Combining socio-economic development with environmental governance in the Brazilian Amazon: The Mato Grosso agricultural frontier at a tipping point

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COMBINING SOCIO-ECONOMIC DEVELOPMENT WITH ENVIRONMENTAL GOVERNANCE IN THE BRAZILIAN AMAZON: THE MATO GROSSO AGRICULTURAL FRONTIER AT A TIPPING POINT

Abstract:

Agricultural landscapes of the Southern Brazilian Amazon are the result of eighty years of governmental policies to install a powerful agricultural sector. Yet, this rapid expansion raised important environmental considerations especially with regard to deforestation. The agricultural frontier is thus now facing a huge challenge: to combine socio-economic development with environmental conservation in a context of frontier expansion. Based on a conceptual model of the agricultural frontier, we review historical changes in environmental and development policies in the Brazilian state of Mato Grosso and emphasize their ambivalent trend to both encourage and control the progress of the frontier. We then extend this model with an integration stage where environmental governance and economic development evolve from competing to complementary concepts. At this stage, the efforts to slow down deforestation are accompanied with programs to promote new agricultural practices and support industrialization. Finally, we put into perspective this recent evolution with regards to the underlying reasons for changing the agricultural model, thus considering the agricultural frontier to be at a tipping point where first positive results need to be confirmed in spite of an unstable economic and political situation.

Keywords:

Brazilian Amazon, Mato Grosso, agricultural frontier, public policies, environmental governance

1. Introduction

Brazil has long been blamed for the severe damage caused by the rapid progress of its agricultural frontier to natural resources and especially to Amazon rainforests and savannahs (Fearnside 2001; Laurance et al. 2001; Morton et al. 2006). As a consequence, for more than a decade, Brazilian policies have faced a huge challenge, that of combining socio-economic development and environmental conservation in a context of frontier expansion. The agricultural frontier now appears to be at a tipping point and efforts are underway to establish effective environmental governance without hampering agricultural development. The spectacular 90 per cent decline in annual deforestation since 2005 (INPE 2016) through (i) the decoupling of agricultural expansion and deforestation (Gollnow and Lakes 2014; Macedo et al. 2012) and (ii) the adoption of new agricultural practices to reduce pressure on forests (Arvor et al. 2012; Gil et al. 2015) is the major achievement of this new agro-environmental governance model.

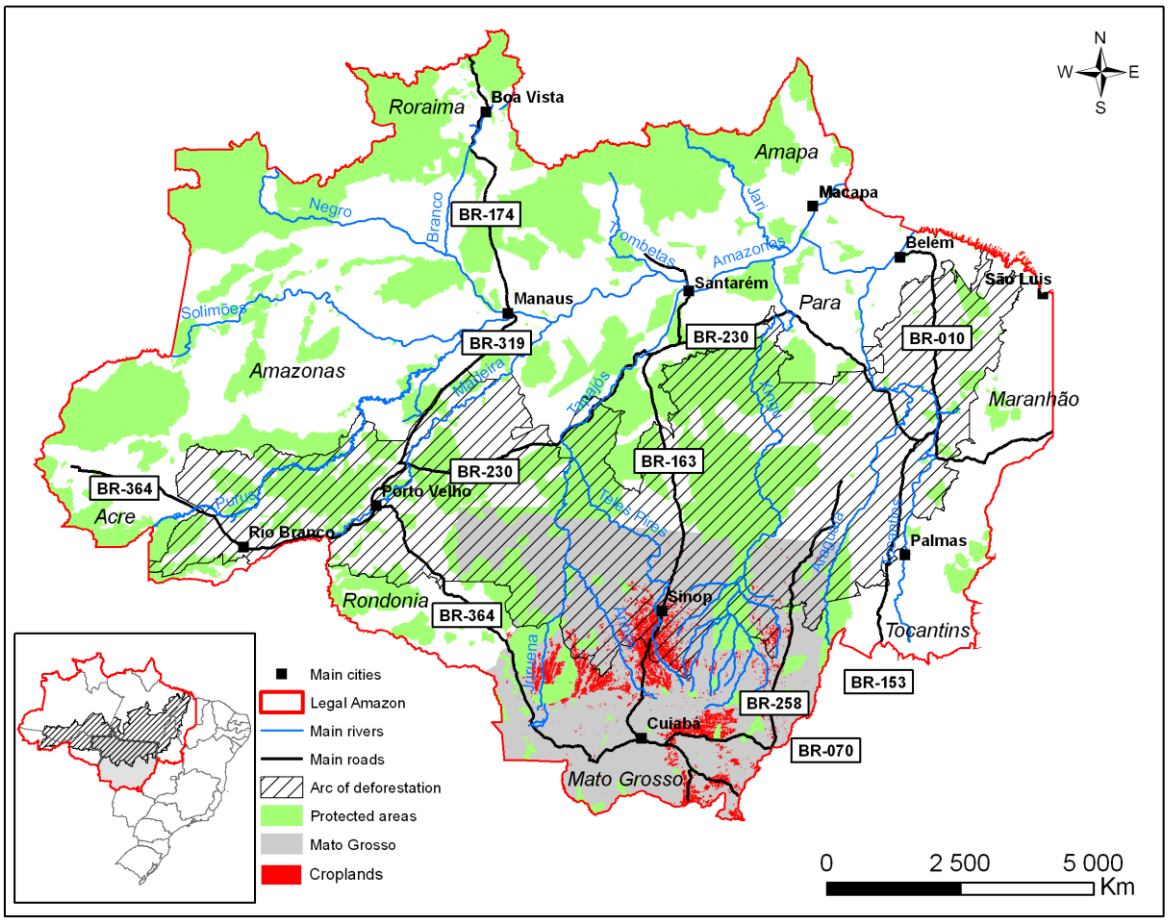
As Brazil is now regarded as one of the few countries to achieve its transition to a major economic power without destroying most of its forests (Davidson et al. 2012), it is important to analyse the past evolution of environmental and development policies that led to the present optimistic expectations of land use sustainability at the agricultural frontier in the Brazilian Amazon (Galford et al. 2013). As a complement to recent studies focused on major policy changes in the last decade to explain the recent land use dynamics (Gibbs et al. 2015; Nepstad et al. 2014), our objective is to review the long term policies that shaped the Amazon agricultural frontier. In this regard, we focused our analysis on the state of Mato Grosso, where the trade-offs between development and conservation are exacerbated by the extent and rapidity of land use changes, the economic importance of the agricultural sector and the social and cultural differences between main stakeholders. To this end, we use the frontier model proposed by DeFries et al. (2004) and evidence the emergence of an additional stage where

environmental governance and economic development evolve from competing to complementary concepts.

2. Environmental and development policies on the Mato Grosso soybean agricultural frontier

The state of Mato Grosso (906,000 km²) is located in the southern part of the Legal Amazon (the part of Brazil's territory recognized as Amazonia by law, fig. 1). It is characterized by the presence of an active pioneer frontier that raises important social and environmental concerns. The frontier concept has long been studied in geography, especially in the United States (Turner 1893) and Brazil (Becker 1986; Droulers and Le Tourneau 2000; Léna 1986; Monbeig 1952; Théry 2006). Pioneer frontiers are characterized by a mosaic of landscapes that are reflected in the wide range of spatial occupation models (Arvor et al. 2012; Dubreuil et al. 2008). In agreement with that view, DeFries et al. (2004) and Foley (2005) suggested understanding and modelling such frontiers using landscape analysis. These authors state that changes in the pioneer frontier take place in five successive stages, which can be defined by specific land use transitions (fig. 2). The pre-settlement stage describes the original stage in a territory before the pioneer frontier begins to evolve. Landscapes are dominated by wildlands. The second stage, the occupation stage, begins with the arrival of the first settlers who start to clear the wildland (usually for timber or subsistence agriculture), whose area consequently decreases. The third stage, the consolidation stage, begins when small scale farms are replaced by large scale farms that cultivate commodities for sale on national and international markets. This process of agricultural expansion is hindered when access to new lands for expansion becomes too costly. In this case, farmers need to intensify their agricultural practices to ensure they can continue to develop. This is the intensification stage (fourth stage). The intensive stage is characterized by a large proportion of the agricultural area

cultivated using intensive practices. In parallel, the development of profitable agriculture attracts new migrants and the towns grow bigger. As the population becomes urbanized, new considerations regarding environment and quality of life appear, allowing the emergence of new protected areas.



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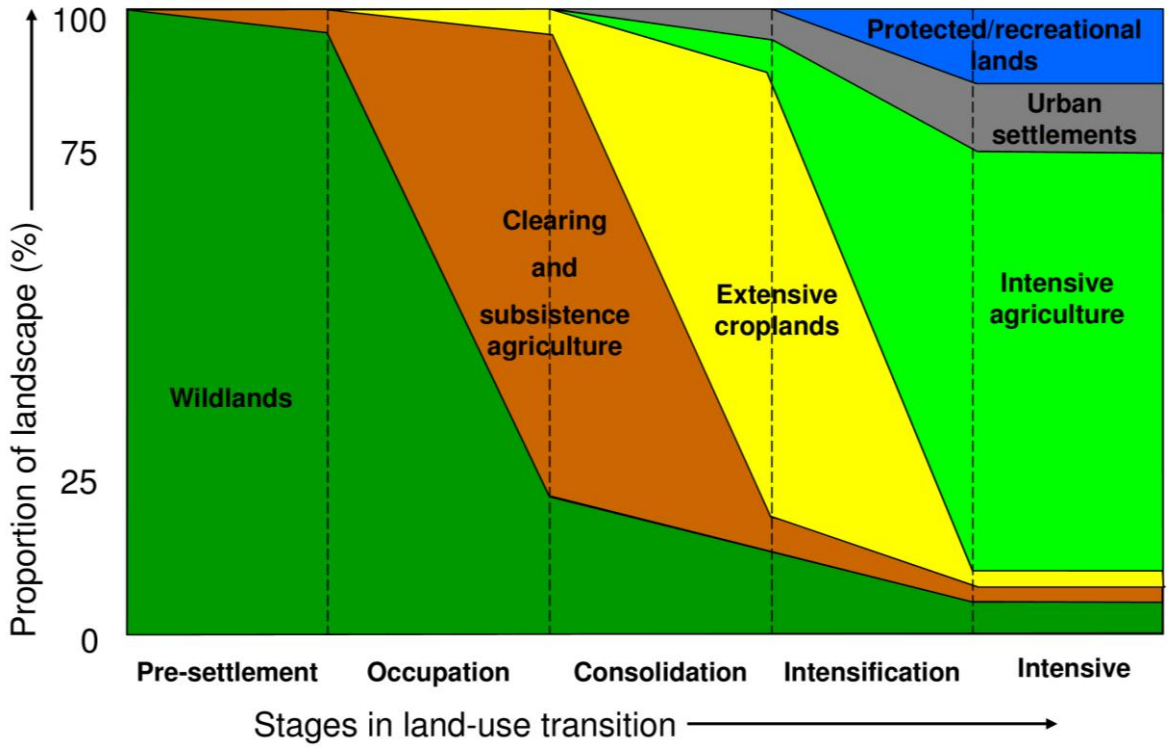

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Although this model appears to be linear, it is noteworthy that the frontier does not change constantly, either in space, or in time. Transition dynamics are both multiple and reversible, and the progress of the demographic and economic occupation of the territory is variable (Lambin and Meyfroidt 2010). One should thus keep in mind that: (i) land use transitions between the stages of the pioneer frontier are not unidirectional, that is a cultivated area can be abandoned and regenerate secondary forest (see the forest transition concept; Barbier et al. 2010; Mather and Needle 1998; Rudel et al. 2010) or intensive practices may be abandoned due to financial restrictions; (ii) not all the stages of the pioneer frontier may affect a given territory, for example one would not expect protected areas to ever be cleared; (iii) the duration of each stage may vary depending on the location and the period. For instance, the entire process of transition from wildlands to intensive agriculture took thousands of years in Europe, whereas it is expected to last only a few decades in recently colonized areas like

Amazonia (DeFries et al. 2004). In the following sub-sections, we apply the model proposed by DeFries et al. (2004) as a conceptual framework to analyse the evolution of development and environmental policies in each of the five stages of the pioneer frontier in the specific case of Mato Grosso.

2.1. Pre-settlement stage

Before first European settlers arrived in Mato Grosso, the territory was inhabited by indigenous populations (today, there are around 42,538 indigenous people which equals 1,4% of the total population of the state). At this time, the primitive vegetation, either Brazilian savannah (*Cerrado*), Pantanal or Amazonian forest, was largely preserved although large-scale transformation of landscapes had already taken place in places now considered to be pristine (Barlow et al. 2012; Heckenberger 2003; Willis 2004). The settlement of Mato Grosso by non-indigenous populations began in the southern regions of the state (based on current boundaries). The *bandeirantes* moved to Mato Grosso in the 17th century to ranch or mine gold, and to capture indigenous inhabitants to be sold as slaves in other areas such as São Paulo. In the 18th century, during peak gold mining activity, a few towns were created including Diamantino (whose name comes straight from diamond mining) and the capital of Mato Grosso, Cuiabá, which, for a while, was the third biggest city in Brazil (Nédélec 2005; Siqueira 2002).

2.2. Occupation stage

Although a few settlements had already started to practice agriculture and ranching in the southern regions of the state in the 18th century, the spatial occupation of Mato Grosso really began in the 1930s with the first governmental colonization programs in Amazonia. These programs were based on a development oriented (*desenvolvimentista*) model that remained

unquestioned until the mid-1980s (Drummond and Barros-Platiau 2006). In 1937, the authoritarian federal government led by President Getúlio Vargas (1934-1945 and 1951-1954) presented a plan to conquer the Amazon basin: the 'March towards the West' (*Marcha para o Oeste*). There were two main reasons for implementing this plan: 1) to ensure national sovereignty in this distant region, and 2) the United States policy of helping Brazil to expand rubber production in the Amazon during the Second World War (Droulers and Le Tourneau 2000). The plan led to the first occupations of the *Cerrado* biome in the states of Mato Grosso, Goiás and Paraná (Droulers 2001). After the Second World War, the new democratic Brazilian government continued to encourage development in the *Cerrado* and the Amazon basin. The "Legal Amazon" was created in 1953 and financial incentives were offered to attract people there. After 1956, President Kubitschek (1956-1961), who wanted to force Brazil to make 50 years of progress in five (Summers 2008), reinforced the process by the building major infrastructure, including the new Brazilian capital, Brasília (1960), and main roads such as the highways linking Brasilia to Belém (the BR-010, built in 1960) and Cuiabá to Porto Velho (the BR-364, built in 1964). The latter road, which made it possible to cross Mato Grosso from east to west, reinforced the occupation process in the southern part of the state.

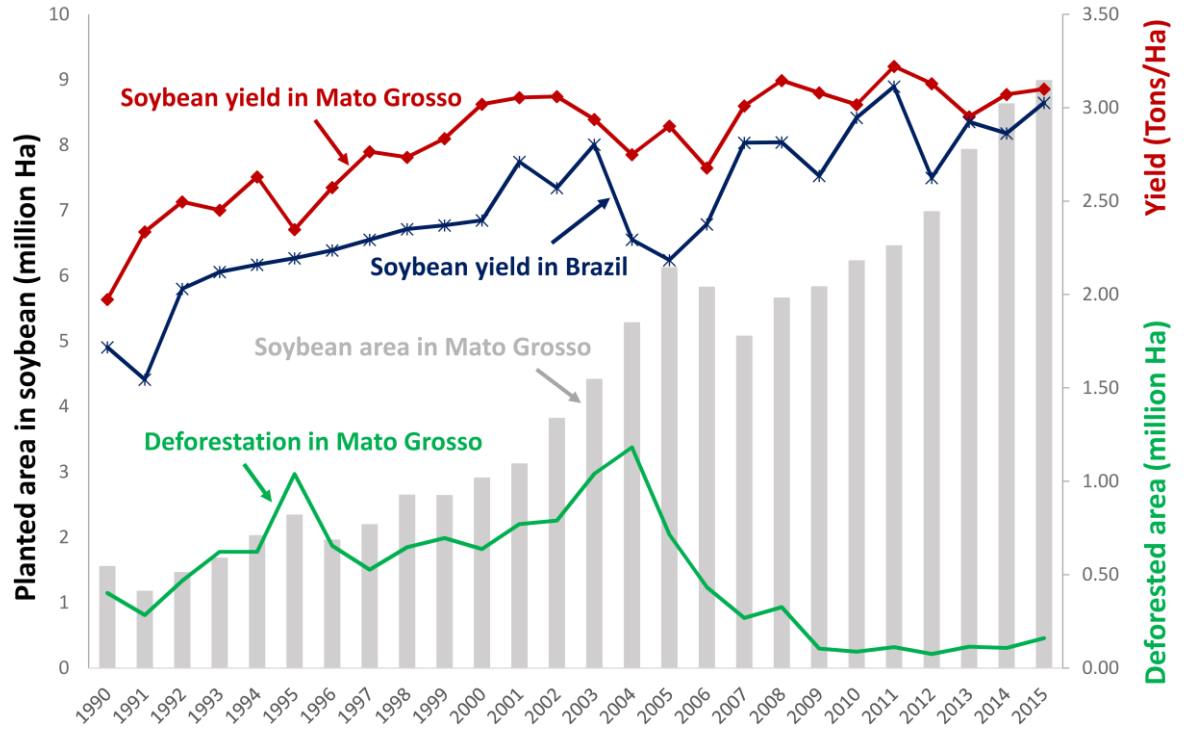
The expensive projects proposed at this time were criticized for encouraging inflation and reducing the influence of large-scale property owners (Droulers 2001; Théry 2005). In 1964, the government was replaced by a military government that remained in power for 20 years, and alternately encouraged colonization by small-scale and large-scale property owners. The Superintendent for the Development of Amazonia (SUDAM) was created in 1966 to manage the 'Operation Amazonia' program aimed at developing, occupying and integrating the Brazilian Amazon in the national economy (Banerjee et al. 2009). This program continued with the launch of the National Integration Plan (Portuguese acronym PIN) in 1970, which

included an agrarian reform (famous for its slogan: land without men for men without land, *terra sem homens para homens sem terra*). This reform was led by the newly created National Institute for Colonization and Agrarian Reform (Portuguese acronym INCRA), which encouraged small farmers to migrate to the Amazon (Droulers 1995; Tritsch and Le Tourneau 2016). New trans-Amazonian roads were built including the BR-230 (1972) from Cabeledo (state of Paraíba) to Labrea (state of Amazonas), the BR-319 (1973) from Porto Velho to Manaus, the BR-174 (1974) from Manaus to Boa Vista to support the expected migrations. The north-south BR-163 road linking Cuiabá to the Amazon River harbour of Santarém in the state of Pará was built in 1973 and allowed the occupation of the most northern regions of Mato Grosso.

2.3. Consolidation stage

Despite the important projects and the many infrastructures built in the territory by the government, colonization of public land by small-scale farmers did not reach the projected targets. During the National Development Plan (*Plano Nacional de Desenvolvimento*, PND II) launched in 1975, the government decided to open the Legal Amazon to private capital through the Program for Agricultural, Livestock and Mineral poles in Amazonia (Portuguese name *Polamazônia*), which emphasized the development of large-scale export-oriented development poles dedicated to mining, livestock and agriculture (Mahar 1990). In Mato Grosso, 33 private colonization companies purchased cheap public land (*terras devolutas*) from the government of the state or from the federal government in order to set up 88 colonization projects that served as a basis for the development of agricultural activities (Nédélec 2005; Siqueira 2002). The occupation of Mato Grosso was thus consolidated through the implementation of a number of isolated spatially-distributed projects, confirming that the progress of the pioneer frontier is made of “breaks and jumps”. After the end of the

military government in 1984, economics gained the upper hand over geopolitics. Powerful mechanized agriculture was encouraged by policies that limited taxes on land and on agricultural income, favoured large-scale land allocations, and facilitated access to credit (Binswanger 1991). In Mato Grosso, these policies attracted farmers with capital who were interested in the agricultural potential of the large plains (Jepson 2006). These farmers mostly came from the southern regions of Brazil (Rio Grande do Sul, Santa Catarina, Paraná), where they had experience in soybean cultivation. Soybean production started in Mato Grosso at that time, and its expansion (from 1.5 million to 8.9 million hectares between 1990 and 2015, fig. 3) relied on favourable politic and economic conditions. In 1994, the government introduced the *Plano Real,* which reduced inflation and triggered a domestic boom in demand, attracted multinational companies and led to a positive rate of exchange between the Real and the US Dollar which, in turn, led to high soybean prices in Brazil (Valdes 2006) (fig. 4). A few years later (1996), the outbreak of bovine spongiform encephalopathy (BSE) in Europe led to a dramatic increase in the demand for Brazilian soybean scrap since it was the only country where non-GMO soybean was being produced (Elferink et al. 2007). Overall, the rapid rise of China's economy implied large demands for agricultural commodities (Fearnside et al. 2013). As a consequence, the soybean complex (raw soybean, soy oil and meals) gained into importance at national level so that, in 2016, it represented 37.1% of all exportations of the Brazilian agribusiness sector. It generated more than 28 billion US$ (2015), from which 15 billion originated from exports to China. Soybean is now the first product exported by Brazil and China is its first purchaser (MAPA 2016). Finally, it is worth mentioning that other crops including corn, cotton and sugar cane, were also cultivated.



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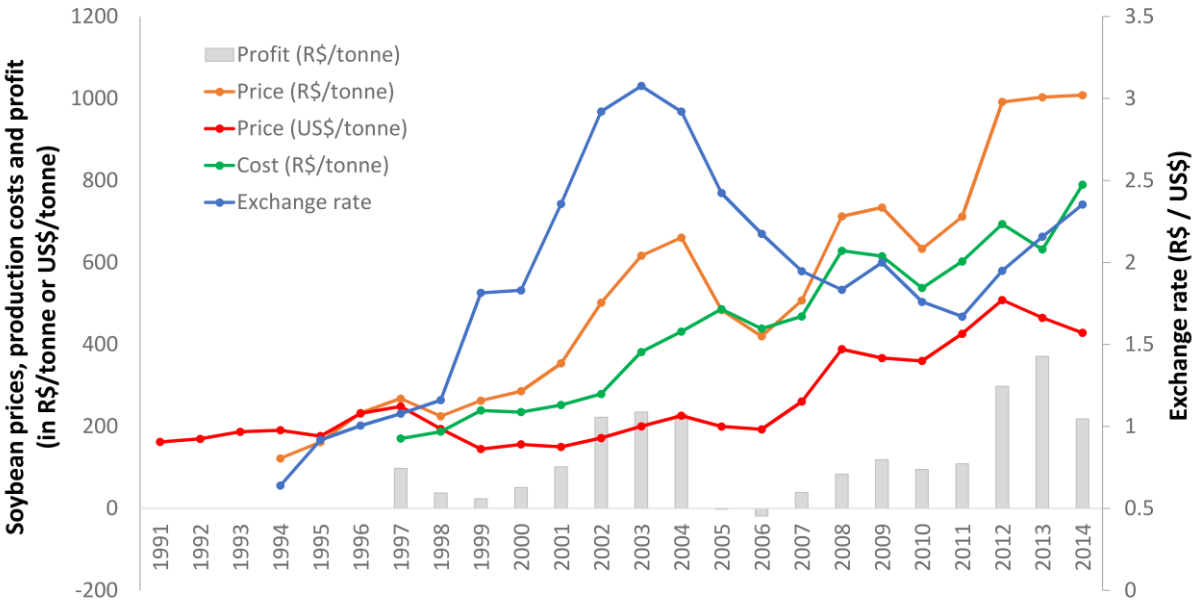


Figure 4 about here

While incentives to promote large-scale agriculture were effective, they also encouraged widespread deforestation (Binswanger 1991). Despite the 1981 National Environmental

Policy, Law 6938 (*Política Nacional do Meio Ambiente*), efforts to establish efficient environmental policies were not taken into account in the geopolitical strategy of the federal government and were of little importance compared with economic priorities. The unstable structure of the federal and state institutions in the 1980s-1990s illustrates the low priority given to environmental considerations. The Fundepan (*Fundação de Desenvolvimento do Pantanal do Estado de Mato Grosso*) was first created in 1983 (law 4560/1983) and was then replaced by the SEMA (State Secretary of Environment; law 5218/87) in 1987. In 1992, while environmental issues were being discussed at the Rio Conference, SEMA was replaced by FEMA (State Foundation for the Environment; complementary law 14/92). Despite the unstable institutional context, a few sustainable experiments in the Amazon led to the creation of a favourable period for the consideration of the environmental dimension, but with different directions and strategies (Mello 2008).

2.4. Intensification stage

As cropped areas expanded, yields also increased rapidly (fig. 3) and Mato Grosso became the main agricultural state in Brazil (28.5 per cent of national soybean production in 2015; IBGE 2016). This increase was strongly encouraged by federal policies. First, since the 1980s, the government encouraged the Brazilian Agricultural Research Corporation (Portuguese acronym EMBRAPA) to develop new varieties adapted to tropical conditions in order to make soybean expansion possible in the Amazon (Bertrand 2004). The intensification process continued in the 2000s with the adoption of intensive practices such as double cropping systems (soybean followed by corn or cotton) promoted by national and regional research institutes. Second, a number of multi-annual federal plans (*Brasil em Ação*, 1996-1999; *Avança Brasil*, 2000-2003; *Brasil de todos*, 2004-2007; *Plano Plurianual*, 2008-2011 ; *Plano Mais Brasil*, 2012-2015) envisaged continuing investment in huge infrastructure projects

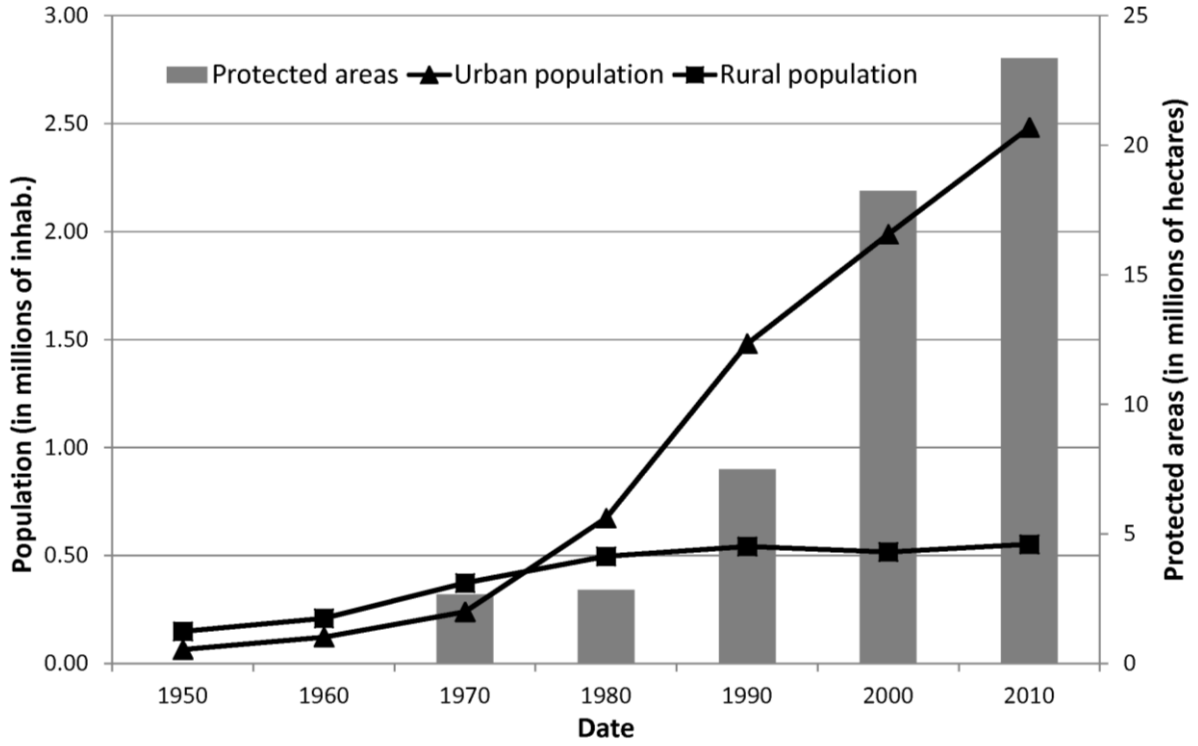
aimed at reducing the cost of transport and energy (the planned asphalting of the BR-163 in the state of Pará is one such strategy). These plans were in response to increasing soybean production costs mainly due to Asian rust disease and to the high variability of the Dollar-Real exchange rates. In 2006, production costs exceeded the price paid for soybean (fig. 4), and soybean production areas decreased (fig. 3), illustrating the fact that the agricultural frontier can slow down or even stop, at least temporarily.

While the main political preoccupation was constructing the necessary infrastructure to enable export of agricultural commodities, environmental protection efforts were limited to a few international and federal programs including PPG7 (Pilot Program for the Conservation of Brazilian Rainforests), PNMA-I and -II (*Política Nacional do Meio Ambiente I e II*). In Mato Grosso, the state government launched the PRODEAGRO (*Programa de Desenvolvimento Agroambiental*) program in 1992 and the SLAPR system (*Sistema de Licenciamento Ambiental de Propriedades Rurais*) in 2000 to ensure environmental registration of rural properties. At that time, Mato Grosso was the first Brazilian state to implement such a system but its efficiency has subsequently been proven to be limited (Azevedo and Saito 2013).

Lula's government then adopted the 'Sustainable Amazon Plan' (PAS - *Plano Amazônia Sustentável*) as an environmental strategy designed for the Legal Amazon. Originally established as a specific part of the *Avança Brasil (2000-2003*) plan, it became the main project of the Environment Ministry, prioritizing transversal efforts across the Amazon. However, in Mato Grosso, the intensification process remained a priority, and the implementation of the environmental plan consequently increased tensions between producers and environmentalists. As a result, the environmental initiatives made no significant progress and deforestation and agricultural intensification continued to increase, and the state of Mato Grosso only integrated the PAS in 2006.

2.5. Intensive stage

Although crop expansion (land occupation and consolidation stages) and intensification processes (intensification stage) are still ongoing preoccupations in Mato Grosso, it is worth noting that recent decades have also been characterized by urbanization and the creation of new protected areas, which according to the theory of DeFries et al. (2004) (fig. 2), are indicators of the final intensive stage. In Mato Grosso, official statistics from (IBGE 2016) show that the urban population has increased dramatically since the 1970s (from 239,524 inhabitants in 1980 to 2,482,801 inhabitants in 2010; fig. 6) while the rural population remained nearly constant over the same period (552,321 inhabitants, i.e. 82 per cent of the population is urban). As such, the deforestation in Mato Grosso is considered as de-linked from migration (Perz et al. 2005). In the meanwhile, a more environmentally aware and more organized civil society emerged, which affected new positive regulations in the Brazilian environmental laws and policies as part of an ecological modernization process (Drummond and Barros-Platiau 2006; Jepson et al. 2005). Protected areas increased after the establishment of the Secretariat for the Environment (Portuguese acronym SEMA) (Decree 73.030, Oct. 30, 1973) and again with the creation of the National Conservation Unit system (Portuguese acronym SNUC) (Law 9.985, 2000). There are two statuses for legally protected areas in Amazonia: conservation units protected for environmental reasons (including areas under integral protection and areas for sustainable use) and areas protected for social reasons (indigenous lands, traditional populations, and *quilombolas*). It is noteworthy that both types of protected areas have proved to be efficient as far as the local preservation of the environment is concerned (Bruner 2001). In 2010, 3,241,178 hectares were protected for environmental purposes in Mato Grosso (Conservation Units, MMA 2015) whereas a further 22,768,647 hectares were defined as indigenous lands (FUNAI 2014), representing 28.7 per cent of the total area of the State (fig. 5).



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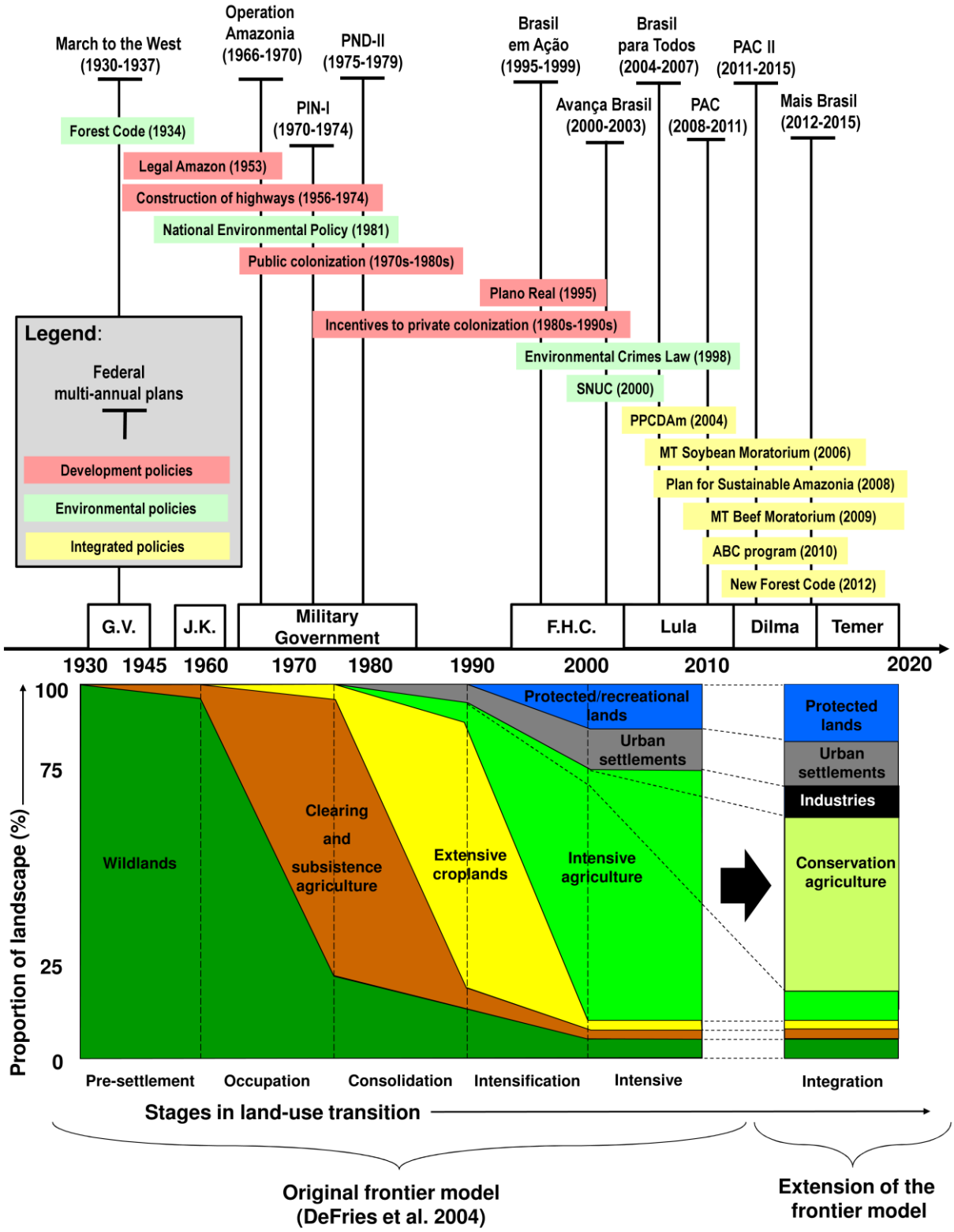
3. Beyond the frontier: the integration stage

The frontier model describing the process to convert wildlands into intensive agricultural areas has been proved to be valid for the specific case of Mato Grosso, with two main particularities: (i) the magnitude of unprecedented environmental damage caused by the occupation, consolidation, intensification stages, and (ii) the rapidity of land use conversions and its associated development, since few agricultural regions reached the final intensive stage in less than 40 years, while other areas remain unoccupied today. One may now wonder about the future of this agricultural frontier at a time when combining socio-economic development and environmental management becomes a priority.

In this regard, the launch of the Action Plan for Prevention and Control of the Legal Amazon Deforestation (PPCDAm) in 2004 can be considered as an important milestone that reflected

the new ambition of the federal government to hamper the progress of the Amazon agricultural frontier after the 2004 deforestation peak (i.e. 27.000 km², Assunção et al. 2012; Aubertin 2013; Gollnow and Lakes 2014). This program has been designed as an integrated system to organize the collaboration between 14 ministries and the coordination between the federal and state governments. It also enabled increased participation of municipalities, institutions and civil society in the establishment of a new governance model focused on three main areas: (i) territorial management and land use, (ii) legislation compliance and command-and-control tools, such as monitoring or licensing systems, and (iii) promotion of sustainable practices.

As a matter of fact, the frontier is still dynamic and the intensive stage should not be looked on as the last stage of the frontier model. We thus propose to extend it by adding an integration stage (fig. 6) marked by important efforts to (i) turn development and environmental policies complementary and (ii) promote the emergence of a new agricultural model based on the adoption of conservation agriculture practices and industrialization.



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3.1. From competing to complementary development and environmental policies

Whereas the historical process of frontier expansion was characterized by competing development and environmental policies, the last decade has been marked by the establishment of a more effective governance model (Tritsch and Arvor 2016), which both (i) benefits from investments originated from a decade of economic prosperity in the agricultural sector, and (ii) turns compliance to environmental legislation a mandatory condition for future socio-economic development.

3.1.1. The forest code and its recent evolution

The environmental governance model in the Amazon has long been based on the Forest Code, which sets out a framework to control deforestation. This code, originally introduced in 1934 (Decree No. 23.793, 1934) and revised in 1965 (Law No 4.771, Sept. 15, 1965), defines sub-areas in private rural properties such as (i) the Permanently Protected Areas (PPAs), along water bodies and in sloping ground, and (ii) the Legal Reserve Areas (LRAs), corresponding to areas to be preserved in native vegetation, i.e. 80% of the entire property area in the Legal Amazon, 35% in Cerrado areas located in the Legal Amazon and 20% elsewhere. Although the Forest Code has long been recognized as an important policy tool to prevent deforestation, the way it was implemented has been severely criticized, what led to its recent revision (Stickler et al. 2013; Tollefson 2012). After years of debate (Roriz and Fearnside 2015), a new Forest Code has been approved, which reduces the requirements for protecting natural vegetation on private farm land (Roriz and Fearnside 2015; Soares-Filho et al. 2014): (i) PPAs are now included in the computation of the LRAs and (ii) local governments can reduce the proportion of the LRAs from 80% to 50% in states or municipalities where Conservation Units or Indigenous Lands cover more than 65% of the total area (i.e. more than 80% of the municipalities in the Amazon).

On the one hand, the new Forest Code may appear to be disappointing as it grants amnesty for illegal deforestation in 90 per cent of Brazilian rural properties (Soares-Filho et al. 2014). But it is actually the result of a "pragmatic" or "realistic" (Le Tourneau 2015) understanding of (i) the past situation marked by a long history of non-compliance by Brazilian producers; (ii) the high cost of restoring natural vegetation, and (iii) the interests of the agribusiness sector, which considers environmental legislation as an obstacle to the development of the agricultural sector. In this regard, the Forest Code has been adapted so as not to curtail the socio-economic development.

On the other hand, the new Forest Code also gives possibility for farmers to compensate for their lack of LRAs by protecting natural vegetation outside their farms. While the Forest Code indicates that the compensation must occur in areas that belong to the same biome and thus potentially in another state, the Decree 420/2016 specifies that compensations from Mato Grosso land owners must occur primarily in the state until no land remain available for compensation. Such compensation mechanism also exists at collective scale through the *ICMS-Ecológico* (*Imposto sobre Circulação de Mercadorias e Serviços*), which is a tax collected by Brazilian states (Mato Grosso adopted it in 2000) and then redistributed to municipalities according to environmental criteria, such as the presence of protected areas (including indigenous lands in the case of Mato Grosso). In that sense, the new Forest Code and the *ICMS-Ecológico* can both be conceptualized as compensation systems to reinvest benefits from past socio-economic development towards the reinforcement of the environmental governance model.

3.1.2. New tools to ensure compliance with the Forest Code

The revised Forest Code has been designed to promote a win-win situation, e.g. support agricultural development in already cleared areas and better protect still standing forests.

However, such situation can only be achieved if the new legislation is effectively enforced and respected to prevent that the expected economic development support new clearings (as it has been the case during many years). For this reason, new monitoring and licensing systems have been designed and reinforced to detect land use conversions and their corresponding land tenure.

Firstly, the National Institute for Spatial Research (INPE) implemented important systems to monitor and quantify land use changes in the Amazon. Beyond the well-known PRODES program (*Programa de Cálculo do Desflorestamento da Amazônia*) created in 1988 and which produces digital annual deforestation map in the Amazon based on Landsat-TM data since 1997, INPE also developed the DETER program (Near Real Time Deforestation Detection System, based on MODIS data) in 2004 for the near-real time detection of large-scale deforestation events within the Legal Amazon. This program was implemented to support land use policies in the Amazon and is now being completed by the DETER-B program based on the use of AWIFS data to detect small deforestation areas less than 25ha. After 2005 and the beginning of the decrease in deforestation rates, new programs emerged such as the DETEX/DEGRAD (2007) to map selective logging in the Amazon and the TerraClass program focused on land use mapping in deforested areas (Almeida et al. 2016). This project has recently been extended to the Brazilian cerrado (TerraClass cerrado) which was hitherto understudied although it had long been known to suffer from intense land use conversions.

Secondly, the Rural Environmental Registry (CAR for *Cadastro Ambiental Rural*, in Portuguese) was implemented in 2012 to ensure compliance of rural private properties with the new Forest Code. The CAR implies the registration of PPAs and LRAs of all rural private properties on the SiCAR platform (*Sistema Nacional de Cadastro Ambiental Rural*) with the exception of few states which implemented their own system. In the state of Mato Grosso,

176.870 properties had been registered by September 2016, that is about 93% of all properties (SFB 2016). A major reason for the acceptance by land owners to contribute to the CAR system relies on the fact that registration is mandatory to get access to credit (Salomon 2016).

3.1.3. Punitive measures to ensure compliance to the Forest Code

This last point (the access to credit) actually emphasizes the importance of punitive measures to restrict socio-economic development in environmentally non-compliant areas, at both individual and collective levels. Firstly, the 3.545 resolution of the Brazilian Central Bank (2008) obliges individual land owners to show evidence of their adherence to the Forest Code. As a result, Assunção et al. (2013) estimated that one third of the rural credit (i.e. around R$2.9 billion) have not been allocated between 2008 and 2011, what resulted in about 2.700 km² of avoided deforestation. Secondly, after realizing that 36 municipalities were responsible for 45% of the 2007 Amazon deforestation, the Ministry of Environment pointed at the collective responsibility of farmers through the public release of a list of Prioritary Municipalities (Assunção and Rocha 2014). Frozen credit and targeted operations from IBAMA on these listed municipalities thus allowed to significantly curb the deforestation rates. In Mato Grosso, 24 municipalities were put on that list between 2008 and 2011, and thus came under the spotlight. In Alta Floresta, one of these municipalities which suffered economically from being on that list, the mayor thus expresses his thoughts as follows: “We thought we were pathfinders, and we suddenly became bandits!”. But Alta Floresta finally received R$ 2.8 million from the Amazon Fund and then become one of the first municipality to leave the list in 2012.

Obviously, turning such punitive measures effective requires important efforts to penalize environmental offenders. While studies after the establishment of the Environmental Crimes Law (*Lei de Crimes Ambientais*, Law No. 9.605, 1998) estimated that less than 10 per cent of

the fines for illegal clearings claimed by the Brazilian Institute of Environment (IBAMA) were actually paid by the culprits (Barreto et al., 2009), Telles do Vale (2016) now emphasizes on the impressive recruitments that were necessary to join a staff of 10.000 environmental officers and over 1.000 prosecutors that enable IBAMA to organize many operations against deforestation (e.g. Curupira operation in 2004, Arco do Fogo operation in 2008). In 2013, 3.500 fines for illegal clearings in the Legal Amazon were attributed, corresponding to a collected value of R$ 1.5 billion (Telles do Vale 2016).

3.2. Towards a new integrated agricultural model

The efforts to integrate environmental considerations in the socio-economic development model are exacerbated in the case of the agricultural sector. As agricultural intensification has been severely criticized due to its impacts on ecosystem services (Matson 1997; Tilman 1999; Tilman et al. 2002), new agricultural practices respecting the basics of Conservation agriculture (FAO 2015) are thus promoted to initiate an ecological intensification process (Cassman 1999). Such process lies on the adoption of a whole-landscape approach that emphasizes the role of tropical agricultural landscapes to achieve multiple objectives such as food production, biodiversity conservation, climate mitigation, etc (DeFries and Rosenzweig 2010). On the other hand, the 2005-2006 crisis (see the negative profits on figure 4) forced the agricultural sector to review its economic model by (i) signing voluntary zero-deforestation agreements to ensure access to global markets and (ii) initiating a "verticalization" process intended to transform raw materials on site.

3.2.1. The ABC program

At the Brazilian scale, the ecological intensification process is being supported through the implementation of the ABC plan (*"Plano para uma Agricultura de Baixo Carbono"*, i.e. Low

Carbon Agriculture program) in 2010 by the Ministry of Agriculture (MAPA - *Ministério da Agricultura, Pecuária e Abastecimento*), as part of the national policy on climate change. The objectives of the ABC plan concern the restoration of degraded pastures, the promotion of integrated crop-pasture-forest systems, the generalization of no-tillage practices, the improvement of biological nitrogen fixation, the increase in forest plantations, the animal waste recycling and the adaptation to climate change. The state of Mato Grosso, due to its strategic position in the national agricultural sector, assumes its role of leadership for the adoption of new environmental-friendly practices. For example, no-tillage practices, which mainly consists in planting a second crop after the soybean harvest in order to improve the quality of the soil by limiting erosion and by retaining water for a longer period (Landers 2001; Scopel et al. 2005), have been widely adopted. The CONAB (*Companhia Nacional de Abastecimento*) estimates that 90 per cent of the area under soybean is sown under no-tillage conditions in Sorriso and Lucas do Rio Verde, two main agricultural municipalities). Also, integrated systems such as crop-livestock systems, livestock-forestry systems, crop-forestry systems and crop-livestock-forestry systems are now promoted by research institutes and already covers about 500,000 ha in Mato Grosso, of which 89 per cent are crop-livestock systems (Gil et al. 2015). Finally, collaborative initiatives to promote reforestation merit special emphasis, such as the Lucas do Rio Verde Legal project (TNC 2011) or the Y Ikatu Xingu campaign launched in 2004. As an example, the Sorriso Vivo project encouraged farmers to reforest 600 ha of riparian forests with native species in the municipality of Sorriso between 2006 and 2009 in order to comply with the Forest Code (Arvor et al. 2009). Although this area may seem quite small compared with the area under soybean in that municipality (around 600,000 ha), this process is evidence for the appearance of new environmental considerations (Le Tourneau et al. 2013) .

3.2.2. Market-oriented agreements to promote new agricultural practices

While the ABC program serves as a framework to orient the agricultural sector towards a new development model, the concrete promotion of new agricultural practices is mainly the result of market-oriented agreements involving the cooperation of various stakeholders, e.g. NGOs, farmers associations, private companies and public authorities. This type of cooperation started in 2006 with the launch of the Soy Moratorium, whose objective was to reduce the impacts of soybean expansion on deforestation: farmers who grew soy on land cleared after 26 July 2006 were no longer able to sell to participating buyers (Nepstad et al. 2014). The reference date has now been changed to 22 July 2008 under the frame of the new Forest Code (ABIOVE 2016). The Soy Moratorium was launched a few months after Greenpeace published a report stressing the link between soy production and deforestation (Greenpeace 2006) and signed by members of the Brazilian Association of Vegetable Oil Industries (ABIOVE) and the Brazilian Cereal Exporters Association (ANEC), which include the ADM, Amaggi, Bunge, Cargill, Dreyfus and Fiagril private companies. A working group, the Soybean Working Group (GTS in Portuguese), now supported by several NGOs (WWF Brazil, IPAM, CI Brazil, TNC and Greenpeace), was then created to monitor the implementation of the agreement (Gibbs et al 2015). In 2008, the Brazilian government (Ministry of Environment), the Brazilian Space Agency (INPE) and the Bank of Brazil entered the group. In Mato Grosso, remote-sensing based analysis emphasized the effectiveness of the Soy Moratorium (Azevedo et al. 2015; Rudorff et al. 2011).

Three years after the Soy Moratorium, the Beef Moratorium (2009) was established in the State of Pará to hamper deforestation due to pasture expansion, which partially resulted from soy expansion on pastures through indirect land use changes (Arima et al. 2011). The Federal Public Ministry (MPF) and NGOs pressured the beef sector by punishing farmers producing livestock on illegally cleared areas and by forcing industries not to buy products from these

farms through the establishment of Conduct Adjustment Agreements *(Termos de Ajustamento de Conduta*, Gibbs et al. 2016). Such agreements were then exported to other states, including Mato Grosso, Acre, Rondônia, Amazonas, so that they are now signed by two thirds of beef industries in the Legal Amazon inspected by Federal Inspection Service (SIF) of the Ministry of Agriculture.

In continuation with these successful voluntary zero-deforestation agreements, the agricultural sector also established new partnerships to encourage the adoption of new environmentally-friendly agricultural practices. In 2009, the Brazilian Roundtable on Sustainable Livestock (GTPS) was constituted as a multi-stakeholder initiative that convenes many stakeholders (including producers, industries, commerce and services, civil society organizations, research and academic institutions, and the government) to increase the sustainability of the cattle supply chain (GTPS 2012). In 2012, the *Instituto Centro de Vida* (ICV) developed the Novo Campo program in the municipality of Alta Floresta (in northern Mato Grosso) to encourage cattle ranchers to adopt new practices developed by Embrapa in an area with a high potential to increase productivity (Marcuzzo 2015). In this regard, the recent announcement (August 2016) of the MacDonald group to exclusively buy Amazonian beef originating from « sustainable » livestock confirms the necessity for farmers to adapt to the continuously evolving market demand and environmental legislation, but overall to consider it as a new opportunity for development.

In the meanwhile, the soybean sector evolved quite similarly. In Mato Grosso, The Nature Conservancy, an international NGO, launched the Lucas do Rio Verde Legal project in 2006 with the objective to turn local rural properties compliant with the socio-environmental legislation, what implied to reduce the use of agrochemicals, reforest the PPAs and respect the social laws such as workers social rights. It has been quickly followed by the *Soja Mais Verde* project launched in 2007 in Bali (COP 13). These initiatives were then generalized to the

entire state by the Mato Grosso Soybean and Corn Producers Association (Aprosoja) through the *Soja Plus* program (started in 2011, APROSOJA 2016). In this regard, the final announced objective is to promote the production of a "green" or "sustainable" soybean through an environmental certification supported by the Round Table on Responsible Soy (RTRS) created in November 2006. By June 2011, first producers were certified in Argentina, Brazil and Paraguay (RTRS 2016). In 2013, the Amigos da Terra Club (CAT) in partnership with the WWF Brazil, Solidariedad, IDH and Bel company started the project *"People that produce and preserve"* (in Portuguese "*Gente que produz e que preserva*") to encourage producers from the municipality of Sorriso to certificate their proprieties.

3.2.3. Industrialization

In addition to the efforts to adapt crop and beef production to emerging environmental considerations, another dimension of the new agricultural model lies in the "verticalization" process. This process aims at diversifying the sources of income by transforming raw agricultural materials on site, thus decoupling the socio-economic development from the frontier expansion and its associated environmental impacts. With the noticeable exception of Manaus where incentives to attract electronic enterprises were introduced in 1967, the economic model developed in the Amazon has always been based on the export of raw materials to other Brazilian regions or to other countries, making it vulnerable to economic fluctuation and resource depletion. To overcome this issue, fiscal incentives programs established in the 1980s enabled firms to invest what they would have paid as income tax in regional enterprises, the latter being granted tax exemption for a 10-year period (Anderson 1990). Mato Grosso benefited from similar incentives for industrial development after the creation of the Program for Industrial Development of the State of Mato Grosso (Portuguese acronym PRODEI) in 1988 that included special terms for companies concerning for the

payment of taxes. This program produced subprograms (PROALMAT, PROARROZ, PROSOJA, PROALCOOL) aimed at the development of agro-industries for the processing of raw material including cotton, rice, soybean and sugar cane. In 2003, PRODEI was replaced by the Program for Industrial and Commercial Development of the State of Mato Grosso (Portuguese acronym PRODEIC) and included compliance with the Mato Grosso Environmental Code. These programs convinced several agro-industrial companies to relocate to Mato Grosso in the last decade in order to process soybeans and other agricultural products. According to the Federation of Mato Grosso Industry (Portuguese acronym FIEMT), the production of soybean oil and meal increased by 236 per cent and 194 per cent, respectively, between 2001 and 2010 (table 1). Other soybean derived products are also currently produced such as textured protein, glycerin or lecithin, which was not the case in 2001. Finally, another way to profit from soybean consists in raising pigs, poultry or fishes, whose production has also increased dramatically in the last decade, illustrating the recent trend to develop industrial agriculture in Mato Grosso.

	2001		2010		Variation (%)	
Product	US$ Thousands	Tons	US$ Thousands	Tons	US$ Thousands	Tons
Soybean meal	280.768	1.508.363	1.554.501	4.434.547	454	194
Soybean oil	37.039	119.940	270.004	403.008	629	236
Soy lecithin	-	-	6.235	2.028	-	-
Textured Soy Protein	-	-	10.706	17.567	-	-
Soy Glycerin (sub-product of biodiesel)	-	-	5.962	33.254	-	-
Pig	25	17	72.803	30.121	-	-
Poultry	10.058	11.633	297.682	170.779	2.860	1.368
Beef	64.105	31.102	734.599	190.783	1.046	513

Table 1. Evolution of the industrialization process in Mato Grosso in the 2000s. (http://www.fiemt.com.br/site/arquivos/689_a_industria_de_mato_grosso_na_1a_decada_do_seculo_xxi.pdf)

4. Conclusion: the agricultural frontier at a tipping-point

About eighty years after the agricultural frontier began to expand in Mato Grosso, successive federal and state policies have led to the emergence of a "soy-belt" as a new agro-ecosystem at the interface between the forest and *cerrado* biomes. Many efforts have then been made during the last decade to promote an integrated model of development, characterized by a better balance between environmental conservation, social considerations (supporting compliance with labour laws) and economic development. This was mainly done through an efficient articulation between institutions and sector-specific stakeholders (private companies, NGOs), often supported by international funding, and overall with different interests. These efforts consisted in the establishment of command-and-control punitive measures (e.g. implying effective monitoring and licensing systems to ensure compliance with Forest Code) and the signature of market-oriented agreements (e.g. Soy and Beef moratoriums), which were actually more efficient to contain deforestation than public policies (Gibbs et al. 2015).

From an environmental conservation perspective, the dramatic decrease in deforestation observed since 2005 is certainly the first major achievement of this new strategy.

However, the past analysis of the agricultural frontier in the Brazilian Southern Amazon has emphasized a long history of ambivalent development and environmental policies. For this reason, the recent efforts to promote complementary policies at the integration stage should be considered carefully and critically: 1) the reduction in deforestation was enabled by the adoption of a very intensive agricultural model (Arvor et al. 2012) whose impacts on soil and water resources are still understudied, 2) farmers may be changing their way to clear forest in order not to be detected by the new elaborated monitoring systems developed by INPE (Richards et al. 2016), 3) the recent revision of the Forest Code appears to contradict recent efforts towards forest preservation since it tends to cancel the environmental debts of farmers, 4) it is unclear how compensation systems will be effective to protect new areas of native

vegetation, 5) markets and banks still do not always differentiate whether a property is in compliance with the Brazilian Forest Code or not before allocating credits (Azevedo et al. 2015), 6) the emergence of a new soybean frontier in the Brazilian *Cerrado* (Maranhão, Tocantins, Piaui and Bahia states) or even in Southern Africa (Gasparri et al. 2016) may counteract the decline of deforestation observed in the Amazon through indirect land use change (ILUC), 7) the on-going construction of numerous hydroelectric dams to support the urbanization and industrialization process (Fearnside 2016), 8) the expected development of irrigation as a main strategy to adapt to climate change raise important social and environment issues, 9) small-scale agriculture has been set aside from the efforts to "greenwash" the agricultural sector, and 10) the devaluation of the Brazilian Real may support exports and encourage new conversions into croplands (Richards et al. 2012; see the similarities between the 2015 situation and the early 2000s on figure 4).

In light of these points, it is worth mentioning that the current Brazilian political and economic crisis may even exacerbate the historical ambivalence between environmental and development policies and jeopardize recent positive results. While political instability has been evidenced to weaken deforestation control in the Amazon (Rodrigues-Filho et al. 2015), the recent *Proposta de Emenda a Constituição* (PEC241/2016) to restrict government spending may dramatically affect the application of command-and-control measures, which need large investments to be effective. Finally, the nomination of Blairo Maggi, also known as 'The King of Soybean", as Ministry of Agriculture may even represent a new milestone towards the return of a development-oriented agricultural model, and also a return to previous stages of the frontier model.

All these considerations may actually question the underlying reasons for changing the agricultural model, better evidencing the high potential of the agricultural sector to rapidly adapt to constraining market conditions than witnessing a real willingness to replace the past

expansionist agricultural model. The Brazilian Amazon agricultural frontier thus appears to be at a tipping point where first positive results need to be confirmed and validated in spite of an unstable economic and political situation. As a guarantee of its intention to continue in that direction, the State of Mato Grosso, under the frame of its new strategy *"Produce, Conserve, Include"* (PCI), recently announced ambitious objectives at the COP21: to restore 2.9 million hectares of degraded land by 2030 and ensure the end of illegal deforestation by 2020. But, while the new governance model proved to be efficient to contain deforestation from large-scale crop farmers and cattle ranchers, recent studies showed that continuing deforestation despite environmental legislation currently appears to be a sign of socio-economic precariousness (Tritsch and Arvor 2016). As a consequence, most deforestation is nowadays performed by small-scale farmers so that achieving these objectives require other policies than traditional command-and-control punitive measures and market-oriented agreements. New incentive measures such as payment for ecosystem services (PES) will especially be required to really turn environmental preservation a source of economic development instead of an obstacle to development (Tritsch and Arvor 2016). For all these reasons, Mato Grosso may thus remain in the spotlight for a while, still being at the leading edge of the experimentation of innovative governance models in the tropics.

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Figures: