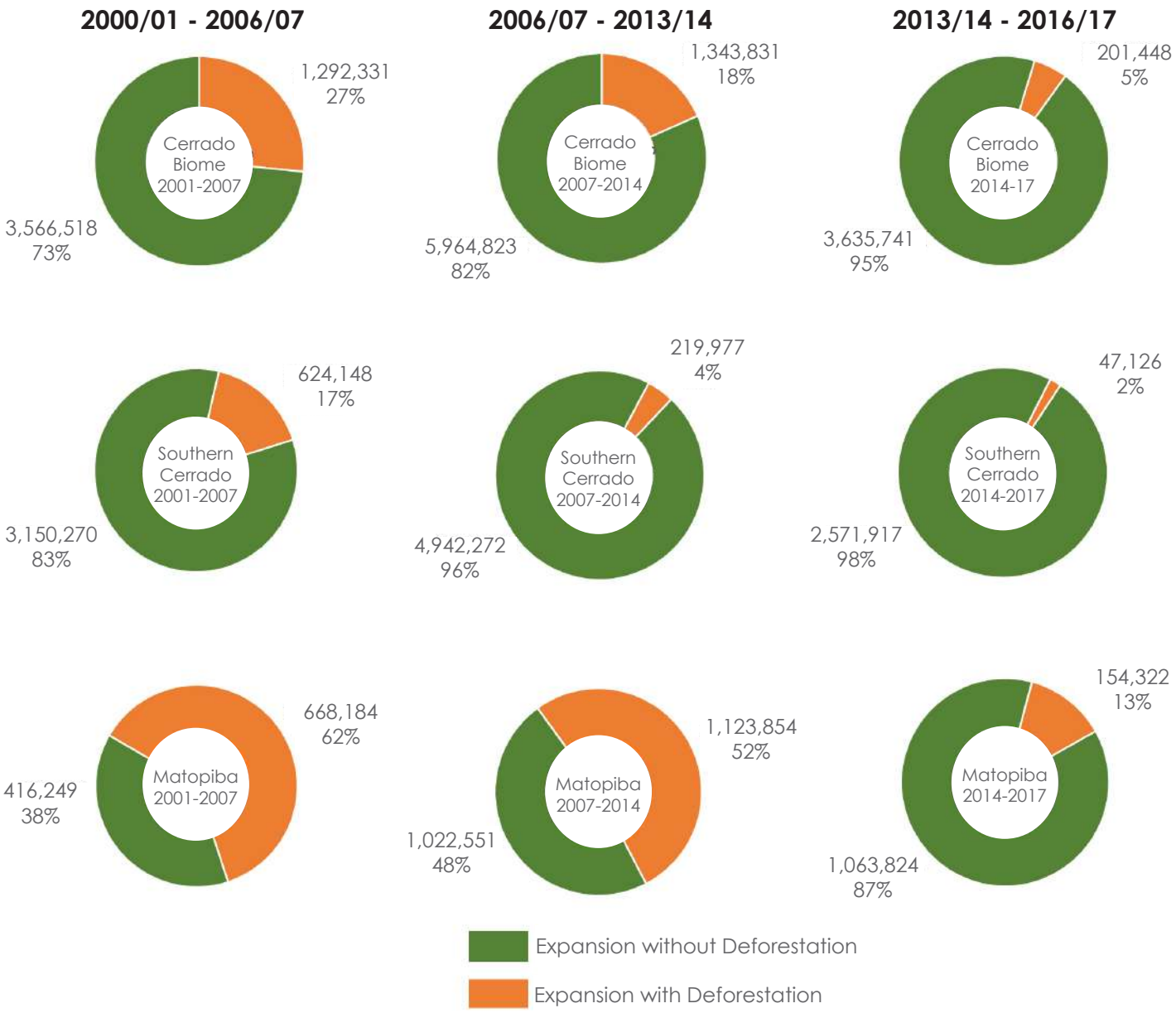


Figure 10 – Soy expansion, with and without deforestation, in the Cerrado Biome in the 2000/01 to 2016/17 crop years.

3.2.2 Soy into native vegetation – 2014, 2015 and 2016

Soy area in the 2016/17 crop year, planted on deforested areas mapped by PRODES-Cerrado in the period 2014-2016, was 201,448 hectares, corresponding to 6.8% of the total 2.94 million hectares deforested in the Cerrado during the same period (Figure 11).

In MATOPIBA, soy area in the 2016/17 crop year, planted on deforested areas mapped by PRODES-Cerrado in the period 2014-2016, was 154,322 hectares, corresponding to 8.7% of MATOPIBA's deforestation; while in the Cerrado's southern states this area was 47,126 hectares, corresponding to 4.0% of the deforestation in these states, according to data from PRODES-Cerrado.

In the MATOPIBA region, Tocantins state had the largest soy area planted on deforested land (61,210 hectares), followed by the states of Maranhão, Piauí and Bahia with 40,731 hectares, 29,865 hectares and 22,516 hectares, respectively. In the Cerrado's southern states, the largest area of soy planted on deforested areas was seen in Mato Grosso state – 22,280 hectares representing 47% of the deforestation converted to soy in this region.

Although only 6.8% of the deforestation between 2014 and 2016 has been converted into soy, this does not mean that new soy area will not be seen in these areas in future crop years because the process of converting native vegetation into soy goes through several stages, such as the removal, bundling and burning of the remains of the native vegetation (trunks and roots), soil correction with lime and production of rice for one or more crop years. Figure 12 illustrates that the deforestation in 2014 had a greater tendency to convert to soy than it did in 2016; in other words, a significant part of the areas deforested in 2015 and 2016 with the intention of converting it to soy is still in the process of conversion.

In this regard, the "stock" of deforested areas not converted to soy in 2016/17 needs to be better understood in respect of its current use and agricultural potential to enable an evaluation of the "potential stock" of areas suitable for future expansion of soy.

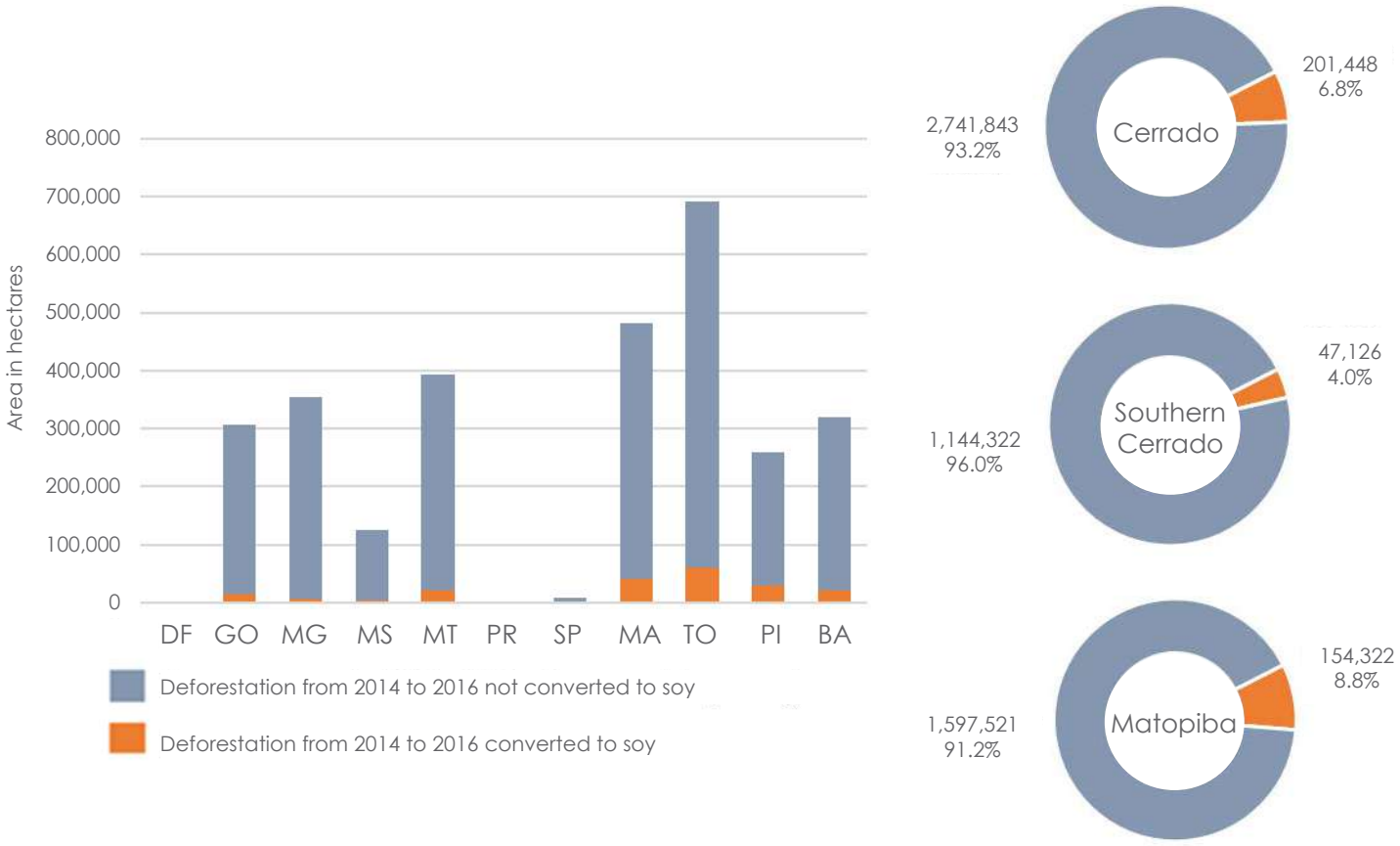


Figure 11 – Expansion of soy in 2016/17 into deforested areas of the Cerrado Biome, according to data from PRODES-Cerrado from 2014 to 2016.

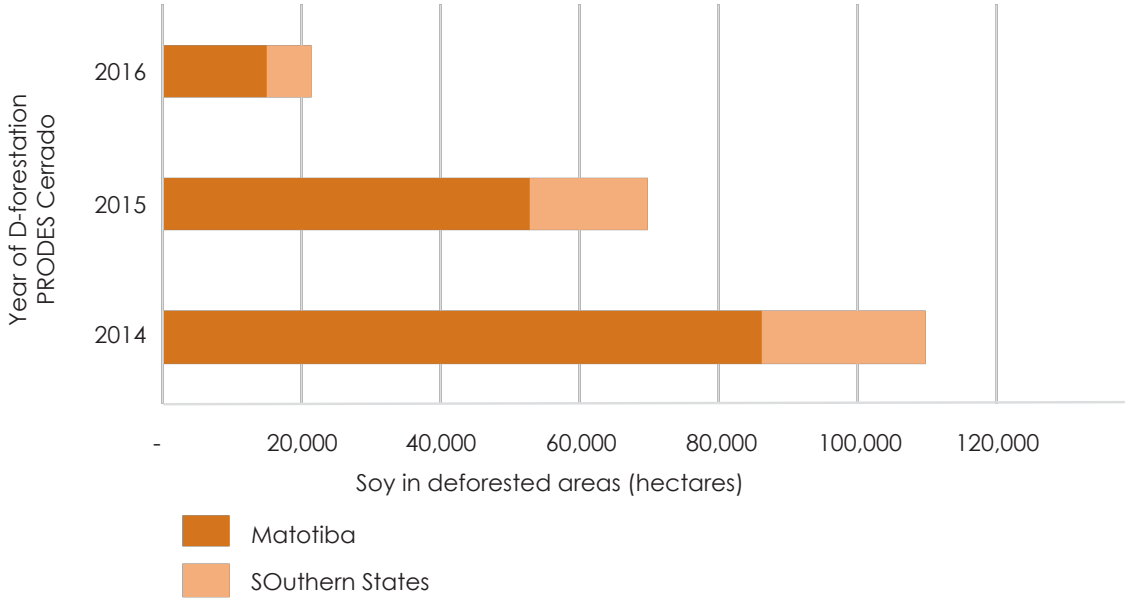


Figure 12 – Soy from the 2016/17 crop that expanded into deforested areas mapped by PRODES-Cerrado in 2014, 2015 and 2016.

3.3 Analysis of soy expansion into suitable areas

Crossing the areas of soy expansion in 2014-2017 with the map of agricultural capacity shows that 70.2% of the soy expanded into areas of high edaphoclimatic potential without slope or altitude restrictions (AA, SR) and 6.7% into areas of medium potential without slope or altitude restrictions (MA, SR) (Table 2). In other words, 77% of the soy expansion occurred in the two classes with greater agricultural capacity, of a total of 13 classes, in accordance with a previous study prepared by Agrosatélite. These classes show the best edaphoclimatic potential, a slope less than 12% (without slope restrictions) and are above the lowest altimetry in which agriculture is practiced in the region (without altitude restrictions). These results attest to the high consistency and sensibility of Agrosatélite's agricultural capacity map to anticipate future movements of agricultural expansion into the Cerrado Biome.

On the other hand, 23% of soy expansion occurred in areas of lower agricultural capacity, with 12.5% in areas of high edaphoclimatic potential and 2.7% in areas of average edaphoclimatic potential, but with slope and/or altitude restrictions. Furthermore, 3.4% of the soy expanded into areas of low edaphoclimatic potential, with 2.4% in areas without restrictions of slope and altitude and 1% in areas with some kind of restriction. Interestingly, 13.5% of soy expansion was in areas of high or medium edaphoclimatic potential, but with altitude restrictions. This is an expected result as, in the more consolidated agricultural production regions in which the offer of higher areas (plateaus) is becoming more restricted, producers tend to occupy peripheral areas at lower altitudes. For this reason, the altitude cut-off criterion needs to be revised and updated frequently, based on new agricultural maps so as to adjust the agricultural capacity maps that continue to be good indicators of the future expansion of soy in the Cerrado Biome.

Also interesting is the fact that 4.4% of the soy expansion was in areas classified as inadequate due to edaphoclimatic deficiency (Table 2). This is mostly due to two factors: (i) expansion with irrigation and (ii) problems associated with changes in the ZARC (Agricultural Zoning for Climatic Risk) ordinances that were considered in Agrosatélite's methodology. It is important to highlight that Agrosatélite's study of agricultural capacity was made for the 2013/14 crop. Up to the 2016/17 crop, ZARC ordinances published by the Ministry of Agriculture on 20th July 2016 established that "Type 1" or sandy soils should not be classified as suitable for soy production in the states of Goiás, Bahia, Maranhão, Minas Gerais, Piauí, Tocantins and in the Federal District (Ordinances 168, 169, 170, 171, 172, 176 and 182, respectively). For the 2017/18 crop, ZARC changed and recommended "Type 1" soil as suitable for soy production in those states (Ordinances 7, 8, 9, 10, 11, 15 and 6, dated 20th July 2017, in the same order as above). There were no changes in ZARC for the remaining states (Mato Grosso do Sul, Mato Grosso, Paraná and São Paulo).

Table 2 – Gross expansion* of soy area in the period 2013/14-2016/17, according to the different classes of agricultural capacity for the Federal District and that part of the states that is within the Cerrado Biome

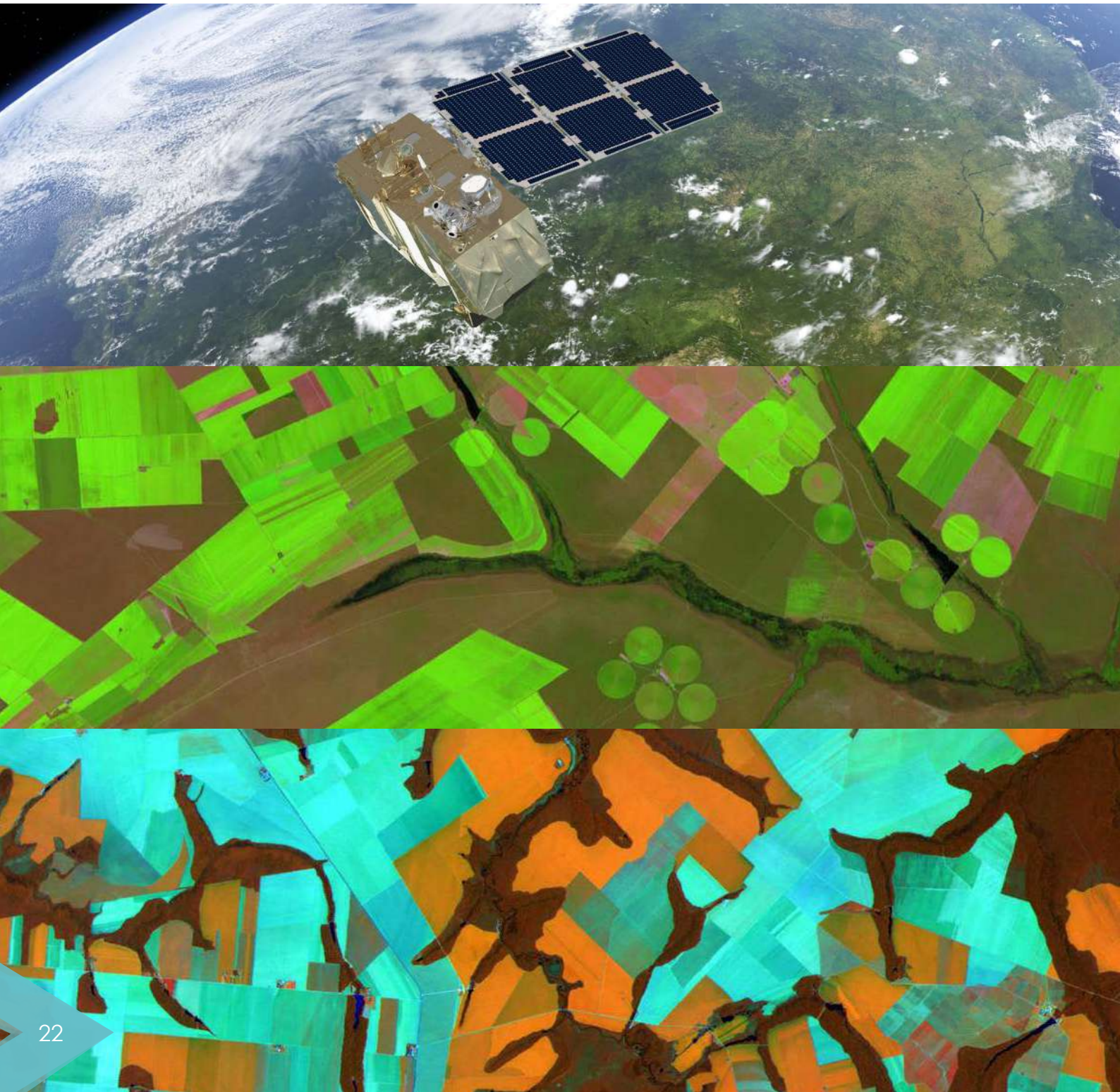
STATE	DF	GO	MG	MS	MT	PR	SP	MA	TO	PI	BA	TOTAL			
RVN_AA_SR	45	13,559	4,471	2,522	11,444	153	3,358	4,033	20,558	357	5,297	65,799	1.7%	70.2%	77%
A_AA_SR	16,979	575,437	428,299	224,652	431,560	18,591	164,744	61,159	144,269	79,070	484,388	2,629,148	68.5%		
RVN_MA_SR	1	216	1,330	3,880	38	_	130	7,300	193	5,048	1,489	19,624	0.5%	6.7%	
A_MA_SR	48	2,636	40,154	90,572	3,539	3	9,753	38,058	385	25,423	27,663	238,234	6.2%		
RVN_AA_RA	23	7,426	2,553	1,473	12,284	85	2,401	2,073	8,810	177	749	38,053	1.0%	12.5%	23%
RVN_AA_RD	1	1,219	1,159	174	299	282	860	20	117	0	0	4,133	0.1%		
RVN_AA_RDA	1	769	571	182	183	163	556	94	56	0	1	2,576	0.1%		
A_AA_RA	1,232	98,654	28,370	37,167	120,491	1,154	45,951	5,868	36,408	375	6,148	381.816	10.0%		
A_AA_RD	40	7,858	14,912	945	1,811	2,879	11,462	59	224	_	10	40,198	1.0%		
A_AA_RDA	35	3,154	3,436	474	1,130	1,414	4,213	69	63	2	9	13,999	0.4%		
RVN_MA_RA	_	105	1,130	2,812	59	1	80	6,576	145	1,877	1,657	14,443	0.4%	2.7%	
RVN_MA_RD	_	0	95	449	5	_	114	67	7	0	0	736	0.0%		
RVN_MA_RDA	_	19	86	192	2	4	84	162	11	8	0	569	0.0%		
A_MA_RA	2	1,242	10,505	40,581	1,656	38	3,027	17,254	428	3,519	4,095	82,347	2.1%		
A_MA_RD	_	17	771	1,230	68	6	1,946	191	20	2	_	4,250	0.1%		
A_MA_RDA	_	21	364	638	4	50	1,189	132	6	6	0	2,408	0.1%		
RVN_BA_SR	_	0	870	529	_	_	_	53	_	2,703	84	4,240	0.1%	3.4%	
RVN_BA_RA	_	_	625	1,145	_	_	_	4	_	3,777	28	5,579	0.1%		
RVA_BA_RD	_	_	53	14	_	_	_	0	_	0	_	68	0.0%		
RVN_BA_RDA	_	_	67	9	_	_	_	1	_	0	0	77	0.0%		
A_BA_SR	_	_	29,404	6,316	_	_	_	480	_	44,646	6,944	87,789	2.3%		
A_BA_RA	_	0	7,414	6,692	_	_	_	374	_	11,689	3,859	30,028	0.8%		
A_BA_RD	_	_	417	49	_	_	_	0	_	0	_	466	0.0%		
A_BA_RDA	_	_	220	41	_	_	_	4	_	1	0	267	0.0%		
Inapto -RVN	1	697	270	269	156	41	14	3,633	16,968	134	1,160	23,344	0.6%	4.4%	
Inapto - A	70	13,450	8,547	3,415	399	297	522	7,525	103,045	1,613	7,148	146,031	3.8%		
Total	18,477	726,479	586,095	426,421	585,128	25,159	250,404	155,189	331,712	180,429	550,730	3,836,223	100.0%		

(i) DF-Federal District; GO-Goiás; MG-Minas Gerais; MS-Mato Grosso do Sul; MT-Mato Grosso; PR-Paraná; SP-São Paulo; MA-Maranhão; TO-Tocantins; PI-Piauí; BA-Bahia
(ii) The agricultural capacity classes are described in Item 2.3.

* The total gross soy expansion was 3.8 million hectares. The net soy expansion was 1.4 million hectares; in other words, 2.4 million hectares correspond to areas of "retraction" (see Figure 9).

It is worth highlighting that the states that had changes in ZARC (Bahia, Federal District, Goiás, Maranhão, Minas Gerais, Piauí and Tocantins) account for 98% (164,262 hectares) of soy expansion in areas considered inadequate. Tocantins heads the list with 103,045 hectares (70% of the total), and this disproportional result indicates that the alteration in ZARC to include sandy soils as suitable was necessary for this state, since soy expansion into these areas is a reality in the state. The available soil maps used in the study of agricultural capacity also have limitations in the classification of soil textures and could be part of the reason for this discrepancy when comparing Tocantins to the other states.

On the other hand, MATOPIBA's sandy soils are more susceptible to water-deficit problems and represent areas with a higher risk of agricultural losses during droughts due to its lower water holding capacity. In this regard, the changes in the Ordinances should be analysed carefully as records exist of soy area being abandoned in MATOPIBA's more sandy soils, especially in the southwest of Bahia state, a region which has suffered recurring losses in agricultural productivity over the last years.



4. CONCLUSION

Soy area in the Cerrado Biome went from 7.53 million hectares in the 2000/01 crop year to 17.07 million hectares in the 2016/17 crop year, corresponding to an increase of 128% and a growth rate of 596,000 hectares per year over these 16 years. However, in the more recent period 2013/14-2016/17, the expansion rate was below average with 471,000 hectares/year, due to less favourable market condition and due to recurring droughts in the MATOPIBA region between 2012 and 2015 that slowed investments.

The lowest rates of conversion of native vegetation to soy, in the last 16 years, were observed in the period 2013/14-2016/17 both in MATOPIBA and in the southern states of the Cerrado. This is due to distinct factors, among them the priority of producers in investing on land intensification and soy crop yield increase, with better use of prior opened land with agricultural potential for soy rather than opening of new areas with deforestation.

Recent data published by PRODES-Cerrado showed that 2.94 million hectares were deforested between 2014 and 2016 in the Cerrado. The present study revealed that 201 thousand hectares (6.8%) of the deforested area in that period was converted to soy in crop year 2016/17, with 154 thousand hectares in MATOPIBA and 47 thousand hectares in the southern states of the Cerrado. The conversion percentage of deforestation to soy was 8.8% in the MATOPIBA region while it was 4.0% in the southern states of the Cerrado.

The analysis of agricultural suitability in areas of soy expansion in the Cerrado Biome in the period 2013/14-2016/17 showed that 77% of the soy expansion was into areas with high and average edaphoclimatic potential, without slope or altitude restrictions.

Execution

Financing