A CIS framework analysis of an Amazonian soybean frontier in Brazil: insights for the policy analysis of interconnected social-ecological landscapes

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PANEL 3F (Wednesday, June 19, 2019): The Challenge of Governing an Interconnected Amazon: Analytical Tools for Sassafras M035 Comparing Adjacent Social-Ecological Landscapes (3:30pm-5:00pm, Sassafras M035)

Introduction

[Brief paragraph on the broad relevance of the Amazon region for environmental significance and as a "microcosm" of frontier governance that can be seen elsewhere – TO BE DRAFTED]

Public policy can often be boiled down to a set of instruments creating or modifying incentives in order to achieve a certain outcome. Environmental policies, for instance, classically aim to internalize externalities by correcting the incentives leading some agent to impose (voluntarily or not) the costs of their activities (i.e. pollution) onto others. However, policies often function as blueprints with the same policy instrument for diverse types of actors. It may thus be ill-adapted, to some degree, to the diversity of situations it aims to address. As a result, the way actors react to policy incentives may produce radically different outcomes depending on local conditions, thus affecting policy efficacy.

The Brazilian Amazon represents a paramount example of this type of situation. Since the 1970s, different areas of this region (frontiers) have been colonized by settlers carrying out a diversity of land-uses (i.e. logging, mining, cattle-ranching, and agriculture), often resulting in extensive clearing of its native vegetation. Areas of Pará, Rondônia, Acre, and northern Mato Grosso, for instance, experienced most of their deforestation due to migrants undertaking cattle-ranching. In others, like Center and Western Mato Grosso, most deforestation occurred due to soybean expansion. Most importantly, the vegetation of the Brazilian Amazon is not uniform, and comprises vast extents of tropical forests (particularly in the Amazon biome) and significant extents of savannas (mostly in the Cerrado biome). This distinction bears much importance for environmental policy and its enforcement.

Prompted by the high Amazon deforestation rates of the 1990s and early 2000s, the Brazilian government reacted strongly in 2004 and subsequent years by reinforcing the monitoring and enforcement of the Forest Code (FC), the country's main anti-deforestation legislation. The FC has been in place since 1934 and requires private rural landowners to set aside part of their area for conservation (called Legal Reserve – LR). After the reinforcement of monitoring and enforcement in 2004, the Brazilian government focused its operations on areas experiencing most deforestation, in the Amazon biome, leaving the Cerrado biome largely unattended.[1] The reduction of deforestation that ensued was as spectacular as unevenly distributed: some areas experienced steep declines in deforestation rates while some others only moderately reduced their activity. What is more, the outcome of this policy did not only vary geographically, but also in terms of the actors responsible for that change, with large landowners reducing proportionately more of their contribution to deforestation than smallholders (Godar, Gardner, Tizado, & Pacheco, 2014; Godar, Tizado, & Pokorny, 2012).

The fact that the same policy applied to frontiers with different land-use trajectories resulted in a variety of outcomes may not appear as 'surprising' to many. More surprising is that we do not currently have answers to questions as simple as: Why has land clearing stopped (or significantly slowed down) in some frontiers while it carried on in others? Are there factors explaining why local actors in some frontiers were more able to implement the policy than in others? And even more daunting: Did the agents responsible for deforestation stop their activities due to the policy or something else?

In that regard, the case of the soybean frontier of Mato Grosso presents an interesting puzzle as well as counter-intuitive insights about environmental policy. This region mostly located in an area of transition between the Cerrado and Amazon biomes (presenting a mosaic of forests and savannas), while a hotspot of deforestation in the 1990s and early 2000s, has spectacularly reduced its contribution to deforestation after the government strengthened its policies in the mid-2000s. Yet, most of the enforcement "action" did not occur in that region, which begs some questions

[1] Witnessing that much land clearing was occurring in the Cerrado biome, the government took additional environmental policy monitoring measures starting in 2010.

about the real cause behind the deforestation slowdown. Some have pointed that the worsening of market conditions in the mid 2000s may have explained this drop, it however does not explain why deforestation did not bounce back when these conditions improved (Assunção, Gandour, & Rocha, 2015; Azevedo, 2009). Others have pointed out to the effective role of zero-deforestation commitments taken by soybean suppliers refusing to buy soybean planted on land cleared after 2006[2] (Gibbs et al., 2015; Kastens, Brown, Coutinho, Bishop, & Esquerdo, 2017), however there are doubts that such initiatives were fully efficient, as the a similar initiative in the case of cattle-ranching has proven (Gibbs et al., 2016).

In this paper, I suggest an alternative explanation about how environmental policies (and other factors) led to deforestation reduction in the soybean frontier and propose research questions to be tested empirically (both quantitatively and qualitatively). More specifically, I argue that both the specificities of and the linkages existing among the soybean frontier of Mato Grosso and other Brazilian Amazon frontiers (local), on the one hand, and between these frontiers and the rest of the world (global), on the other, have had critical implications for the way local actors have decided (or have been able) to comply with environmental policies. In other words, the interactions between local actors and policies in frontiers of the Brazilian Amazon region are interconnected and represent adjacent action situation (McGinnis, 2011), the outcomes of which influence(d) each other.

To give but an example of how such interconnectedness speaks directly to our case of soybean frontier, many have written about how the slowdown of deforestation in soybean areas has been a deceiving phenomenon, because its expansion onto former pastures instead of forest has simply displaced cattle-ranching further down into the Amazon, on pristine land (also called Indirect Land-Use Change – ILUC) (Arima, Richards, Walker, & Caldas, 2011; Richards, Walker, & Arima, 2014). Thus, some deforestation may have been avoided in one frontier simply because it could be "externalized" to another, adjacent one. It is thus particularly relevant to analyze this frontier since it offers a window into the mechanisms and real implications of sustainable intensification (Pretty, 2018; Rockström et al., 2017). At stake is a debate about whether the soybean frontier represents some "ideal" model of development and environmental policy, for the

[2] The date was later change to 2008 to align with the revision of the Forest Code in 2012.

rest of Amazon as much as other frontiers in the world. This model is however widely questioned since it has undoubtedly brought economic and social development while also casting concerns about inequality and environmental damages (Fearnside, 2001; Rachael D. Garrett & Rausch, 2015; Martinelli, Batistella, Silva, & Moran, 2017).

I rely on the combined version of the Institutional and Analysis (IAD) framework and the Socio-Ecological Systems (SES) framework (hereafter, Combined IAD-SES framework, or CIS) (Cole, Epstein, & McGinnis, 2019) to specify the institutional conditions in place in the soybean frontier before and after anti-deforestation policies were reinforced starting in 2004, at the scale of the entire Brazilian Amazon. I use the CIS framework to address the two questions proposed by this panel: (1) How can we extend current analytical tools to examine the strategic interactions occurring in these interconnected social-ecological landscapes? (2) Does using such tools help us compare how local actors respond to policies and interact across interconnected scales and places? The objective of the analysis is less to demonstrate specific answers than to raise important research questions and generate hypotheses to be explored/tested in future research. Nonetheless, I rely both on empirical data (land-use change analysis, semi-structured interviews) and secondary data (literature) to support the analysis.

The results of the analysis reveal that anti-deforestation policies may have produced unexpected outcomes, in the sense that they have worked better in areas in which they focused less of their (monitoring and enforcement) attention. Despite not being the focus of monitoring and enforcement, local actors in the soybean areas of Mato Grosso have been able to comply with the Forest Code[3] and have experienced barely any deforestation since the mid-2000s, quite contrary to the rest of the Amazon in which deforestation rates have declined overall but still remain sizeable and constant. I argue that such an outcome partly rested on the interconnectedness between adjacent action situations (i.e. adjacent frontier) in the region, explaining why (1) deforestation would perhaps not have stopped if it were not for how other frontiers of the Amazon triggered policy responses to deforestation in the region as a whole ; (2) deforestation *could* be

[3] I am speaking here less about "exact" compliance with the FC, which is a very tricky thing to determine, than the stopping of deforestation.

stopped in the soybean areas because of the particular conditions in which this frontier was at the times the policies were enforced. For a variety of reasons, soybean producers managed to keep their activity profitable by intensifying production on already available land (including expanding on former pastures) instead of expanding further onto pristine land, a strategy not chosen by other actors of the Brazilian Amazon.

In the remainder of this paper, I outline in Section 1 the literature and theory relevant to the study of environmental policy in interconnected frontiers. In Section 2, I describe the methods used for the argument and analysis of this paper (CIS framework), while I briefly detail the empirical data most of the insights about the soybean frontier of Mato Grosso rest upon. In Section 3, I detail the results of the analysis through a reinterpretation of the way soybean producers (the actors) changed behavior before and after environmental policies were strengthened. Finally, in Section 4, I discuss the results and outline the research questions that may enable a new outlook on policy analysis in the context of interconnected social-ecological systems.

Section 1. Theory / Literature review

In this paper, I argue the impact of deforestation policies in the Brazilian Amazon cannot be fully understood without taking into consideration the differences between the frontiers composing the region, and their interdependence with one another. The word "frontier" is a concept proposed by Frederick J. Turner and referring to the colonization of the American West: areas not densely-inhabited by productive forces, which are unified to the rest of the country through successive stages, in a uniform moving line (Turner, 2010). Frontiers are places that were typically seen as the last place before the border of another country (or the 'enemy') and the place of the furthest settlements (Mood, 1948). The concept has been subject to further development, especially in Brazil. Historian Pierre Monbeig preferred the concept "pioneer front" to that of a unified frontier. He clarified that the expansion of modern societies in such "pioneer areas" is only a temporary process, as they lose their distinctiveness once they develop enough to resemble and function just like the region at the origin of transformations (Monbeig, 1952). Others have observed that colonization areas in the Amazon have traditionally been marked by spatial discontinuity, since

colonization settlements seem to present different degrees of advancement and are not necessarily connected to one another or perfectly integrated with the rest of the country (Dubreuil et al., 2009; Le Tourneau, 2019; Théry, 1996).

In a similar vein than Turner, deforestation in the Brazilian Amazon region has often been described as an "arc" of deforestation (or fire). Authors have pointed out that such an expression is misleading since it gives the idea of a continuous 'line' of modernization advancing on the forest, while the region is in fact best characterized by a mix of frontiers, at different stages of development and land-use types, not necessarily well-connected with each other in terms of infrastructures (Le Tourneau, 2016).

[This section should be about differences between frontiers as social-ecological landscapes, and describing the evolving relationships between them, both of which are factors influencing the interactions of local actors with policies producing different outcomes. Some examples from recent research have pointed out to the specificity of frontiers as an important factor of environmental policy compliance (linking supply chain development and deforestation slowdown, for instance) (Garrett et al., 2018; Meyfroidt et al., 2018; Meyfroidt et al., 2014) – TO BE DRAFTED]

Section 2. Methods & Data

Institutional Analysis based on the CIS framework

I rely on the CIS framework as a way to frame the analysis of different frontiers (conceptualized as socio-ecological systems), each containing various action situations that may (or may not) influence each other, and ultimately influence place-specific environmental policy compliance. The framework allows to detail the universe of biophysical, institutional, and economic relationships that shape the interactions of local actors for a variety of action situations (e.g. land clearing, environmental policy monitoring, environmental policy enforcement, and so forth).

According to Ostrom, the purpose of frameworks is to "identify the elements and general relationships among these elements that one needs to consider for institutional analysis and … organize diagnostic and prescriptive inquiry" (Ostrom 2011: 8). Such frameworks are interdisciplinary in nature and are needed to improve comparability across socio-ecological systems case studies, ensure an exhaustive review of all key variables influencing a particular outcome, and provide a necessary basis for establishing strong causal relationships between political, economic, institutional variables and ecological outcomes (Ostrom, 2011; Robbins, Chhatre, & Karanth, 2015). The CIS framework rely on two major frameworks, both developed by Elinor Ostrom and colleagues, which have influenced the study of socio-ecological systems: the Institutional Analysis and Development framework (IAD) and the Socio-Ecological Systems framework (SES). Recently, researchers in this line of inquiry have developed a combined IAD-SES framework (CIS) to address the shortcomings of both approaches (Cole et al., 2019).

The IAD framework (**See Figure 1**) was developed to explain how actors with diverse interests interact strategically with one another under the influence of three key factors: the actors' social environment (i.e. the communities and context in which they live), the type of natural resource or goods at stake, and the 'rules-in-use'[4] shaping collective and individual action (Cole et al., *unpublished*). It provides a useful way to analyze how a broad set of variables (physical, social, economic, and institutional) shape how actors make individual and collective decisions that will in turn have an impact on collective-choice, policy or constitutional change, depending on the level at which such interactions occur.[5] The framework examines such interactions within an "action situation"[6] that corresponds to a defined set of actors, processes, and fixed period in time. When analyzing multiple successive time periods, outcomes of past phases will affect the conditions that will prevail for the next phase (feedback mechanism), and each action situation can also influence or be influenced by other adjacent action situations occurring at similar or different times

[4] As explained by Cole et al., 'rules-in-use' "incorporate explicit legal rules as well as more informal norms and shared understandings" (Cole et al., 2019)

[5] Ostrom (2005) distinguishes between three level of interactions or "action situations": (1) operational choice level (how actors adapt their behavior in response to policies and rules); (2) collective-choice level (how actors make collective choices about the rules that will structure their behavior at the operational level); and (3) constitutional choice level (how actors define who and how collective choices will be made)

[6] As defined by Ostrom (2011: 11): "Action situations are the social spaces where individuals interact, exchange goods and services, solve problems, dominate one another, or fight (among the many things that individuals do in action situations)"

(McGinnis, 2011). For example, the characteristics of agricultural development in one region in the 1950s might affect, at least partly, how agricultural expansion works in another region in the 1960s.

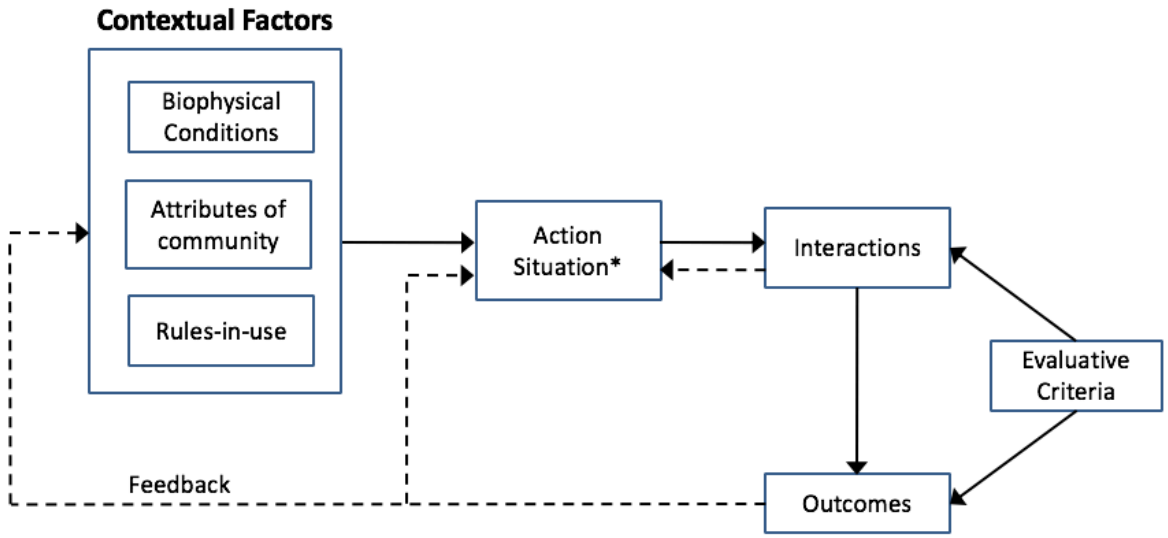

Figure 1. The IAD framework and its basic components (Adapted by Cole et al. 2019 based on Ostrom 2010: 646).

The SES framework was developed by the same community of researchers in response to criticism that the IAD did not sufficiently embrace the complexity of socio-ecological systems and the key influence of ecological variables (Epstein, Vogt, Mincey, Cox, & Fischer, 2013; Ostrom, 2007; Ostrom & Cox, 2010). The main innovation of the SES framework was refining the analysis of IAD's biophysical conditions box by distinguishing between resource systems (RS) and resource units (RU), allowing the analyst to choose from an exhaustive menu of variables of potential relevance to explain interactions. This innovation had however the unintended effect of displacing attention from action situations to a complex menu of variables, making the analysis more static than dynamic (Cole et al., 2019).

The combined IAD-SES framework (CIS) combines the strengths and avoids the pitfalls of both frameworks by incorporating the categories and list of variables of the SES framework directly into the IAD framework structure (**See Figure 2**). First, this allows for a finer interpretation of the interplay of physical, social and institutional variables but keeps a central focus on the main processes and interactions studied. Second, the central "action situation" box of the IAD has been replaced by a box potentially including all action situations relevant to a given case. Finally, the

feedback loop of the IAD whereby current patterns of interaction influence the pre-existing conditions of future interactions is now logically a feed-forward arrow: outcomes of a past action situations directly affect the conditions of the action situations under study.

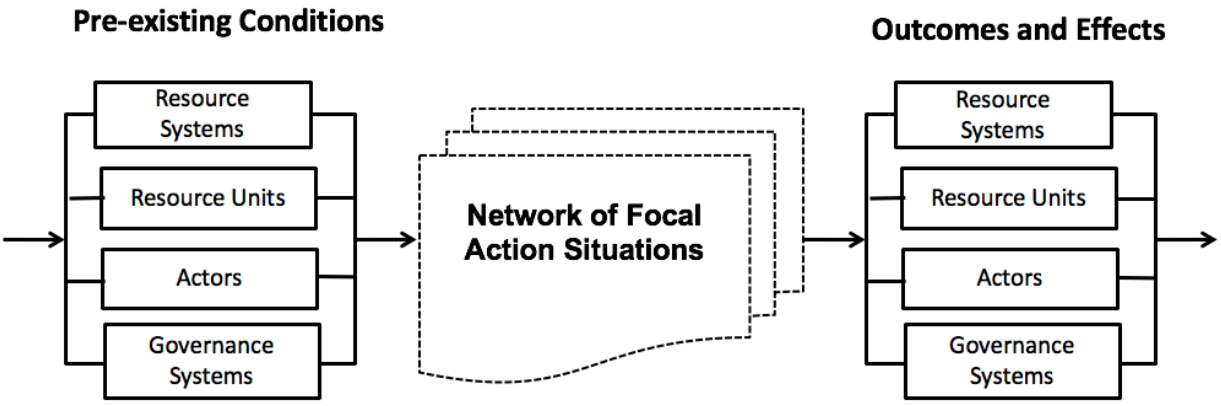

Figure 2. Generic representation of the CIS framework (Cole et al., 2019)

If the CIS is not a theory or a body of theories per se, it is a useful way to map out all the key variables and processes at play in a given situation (e.g. the management of a common-pool resource such as fisheries), and thereby increases the comparability of the impact of rules and institutions across diverse case studies. By adopting an exhaustive set of categories to describe variables relevant to socioecological systems, it also allows for the formulation of new hypotheses and may potentially lay the groundwork for causal inference between remotely connected variables and local outcomes in commodity production areas of various kinds (Robbins et al., 2015), as the literature on telecoupling reveal (Liu et al., 2013). It can help case studies to look beyond just local conditions and explore, for instance, the relationship between a growing protein demand in China and local outcomes like soybean cultivation in Brazil (Silva et al., 2017).

As various policy issues in the Amazon have already been described as complex interconnected socio-ecological systems (Brondizio, Ostrom, & Young, 2009; Brondizio et al., 2016), one of the question motivating this panel was whether the policy failures of the Forest Code (FC) in Brazil can be traced back to a failure to understand the object of the policy (i.e. the area where it applies) as an interconnected socio-ecological systems (best described with the CIS framework). Using the CIS to describe the specificities of the soybean frontier of Mato Grosso and examine its relationship with adjacent or distant frontiers is useful to raise new questions about the interaction

of local conditions with policy incentives. This way, I intend to address the two questions set by the panel: (1) How can we extend current analytical tools to examine the strategic interactions occurring in theses interconnected social-ecological landscapes? (2) Does using such tools help us compare how local actors respond to policies and interact across interconnected scales and places?

Data & Study Area

The main focal action situation examined in this paper is that of large-scale soybean producers in the state of Mato Grosso, as situated in the broader Brazilian Amazon region. The study area consists of the two main consolidated frontiers of Mato Grosso (BR-163 highway region and Chapada dos Parecis region) representing the lion's share of soybean production in the state. The first area is located along the BR-163 highway connecting Cuiabá to Santarém, and comprises the municipalities of Nova Mutum, Lucas do Rio Verde, Sorriso, and Sinop. The second location is in the Chapada dos Parecis, and includes the municipalities of Campo Novo do Parecis, Sapezal, and Campos de Júlio (**See Figure 3**). Together these 7 municipalities represented 26.5% of Mato Grosso's soybean production in 2016 (6.9 million tons of soybeans). Municipalities provide a coherent political-administrative boundary to the study of soybean agriculture and deforestation since most of these municipalities were created following the colonization of the frontier.[7]

Colonizers, mostly smallholders from the South of Brazil, moved into the area in the late 1970s and 1980s with their families and/or business partners in hopes of cultivating rice, and shortly after, soybean (Jepson, 2006; Rivière d'Arc, 1977; Rivière d'Arc & Apestéguy, 1978). They settled on private rural properties either by purchasing land lots from colonization firms or by settling spontaneously on public land. Despite a few difficult years when the government retreated

[7] Municipalities are the smallest spatial units of Brazil's political-administrative division, with the exception of districts (which are sub-divisions of municipalities). Their size can vary greatly depending on the state, and whether the area is urban or rural. These territories are headed by a *prefeito* (the equivalent of a mayor or county administrator in the United States). At the time of the separation of Mato Grosso into two states (i.e. in 1977 this state was split between "Mato Grosso do Sul," the southern part, and "Mato Grosso", the northern part) only counted with a few municipalities that covered a very large part of the states (For instance, the municipality of Chapada dos Guimarães or Nobres). As the colonization of the frontier progressed, residents of these new areas petitioned for the delineation of their own municipalities, which would give them some fiscal autonomy and public service missions. Today, Mato Grosso has 141 municipalities.

most agricultural support, in the late 1980s, the region experienced exponential growth in the 1990s with the arrival of multinationals exporting soybean for the European and Asian markets (Nepstad, Stickler, & Almeida, 2006). The large-scale land clearing of the initial years was thus furthered by the increasing linkage of this region with global market's demand for soybean, which logically resulted for producers in a strong economic incentive to plant and produce more.

This group of municipalities nonetheless transitioned from high to low deforestation at the very moment soybean production exploded in Brazil and environmental policies were strengthened, in the mid 2000s, making it a particularly interesting case from the viewpoint of environmental policy analysis (Arvor, Meirelles, Dubreuil, Bégué, & Shimabukuro, 2012; Dubreuil et al., 2009). The increase in agricultural production in such a region occurred during a period when deforestation rates were high throughout the 1995-2005 period but much lower during the 2005-2015 period, demonstrating that part of the production expansion happened through agricultural intensification and expansion over former pastures more than expansion over forests (i.e.) (Arvor et al., 2012; Morton et al., 2006). The development of double-cropping system (i.e. allowing a second harvest within the same calendar year) caused similar production volume explosions for maize and cotton starting in the 2000s although not in the same proportion in each study area (Arvor, Tritsch, Barcellos, Jégou, & Dubreuil, 2017). It seems that maize has been the privileged crop for a second harvest in the BR-163 region while the larger-scale farms of the Chapada dos Parecis have embraced more capitalistic production systems by adopting cotton. Despite such a transition, 20% to 45% of the native vegetation cover is still preserved in the municipalities of the study area (INPE, 2018a, 2018b).

The analysis covers the period from 1985 to 2015, thus comprising the two periods, before and after environmental policies were reinforced by the government starting in 2004. The primary data used for this analysis come from a dataset built for my dissertation research, comprising a sample of 104 large-scale producers (defined as owning > 2,000 hectares of land and producing soybean) with whom I conducted semi-structured interviews during fieldwork in 2017 as well as land-use change analysis data on 56 rural property boundaries belonging to interviewed producers who provided an authorization for such analysis of their property. Although the nature of the evidence

313 presented in the Results section is under a narrative form, much of this evidence come from
314 thorough qualitative analysis of interview questionnaires, interpretation of land-use change data
315 over time (period of analysis 1985-2015), and secondary literature.
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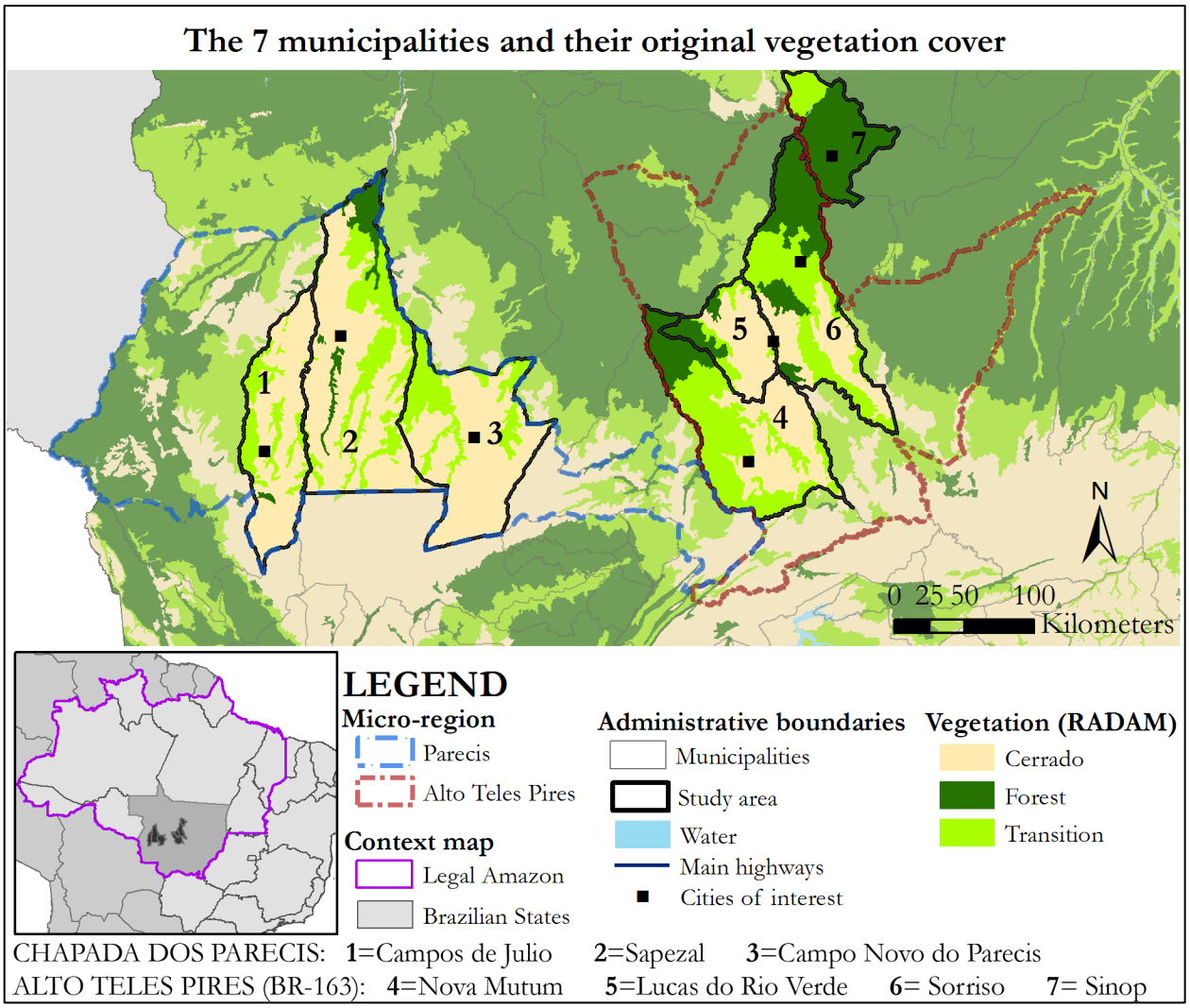

317
318 **Figure 3**. Map of study area outlining the municipal boundaries and microregion of the Alto Teles Pires (BR-163) and
319 the Chapada dos Parecis boundaries.

320 The analysis relying on the CIS framework is detailed in Figures A.1, A.2, A.3 (in the Annex), and
321 summarized in Figure 4.
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Section 3. Results

When migrants moved to Mato Grosso in what would become a prosperous soybean frontier, they probably did not suspect that things would turn out for the better, economically speaking. Several factors led them to clear land quickly on their individual plots: the easiness with which to clear non-forest savanna areas (Cerrado biome), the need to secure tenure, the drive to produce the maximum total crop volume, and the virtual absence of environmental policy monitoring. In fact, government policies at this stage mostly translated into an encouragement to clear land because of the financial support to agriculture and the need to have cleared areas in order to be able to claim a land title.[8] Despite the obstacles to land clearing created by the lack of capital, many joined forces and helped each other out to realize their crop cultivation plans, which were galvanized by the development of tropical soybean varieties by public agricultural research and financial support through various government programs. This led to extensive clearing, but also to soil exhaustion since producers still relied on tilling and were not investing enough resources in to replenish the soils (**Figure 4**, left-hand side).

In the beginning of the 1990s, producers started noting the limits of their production models: with exhausted soils and productions costs rising, they needed to innovate. Part of the solution came from public research. The EMBRAPA[9] helped developing numerous techniques to improve the profitability of soybean agriculture (no till systems, biological nitrogen-fixation, etc.) (Döbereiner, 1997; Souza et al., 2000; Spehar, 1995; Wilkinson & Sorj, 1992) while the rest of the innovation came from the ingenuity of producers who started double-cropping systems consisting of soybean and corn to enhance the impacts of no till systems. These multiple innovations allowed agriculture not only to keep going in the area but also to thrive under ever-increasing soybean prices. Had such technological innovations been marginally important, producers would not be telling that no till systems represented the "salvation" of the area to them (Source: ITWs) (**Figure 4**, center).

[8] This however did not apply much to the study area since they had land titles provided by colonization companies, a fact that is very unique as compared to the rest of the Brazilian Amazon.
[9] Brazilian Corporation for Agricultural Research

The early intensification of production systems set large-scale soybean producers on a prosperous economic path. It is no surprise that many of them significantly expanded their area starting in the mid-1990s with the betterment of production conditions (after difficult first years). This also corresponded to a time at which the pioneers' children were entering the activity and it was thus necessary for them to expand operations to include them, especially after they divided the farms they had originally formed with family members or business partners when they arrived in the area. It is no more a surprise that deforestation peaked in the area in 2003-2004 following favorable economic indicators (soybean prices, and exchange rate) and increased farm profitability induced by double-cropping systems, a trend that can be verified both at the property level and the municipality level (representing the properties of all producers there) (See **Figure 5**).

It is with this context of intense deforestation in the soybean frontier, but mostly because of unfettered cattle expansion in the rest of the Brazilian Amazon, that the Brazilian government reacted by strengthening environmental policies (Le Tourneau, 2016). After increasing the Legal Reserve (LR) percentage on rural private properties in 1996, with no notable impact, it created the PPCDAM, a plan consisting of a set of enforcement measures to empower environmental agencies to undertake enforcement operations in the Amazon (Pires, 2014). At first, the priority of the government was more to create additional protected areas on public lands than to actually carry out enforcement operations. In 2008, however, the PPCDAM entered its second phase which consisted of more enforcement operations. The government created a "blacklist" of the counties (municipalities, in Brazil) with the worst and most alarming deforestation rates. Enforcement operations focused there, and none of the municipalities of the study area were included in the blacklist (however, several of their neighbors were).

The action situation(s) going on in the cattle-ranching frontier, in the states of Pará (north of Mato Grosso and completely in the Amazon rainforest) and northern/western Mato Grosso have thus been mostly responsible for triggering a policy response that applied uniformly to the Brazilian Amazon, and therefore to the action situation(s) ongoing in the soybean frontier of Mato Grosso (i.e. the study area). Although a link between the counties at the origin a policy response and the response itself is not easy to draw, it is relatively safe to say that the municipalities of the study area were not the focus of government policy, since they were neither included in the blacklist, nor

386 they were subject to many environmental fines in the years following. Part of the reason for this
387 has to do with the fact that the municipalities of the study area were located in vegetation areas
388 that were difficult to spot by the satellite-based deforestation systems of the Brazilian government
389 at the time (hence there might not have been enforcement actions if there was no detection).
390 Additionally, and most importantly, deforestation simply dropped in such places, which
391 mechanically reduced the likelihood of deforestation events being sanctioned.
392
393 This set of evidence give support to the first part of the argument according to which the particular
394 characteristics of the studied frontier played a role in environmental policy compliance. However,
395 this is not enough to explain why producers complied with the policy. What the interviews and the
396 land-use change analysis have revealed is that not all producers dealt with deforestation the same
397 way. At a time when soybean production exploded in Mato Grosso, the large variability in the
398 extent of deforestation within property and time at which producers stopped clearing suffice to
399 demonstrate that the behavior of producers did not depend only on general macroeconomic factors
400 (e.g. world soybean prices). They were other factors due to the particular identity, environmental
401 values, and economic strategy of soybean producers.
402
403 For instance, some producers disapproved early on (1990s) of the fact that some of their neighbors
404 deforested riparian areas, shaming the bottomless greediness of others. The reasons large extents
405 of riparian areas are preserved (especially in the Chapada dos Parecis area) today has partly to do
406 with the fact producers attached greater importance to these forest areas than those located on flat
407 lands (more likely further away from rivers and thus encompassed in the property's Legal Reserve
408 -LR- not the Area of Permanent Protection - APP).[10]

[10] Some pointed out that farmers preserved riparian areas because they tended to be sandier and less fertile soils. However true this explanation is, the dissertation demonstrated that producers nonetheless preserved either small or large amount of forests both within and across the two regions included in the study area, a variation potentially greater than that of soil quality alone. Furthermore, recent research has demonstrated that soybean expanded even on low and medium land suitability areas in the 1990s and the 2000s (Garrett et al. 2018). Planting soybean on less fertile soils can always be made more attractive when productions costs are lowered by the proximity to production infrastructures (storage units, transport, etc.), the improvement of agricultural technology, or the low price of land. Hence an explanation of forest preservation based on soil quality is very incomplete since preservation always depend on a number of factors, among which the need for expansion or the pro-environmental values held by producers.

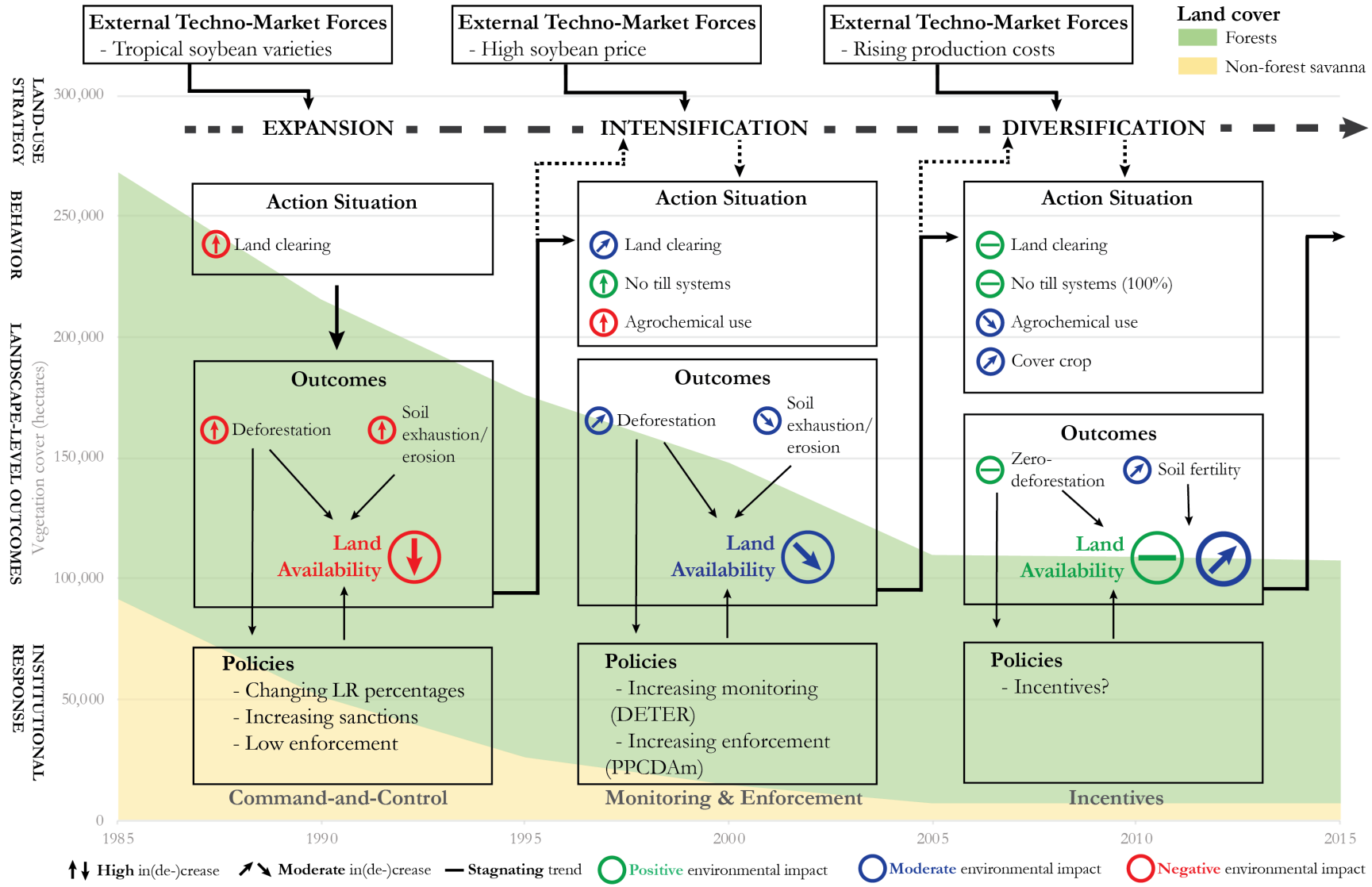

Figure 4. The evolution of large-scale soybean producers as the result of different action situations and contextual factors. The figure represents a condensed version of the CIS framework representations in figures A.1, A.2, A.3, outlining the dynamic relationships existing between each time period of colonization. Deforestation data is in hectares.

What seems to have been critical, however, was their economic strategy, which changed as a result of the combined shock of the soybean economic crisis in 2004-2005 (e.g. price drop, exchange rate worsening for exports) with the reinforcement of environmental policies (starting in 2004). The fact that producers became highly indebted after a period of swift expansion of the planted area may have signaled that expanding fast had not been the best idea they had. Furthermore, they started feeling that the accumulation of environmental policy measures both by the government (e.g. PPCDAm) and the market (e.g. Soybean Moratorium) made further deforestation economically unattractive. Having been on the path of intensification, they perceived that it was possible to remain profitable with the same area (or even less), especially as they increased the volume of maize they produced every year as part of the second harvest. In addition, the multiplication of pests required better monitoring of crop land and investments in soil quality, which in turn required an ever-increasing quantity of agrochemicals to be put in the land (**Figure 4**, **center**). If we add up the increasing land price, increasing production costs, and increase costs of illegal deforestation, it is hard to remain profitable unless one improves profitability through greater production efficiency. This situation differs greatly from the times at which pioneers could 'plant and go to the beach' (Source: ITWs) in the 1980s, and required producers to become real entrepreneurs managing a large number of production variables (Carauta et al., 2016), including non-production ones such as crop commercialization on commodity markets.

The focus of producers has however now shifted on improving production by investing in soils, based on within-property differences in plot fertility. They try to reduce agrochemicals insofar as it reduces operational costs, but also driven by rising concerns about toxicity. A few have clearly expanded their production planning horizons to the medium- and long-term by doing crop rotation and leaving the less fertile soils on their property under cover crops for one or more years (i.e. taking land out of production) (**Figure 4, right-side**). Although this is not a widely shared perception, a significant part of large-scale soybean producers are increasingly concerned by the changes that occurred in the local climate as a result of their expansion onto native vegetation (in addition of water-related and biodiversity-related concerns). Thus, the same way they realized the limits of their agricultural practices with soils in the past, some of them realize the limits of their agricultural model and seek for new strategies to produce sustainably. The right-hand side of

Figure 4 shows the current state of soybean production areas, in between producers intensifying productions with the only perspective of profitability and new pioneers that look for the most sustainable way to minimize environmental impacts and ensure production over the long-term.

Thus, the second part of the argument is that local actors in the soybean frontier action situation modified their strategies due to changing conditions (caused partly by adjacent action situations) but relying on the specific economic trajectory on which they had started to be (possibility of production intensification strategies) before conditions changed. To be sure, the zero-deforestation state in which all rural properties in the sample found themselves after 2005, regardless of their location or cleared extent, demonstrates that environmental policies have played an important role (**Figure 4, center and right-hand side**). Had they not, one would have expected producers with a significant area of remaining vegetation to clear after 2005 given the gradual improvement of economic conditions. The intensification of the soybean frontier led to a situation where soybean agriculture (combined with maize as a second crop) became so profitable that it started replacing pastures in nearby areas (including neighboring counties included in the blacklist) (Arima et al., 2011; Richards et al., 2014). Yet, there is unfortunately not enough space to mention other "feedback" or "feedforward" loops into other adjacent action situations, such as how soybean expanded greatly in the portion of the Cerrado biome outside the Legal Amazon (the area in which environmental policies were focusing) (Carneiro & Costa, 2016; Trase, 2018).

In conclusion, after being affected by the adjacent action situation of cattle-ranching expansion, the soybean frontier influenced -in turn- the disappearance of pastures in areas within reach, displacing further away pastures into other action situations in the Amazon.

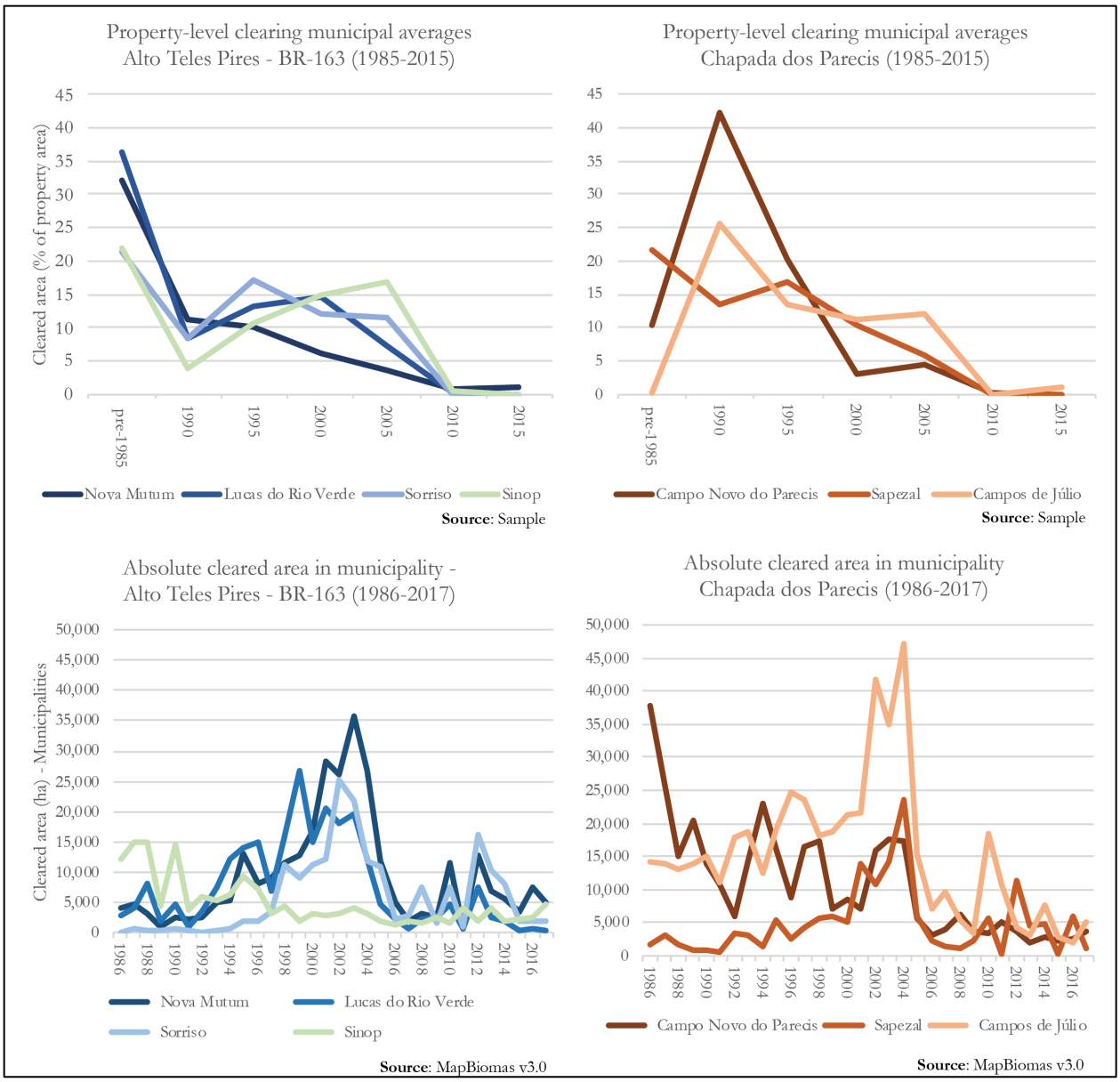

Figure 5. Comparison between the municipal-level average for property-level 5-year clearing estimates in the sample (in % of total property area cleared) (1985-2015) and the absolute yearly land clearing in each municipality (in hectares) (1986-2017). The absolute land clearing. The absolute land clearing data comes from the MapBiomas v3.0 dataset. The way I calculated land clearing for each municipality is only indicative of the trend and should not be read as the exact amount of clearing (Methodology explanation in footnote[11]).

[11] The MapBiomas v3.0 dataset provide land-use change matrices for each year from 1985 to 2017 for all Brazil. The land-use change data allow for a quick calculus of land clearing by calculating how much native vegetation cover turns into non-vegetation areas from one year to another. However, one limitation is that, from one time period to another, measurement errors or regrowth of vegetation areas (areas that may have previously been cleared) may be considered again as vegetation susceptible to be converted into agriculture again, creating an issue of double-counting of deforestation. Although it is uncertain how much this error may affect estimates (due to the particular methodology used here), it is likely to be minimally significant for the observation of broad municipal trends in land clearing.

Section 4. Discussion

What should be surprising about Brazilian environmental policies is not how they fail to work in some places (e.g. cattle-ranching frontiers), but how stunningly well they worked in others (e.g. the soybean frontier). The study area is the foremost example of this. Yet, the current analytical tools available do not seem to help much with characterizing this kind of policy effect, besides characterizing them as 'spillovers' or else. Such names fail to capture the richness of how local actors interact with a variety of incentives available (including biophysical conditions[12]) to produce outcomes that escape policy-makers, even when such outcomes can be assessed as positive as the deforestation slowdown in soybean areas. Although the overall regional policy effect has been hailed as a success (Nepstad et al., 2014), one must note that deforestation in 2018 (and several years prior) for the Amazon biome (only) has reached 7,900 square kilometers, more than 50% of its historical average over the 'worst' period (1996-2005) (INPE, 2018a).

The CIS framework thus sheds a timely light on the complex temporal dimensions and local characteristics with which policies must deal with. If we look at the Brazilian Amazon as a whole, it is uncertain whether the "successful" of environmental compliance of soybean areas has to do with the policy, since the same policy has failed in other places or have not eliminated deforestation rates over the long-term. It remains an empirical (perhaps quantitative) question to examine how effective the environmental policies were given how deforestation shifted from one action situation to the other. Another daunting question is whether there would have been as much deforestation had soybean frontiers not intensified production the way they did (both in their own location and in other places, through indirect land-use change).

The temporal dimension is one in which research in the Brazilian Amazon has not dealt with very effectively so far. As in any region, at constant policy, incentives may change because of other forces. Anti-deforestation policies in Brazil were reinforced at a time of high deforestation rates, but the government was mostly alarmed by the expansion of cattle-ranching into the Amazon biome (and to a minor extent, that of soybean cultivation). Thus, in a way, it is the extensive land-

[12] On that note, there would be much to be said about how environmental policy worked in places were native vegetation cover was still very abundant, such as over 80% of a county's territory.

clearing occurring in forest areas of the Legal Amazon (an adjacent action situation to the one of interest) that created momentum for a policy that applied also to soybean production areas in the Cerrado portion of the Legal Amazon (the action situation of interest). When asked about the influence of environmental policies during fieldwork (in 2017), most producers declared that they had a limited influence, except those located in the Amazon biome that seemed to attribute a greater impact to them. It is possible therefore, that the effect of environmental policy has been more one of perception of potential enforcement coming from adjacent actions situations rather than one of actual enforcement (Producers in Sinop have witnessed IBAMA operations to shut down illegal sawmills on 2005, which may be an example of perceived enforcement). It is equally possible that, a decade after the fact, local actors have reinterpreted the policy changes that occurred in the region because they have come to accept them. What is however sure is that, at the regional level, deforestation rates have gone down and up again, showing that local actors who stopped deforesting once may start again depending on changing institutional conditions.

Research in the Brazilian Amazon, but about environmental policies in general, need to take more seriously the complexity and variability internal to the area where policies apply. Here are a few proposals of new research designs or questions that may help with describing the interactions between adjacent and interconnected action situations:

- **Conduct policy analysis based on the clustering of areas defined by similar processes (e.g. type of land-use in frontiers) instead of defining the clusters based on variables that are 'assumed' to provide a random distribution of certain characteristics**. For instance, in the Amazon, it is fairly common to use different geographical scopes (different group of counties) to study whether rural property size influence conservation of forests. This lead studies to have opposite conclusions simply based on whether the study looks at one state, a group of state in the Amazon, or just the Amazon biome (Godar et al., 2012; Richards & VanWey, 2016).
- **Include variables from other action situations (nearby areas) that may affect the action situation of interest, or conduct fieldwork in areas surrounding an area of interest in other to document the linkages existing between them**. In the Brazilian Amazon, much has been written on how soybean displaces cattle-ranching, but inquiries

on the ground about this process have -so far- been inconclusive according to some authors (Richards, 2012). In other words, the interview of a cattle-rancher that has been bought out by a soybean farmer and had to settle elsewhere has yet to be done.

[*Limitations – TO BE DRAFTED:*

- Data in the soybean frontier limited to large-scale landowners]

Conclusion

During my fieldwork in Mato Grosso in 2017, when I asked producers why they had stopped deforestation in after 2004-2005, they often replied to me that "there was nothing else to clear." It took me perhaps a while to understand it, but it actually did not mean that there were no more forests *per se* (since I have been in properties and municipalities with a significant amount of remaining forests), it actually meant that it was *not interesting to them anymore* to clear. If the research reveals one thing, it is that decisions about forest preservation are intrinsically related with those of crop cultivation, and that these two decisions are two action situations influencing each other, or two sides of a same action situation. There is much to be gained from conducting policy analysis looking at how specific processes occurring in separate action situations influence each other. If it is especially relevant for environmental policies applying to the Brazilian Amazon, it is surely relevant to processes outside the Amazon.

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ANNEX

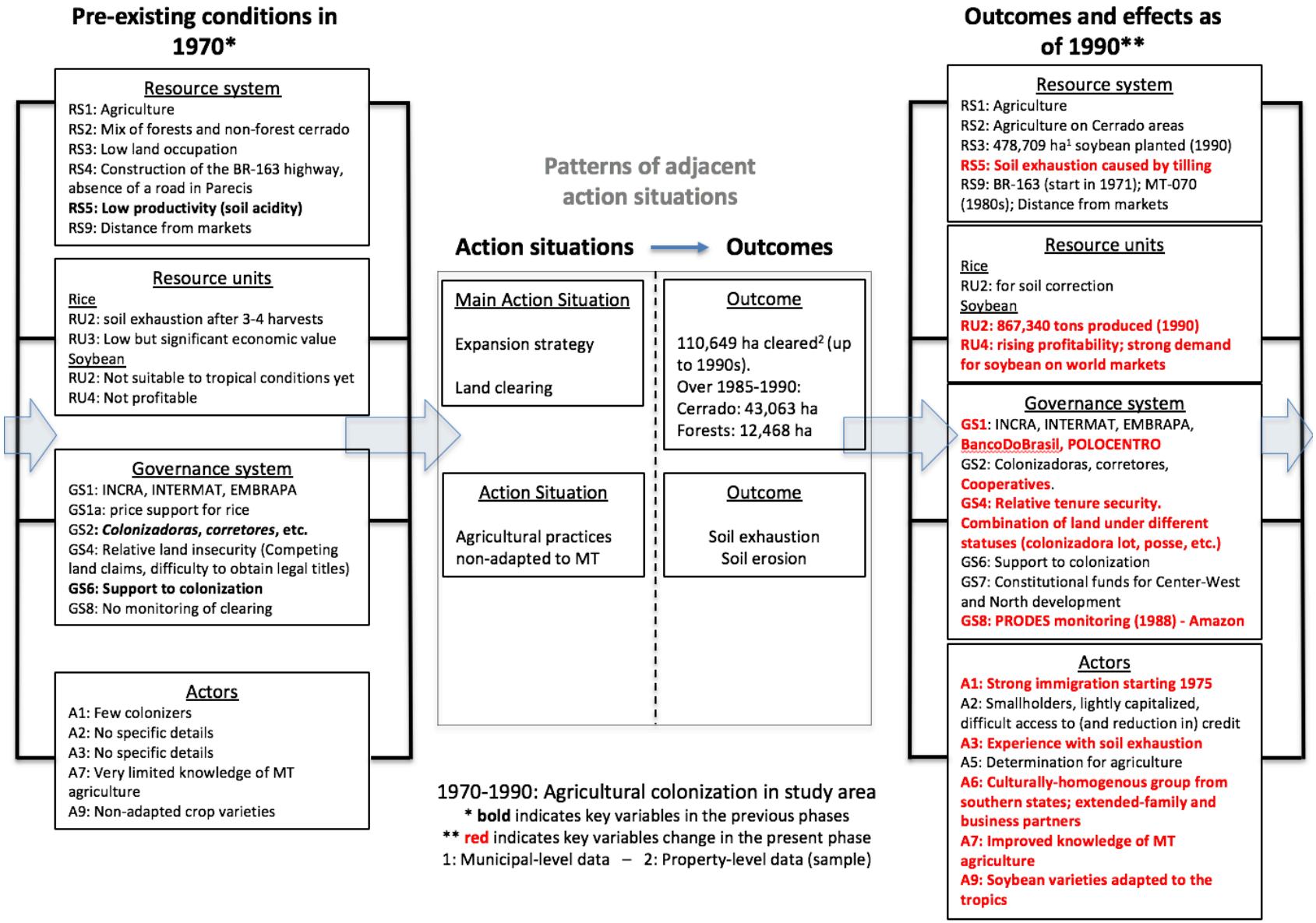

Figure A.1. CIS framework representation of the transition of large-scale soybean producers from the early stages of the colonization (starting in the late 1970s) to right before the great acceleration of soybean production in the 1990s

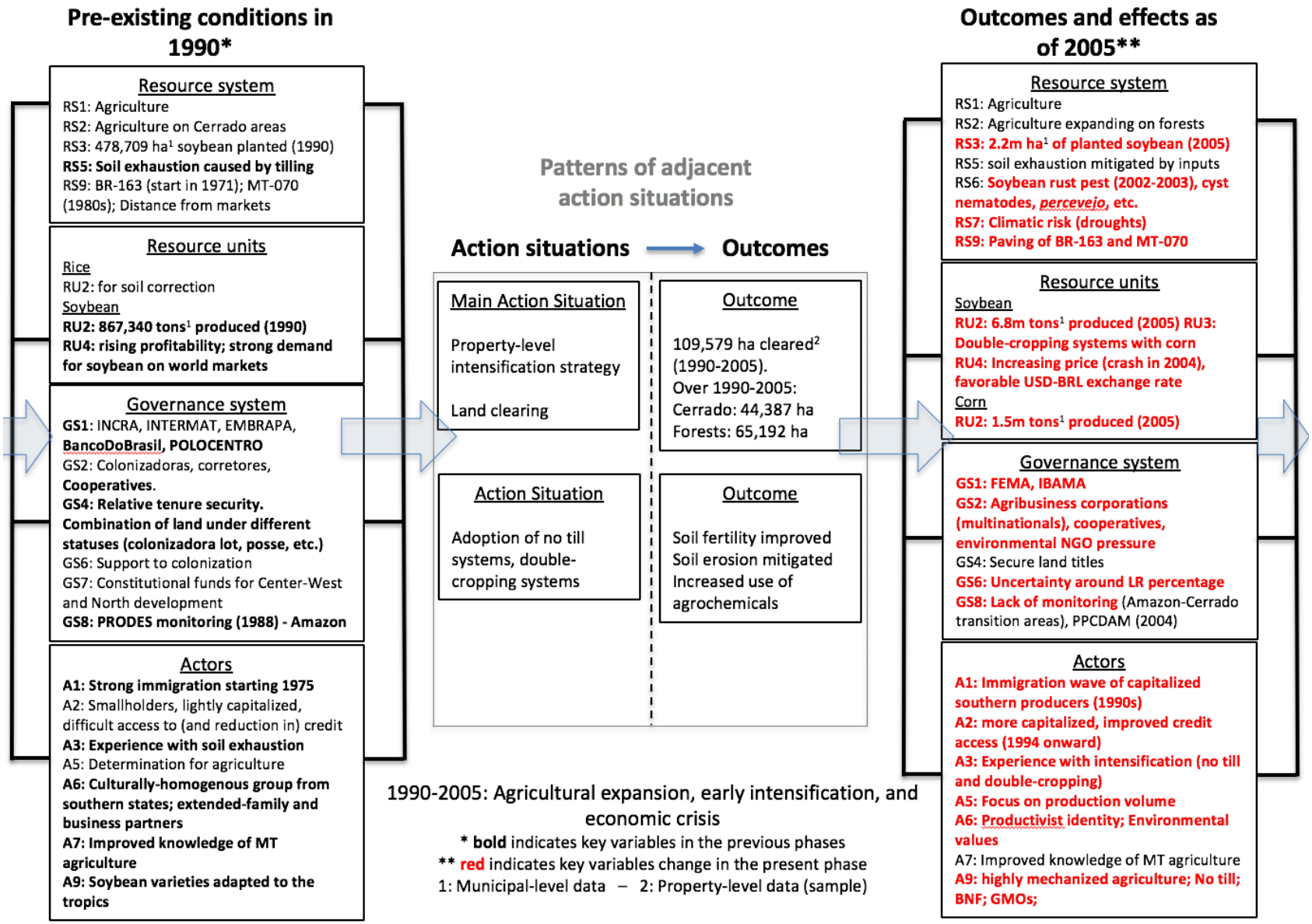

Figure A.2. CIS framework representation of the expansion of soybean production under the impulse of global markets to the soybean crisis of 2004-2005 and heightened environmental policy enforcement of 2004.

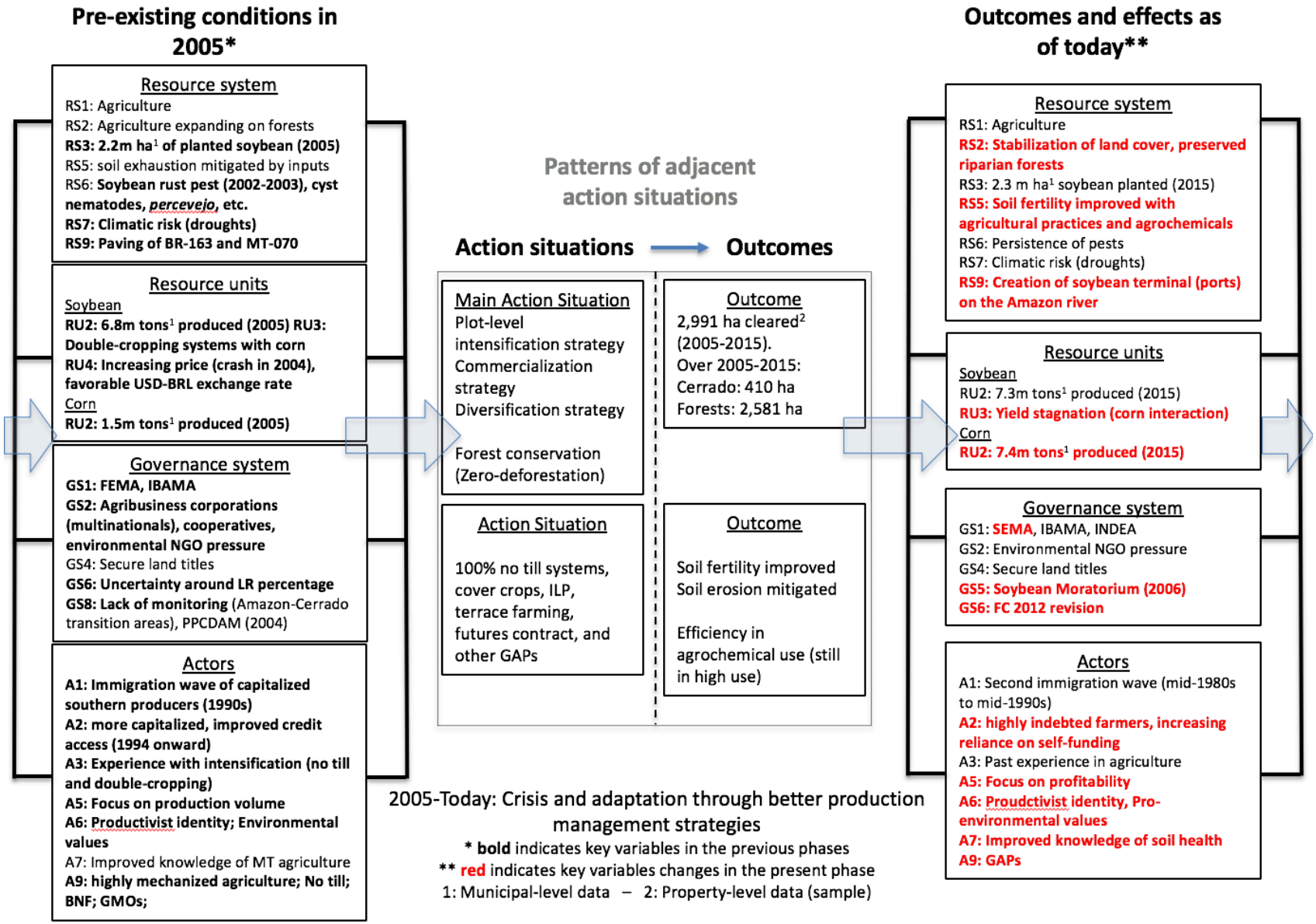

Figure A.3. CIS framework representation of the large-scale soybean producers' strategies and land-use decisions from the mid-2005s to today, after the revision of the Forest Code (FC) in 2012.

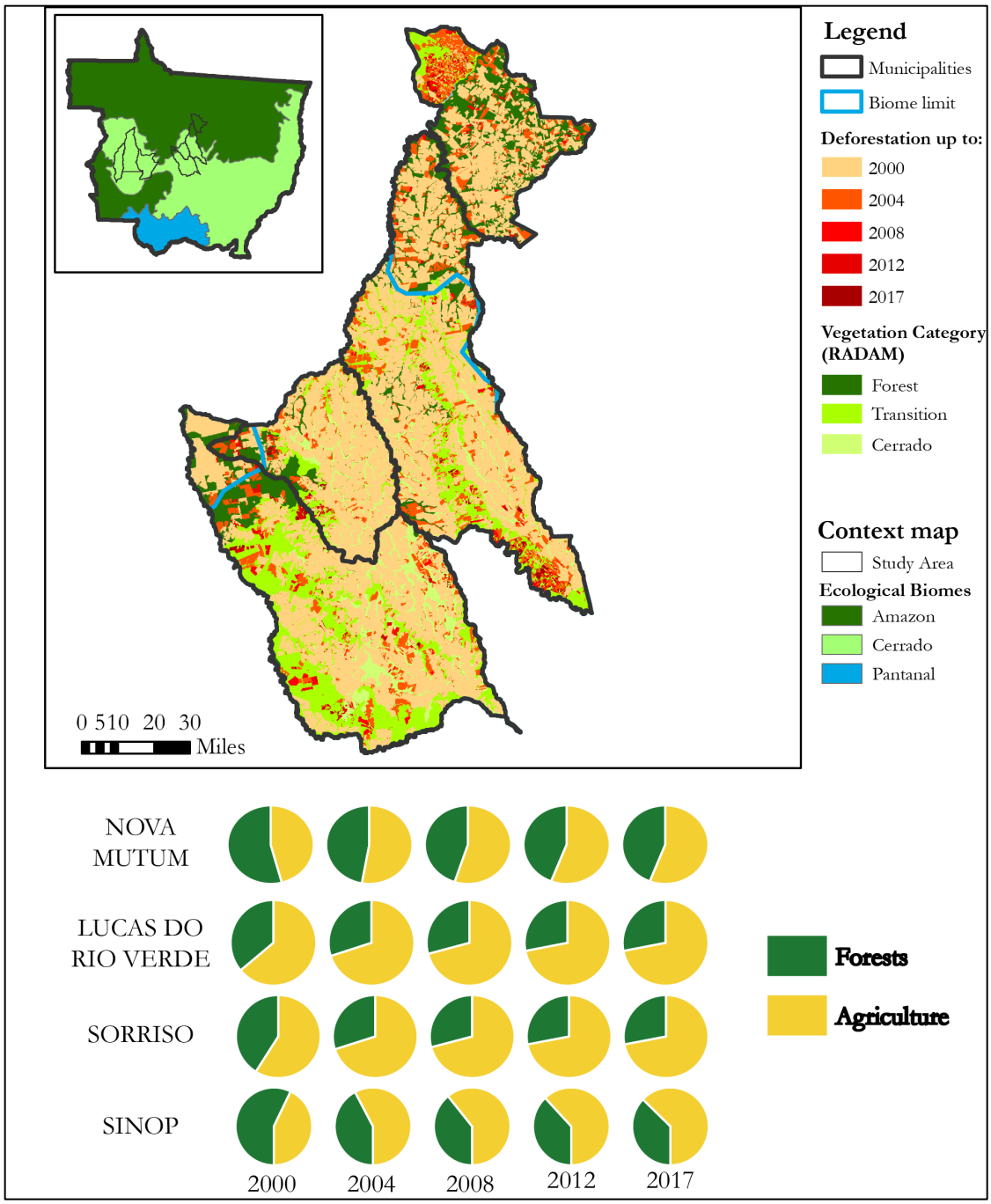

Figure A.4. Native vegetation clearing in selected municipalities of the BR-163 highway study area. **Data**: (1) Deforestation data: PRODES and PRODES Cerrado; (2) Vegetation cover: RADAMBRASIL vegetation map.

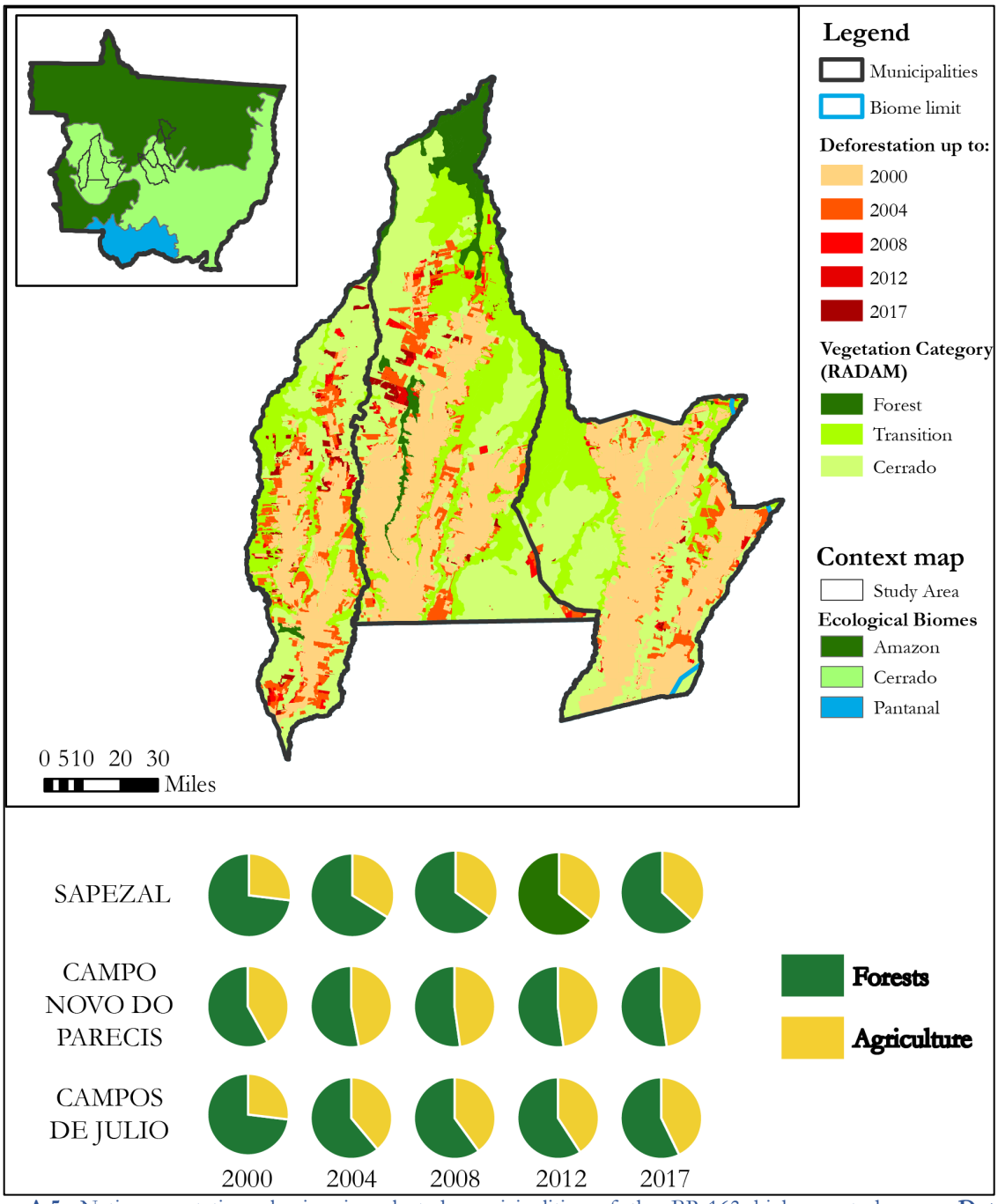

Figure A.5. Native vegetation clearing in selected municipalities of the BR-163 highway study area. **Data**: (1) Deforestation data: PRODES and PRODES Cerrado; (2) Vegetation cover: RADAMBRASIL vegetation map.