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The revision of the Brazilian Forest Act: increased deforestation or a historic step towards balancing agricultural development and nature conservation?

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ABSTRACT

Almost two-thirds of the Brazilian territory still has prevalence of natural vegetation. Although not all pristine, much of these areas have high conservation value. 170 million hectare (Mha) of the natural vegetation is located within Federal and State protected areas. Most of the remaining 367 Mha is on private agriculture lands, where the Forest Act is the most important legal framework for conservation. In July 2010, the Brazilian parliament began the analysis of a substitutive legislation for the Forest Act. The main motivations for the revision is that, on the one hand, it has been found ineffective in protecting natural vegetation, and on the other hand, it is perceived as a barrier against development in the agriculture sector. The substitutive Forest Act, as it presently stands, does not represent a balance between existing standpoints and objectives; it may drive development towards either more private protection through market-driven compensation actions, or increased deforestation and less nature protection/restoration. This article uses outcomes from modeling analyses to discuss weaknesses of the substitutive Forest Act and to suggest possible improvements.

1. Introduction

Brazil is among the biologically wealthiest nations and holds substantial areas of high value for biodiversity conservation, covering biomes such as the Amazon rainforests, savannas (Cerrado); the typical sparse, thorny woods with drought-resistant trees in northeastern Brazil (Caatinga); the tropical wetland (Pantanal); the world biosphere reserve complex along the Atlantic coast (Atlantic Forest); and the grassland of South Brazil (Pampa).

The pressure on Brazil's biodiverse lands has varied over time. Studies point to evidence of large pre-European (400–500 years ago) occupations and large-scale transformations of forest and wetland environments within the Amazon region, thus refuting the view on the Amazon as a primordial forest, only minimally impacted by small, simple and dispersed groups that inhabit the region (Heckenberger et al., 2007). Yet, economic development and the construction of a network of highways in the early 1970s (including the Transamazon) lead to deforestation far beyond historic rates in the Amazon region (Fearnside, 2005; Mittermeier et al., 2005; Fearnside, 2007). The deforestation of the Atlantic Forest that once covered about 15% of the Brazilian territory (Brondizio and Gurgel, 1990) started in the early 1500s. It accelerated in the twentieth century and today less than 10% of the original area

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remains (Camara, 2003; Tabarelli et al., 2005). The Cerrado – which has the richest flora among the world's savannas (>7000 species), a high level of endemism, and equally high species richness of birds, fishes, reptiles, amphibians, and birds – has during the last 35 years lost more than half of its original 200 million hectare (Mha) area due to expansion of pasture and agricultural lands (Klink and Machado, 2005; Brannstrom et al., 2008).

Yet, from Brazilian continental territory (850 Mha) an area of 537 Mha still has prevalence of natural vegetation. These areas are not all pristine. Some may be used for grazing, low impact extraction, undergo regeneration, or be occupied by less intensive agriculture; all productive activities possible without the complete removal of the natural vegetation. Although not all being pristine, much of these areas have high conservation value, as shown by their reflectance pattern in satellite images being similar to those of the corresponding natural sites.

Parallel with the progressing conversion of natural ecosystems, there has been a growing awareness of the need to protect natural areas – especially during the most recent 30–40 years. From mid 1970s, large commitments to parks and other protected areas have been made at federal, state, municipal and private levels. In addition, the connection between deforestation and anthropogenic climate change, and the view that forest protection and forestation strategies can contribute to climate change mitigation, has resulted in increased attention to the state and management of Brazil's forests during the recent decades (IPCC, 2000; UNFCCC, 2005; Gullison et al., 2007; Phelps et al., 2010).

In recent years, there has also been concern that deforestation arising – directly or indirectly – from establishment of bioenergy projects can seriously undermine the contribution of such projects to greenhouse gas emissions reduction (see, e.g., Fargione et al., 2008; Searchinger et al., 2008; IEA Bioenergy, 2010; Lapola et al., 2010; Arima et al., 2011; IPCC, 2011). This as further increased the attention to deforestation and other conversion of natural vegetation in Brazil, since Brazil is among the leading biofuel producing nations.

Presently, 170 Mha out of the 537 Mha of natural vegetation land are located within federal and state protected areas and Indian Reservations (FPA/IR), where legislation and its enforcement is reported to be highly efficient (95%) in keeping the natural vegetation (Sparovek et al., 2010). The remaining 367 Mha is mainly on private lands used for agriculture, upon which the Brazilian Forest Act (FA) applies. The FA is the most important legal framework for regulating conservation and restoration on private land, covering all natural vegetation; i.e., not only forests, as the name of the law may suggest, but also the non-forest biomes.

Another part of the natural vegetation, mainly located in the Amazon Region and difficult to define in terms of precise location and area, is on public land that has not yet been converted to FPA/IR, or assigned for private ownership. The unclear ownership situation is an additional threat to natural land in these cases since legal measures cannot be effectively applied until the land status has been defined.

In July 2010, the Brazilian parliament began the analysis of a substitutive legislation on natural vegetation protection on private land, i.e., a revision of the FA[1]. The revision is partly motivated by the ineffectiveness of the current legislation. Assessments of the compliance of Brazilian agriculture with the legislation report a large deficit in protection of natural vegetation on private farmland (Sparovek et al., 2010).

Even though changes towards a more flexible FA is considered by many authors a threat against natural resources conservation (Martinelli et al., 2010a; Metzger et al., 2010; Michalski et al., 2010). There is also the perception in the agricultural sector that the FA in its present form is a barrier against agriculture development. Not the least important, the perceived consequence of enforcing full compliance is a strong motivation for the agriculture sector to lobby for a revision of the FA. Achieving full compliance with the FA as it presently stands would require drastic changes in agricultural land use, where at least 85 Mha of agriculture land is taken out of production and converted back to natural vegetation (Sparovek et al., 2011). This could lead to very substantial social and economic consequences due to the production losses and also since such a large-scale restoration would be costly, if not impracticable.

Furthermore, there exist large areas (about 100 Mha) of legally unprotected natural vegetation in regions experiencing agriculture expansion. There is a risk that "restricting land use may force the market to look elsewhere to satisfy material needs" (Dekker-Robertson and Libby (1998) quoted by Lambin and Meyfroidt (2011), pp. 3467), i.e., that such unprotected natural vegetation would become under increased conversion pressure from agriculture to compensate for the lost production associated with re-conversion of current agricultural land to natural vegetation. Such leakage effects (IPCC, 2000) could seriously undermine the environmental benefits of enforcing full compliance with the FA. Illustrative of this, Soares et al. (2006) forecasted a total of 60–170 Mha of deforestation in Brazil by 2050 depending on the level of governance and law enforcement. Even when considering the strict compliance of the actual FA the deforestation outcome was still forecasted to be approximately 140 Mha. Productivity improvements in agriculture might mitigate the leakage effects, and there is especially high potential for improved productivity in the Brazilian meat and cattle production (see, e.g., Lywood et al., 2009; Lapola et al., 2010; ICONE, 2011; IPCC, 2011).

We present results from analyzes of the different legal mechanisms in the substitutive FA as it presently stands, and point out weaknesses and legal inaccuracies. We also present possible improvements and propose a way forward for Brazil towards balancing agricultural development and nature conservation.

2. Methodology and data

Based on preliminary information released before the substitutive FA was public, a national spatially explicit database and modeling framework was used to analyze legal mechanisms for conservation, and also to develop suggestions for possible improvements (Sparovek et al., 2010). After the submission of the substitutive FA to the parliament in July 2010, the same

[1] See SI, Section 1.

database and modeling framework was used for additional analyses of individual and combined effects of important legal requirements using assessments of land suitability for agriculture as described in Sparovek et al. (2011).

Quantitative data on the implications of the most important suggested legal texts on natural vegetation conservation are presented and used to show possible pathways for agricultural development maintaining high conservation ambitions. Supporting information (SI) available in Sparovek et al. (2010) provides, together with SI of this article, a comprehensive and detailed overview of data sources, model steps and associated GIS and database processing methods.

The principal model tool the ''Agricultural Land Use and Expansion Model-Brazil (AgLUE-BR)'', employs rule-based processing of spatial explicit information (e.g., land use, biophysical conditions). The model structure is divided into two sub-models (A and B).

Sub-model A is a Land Suitability evaluation of biophysical conditions (Soil, Climate and Topography) in relation to the requirements for high input industrial crop production, based on a FAO framework for land evaluation (FAO, 1976). Sub-model B is the core of complex integration of spatial information and is divided in two process phases: data collection, preparation, audit and standardization (phase 1) and high-level data processing (phase 2). Phase 2 was based on Boolean operators applied on raster files resulting from Phase 1, each file representing a single binary (occurrence or not-occurrence) variable covering the entire continental Brazilian territory. The pixel size in the raster files has a dimension of approximately $90\,m \times 90\,m$. The binary raster variables resulted from mostly publicly available information. The conversion of the original information to binary variables was based on assumptions, data aggregation and transformation from low to high complexity, and varying according to the original formats.

The methodology is described in SI, divided into two parts. Section S3.1 describes the Original Information sources and conversion procedures to obtain the binary raster variables (Phase 1) used in the high level data processing (Phase 2). Section S3.2 gives a description of the Boolean operators used in Phase 2, and the adopted IT tools.

3. The present Forest Act

3.1. *Functioning of the current Forest Act*

The FA includes two types of conservation concepts: Permanent Preservation Areas (PPAs) and Legal Reserve Areas (LRAs). PPAs aim at protecting water resources, soils, and biodiversity, and also at serving as green corridors in the landscape. They are defined in a geographically explicit way, consisting of riparian areas along water bodies, steep slopes, high altitude areas and hilltops. PPAs are established exclusively for the purpose of conservation and must be covered by natural vegetation. LRAs are not geographically defined and aim at biodiversity conservation in more general terms. LRAs correspond to the proportion of each private farmland, with location suggested by the landowner and approved by an official environmental agency, where natural vegetation should not be removed to make place for conventional agriculture. Some productive uses are possible, but only if they can be combined with natural vegetation preservation, i.e., no clear cutting is allowed. In the Legal Amazon Region, the LRA requirement varies from 80% to 35% of private farmland, and outside the Legal Amazon Region the proportion is 20%.

According to the FA, each farm has to keep the PAAs covered with natural vegetation and also follow the land use restrictions imposed for LRAs. The current FA includes a compensation mechanism that leaves some room for reducing the protection on the farm, but this mechanism has proven to be difficult to apply and is not frequently used by the farmers. Legal enforcement of compliance with the FA requirements is usually carried out by compelling landowners to stop agricultural production and reforest at their own costs.

3.2. *Effectiveness of the current Forest Act*

The land use restrictions that apply on PPAs and LRAs result in significant opportunity costs, especially on lands with high agricultural suitability. There can consequently arise tensions between farmers and authorities, both in areas where agriculture is well established, and in naturally preserved regions with high suitability for agriculture. These tensions between farmers and authorities have resulted in a low level of law enforcement and a widespread accumulation of legal deficits regarding PPAs and LRAs. Farmers look at the FA – and especially the more diffuse conservation concept of LRAs – as a barrier against development. The concept of PPAs, which is more directly related to water conservation, reduction of soil erosion and sediment flows in rivers, is perceived by the farmers as a more acceptable restriction on their land use.

Assessments show that out of a total PPA area of 103 Mha, 44 Mha is used for crop production or as pastures, i.e., land uses that do not conform to the FA requirements and that do not effectively protect water resources in riparian areas (Sparovek et al., 2010, 2011). The area needed to meet the LRA requirements is approximately 254 Mha in total. This is about 43 Mha more than the existing natural vegetation area on farmlands that is outside PPAs and FPA/IR areas, i.e., full compliance with the LRA requirements would require that 43 Mha become reserved by farmers as LRAs (Sparovek et al., 2010, 2011). The non-compliance with PPA and LRA requirements occurs in all regions that have significant agricultural land use (Fig. 1).

As noted above, even in the event of full compliance with the present FA, there would still be large areas (103 Mha) of unprotected natural vegetation on private farms that have larger share natural lands than required, i.e., lands that could be legally converted to agriculture. Part of these 103 Mha is located on land that is not suitable for crop production (approximately 73 Mha has severe soil or climate restrictions for intensive cropping), but extensive pasture based beef cattle production is viable on much of this land (Sparovek et al., 2011). In a hypothetic situation of full compliance with the current FA, where 87 Mha (44 Mha PPAs + 43 Mha LRAs) of agriculture land has been re-converted to natural land, the conversion process would likely induce substantial leakage where some of the 103 Mha

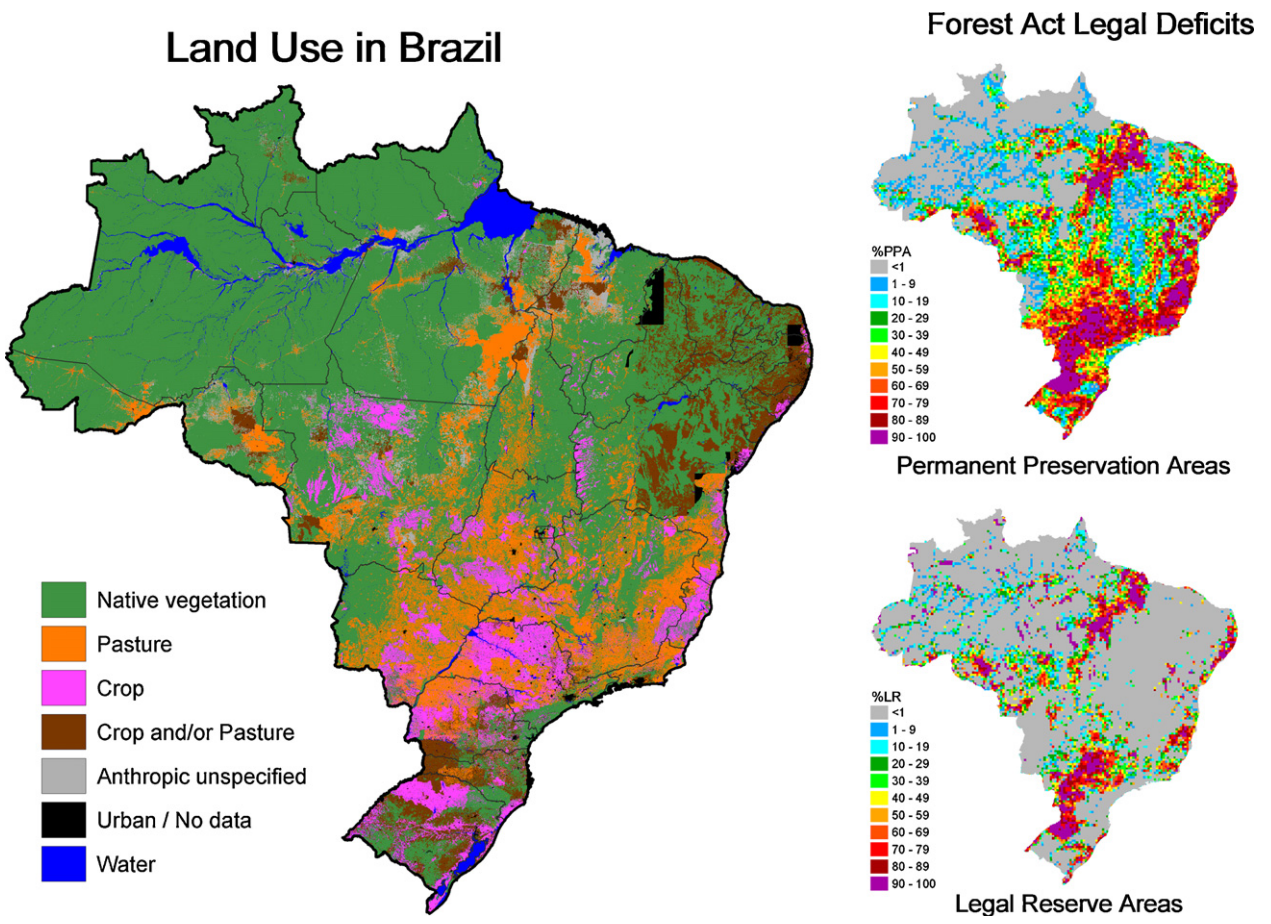

Fig. 1 – Land use in Brazil and the extent and geographical distribution of FA legal deficits.

of unprotected natural vegetation become converted to agriculture land, significantly reducing the conservation benefits of full compliance. Furthermore, while the impacts of natural land conversion is immediate and may be difficult to revert, re-establishment of natural vegetation by planting may require a long time to attain the ecological values of comparable preserved sites. Thus, preservation of lands that currently host natural vegetation, combined with restoration where the benefits are highest (PPAs), may result in higher ecological benefits.

3.3. *The underlying rationales for the Forest Act revision*

To summarize, the underlying rationales for the revision of the FA are the following:

(i) the long history of non-compliance with the FA, involving extensive deforestation, has placed a large part of the Brazilian producers in an illegitimate situation;
(ii) national and international awareness about legality and environmental consequences of land use is increasing (e.g., certification, no-tariff barriers, social and environmental activism, improvements of surveillance technology using remote sensing) and this has placed the Brazilian agriculture sector in a vulnerable and uncomfortable position
(iii) total compliance with the FA as it presently stands, if achieved through the restoration of natural vegetation through planting, would be very costly;
(iv) there is a perception in the agriculture sector that the environmental restrictions on private farmland are too strict and prevent agriculture development, and also that conservation of natural vegetation should take place mainly on public land.

3.4. *Challenges for the Forest Act revision*

Legislation and policy decisions are critical for land use development (Nepstad et al., 2009). Clearly, if legislation is not effective in relation to the underlying objectives – and if corrections through enforcement can be expected to lead to undesirable socioeconomic outcomes and also risk being ineffective due to leakage – revision is needed. This revision should aim at improving the fulfillment of the underlying objectives (in this case nature protection) and solve the illegality problem of the present Brazilian agriculture. Given that natural vegetation protection requirements on private farmland in the present FA embraces approximately twice the area protected on public land, revisions of the FA needs to be based on careful assessments of a wide variety of relevant aspects: it is essential that revisions take into account conditions for agricultural and forestry practices, but also

reflect how the Brazilian society understands and prioritize nature conservation and soil/water/biodiversity protection

4. The substitutive Forest Act

4.1. *The announced pillars of the substitutive Forest Act*

The substitutive FA includes two complementary mechanisms intended to help the Brazilian agriculture sector to comply with the legal requirements, without having to abandon large areas of agricultural land. These are: (i) reduced requirements for protection of natural vegetation on private farmland; and (ii) the possibility for farmers to protect natural vegetation outside the farm as compensation for lack of protection on the own farmland.

The pillars of announced substitutive FA are the following:

(i) major reductions of legal requirements for both PAAs and LRAs;
(ii) less restoration on the hot-spot PPAs of the riparian systems;
(iii) creation of a market based compensation scheme that allows farmers to compensate for the LRA deficits by protecting natural vegetation outside their own farms, aiming at protecting at least part of the natural vegetation on private land that is presently not legally protected; and
(iv) suspension of deforestation permits during a time period when farmers adapt to the new rules.

The reduction of legal requirements for conservation will obviously reduce the need for restoring native vegetation on productive farmlands to achieve legality of agriculture. The combining of reduced requirements for on-farm nature protection with market based off-farm protection compensation can promote development where agriculture makes best use of the current agriculture land while contributing to protection of presently unprotected natural vegetation. However, it is important to note that these two revision pillars are interlinked and need to be balanced. If balanced, these pillars could stimulate increased conservation, agricultural development, and provide a way out of illegal land use for Brazilian farmers.

4.2. *Analysis of the substitutive Forest Act*

Our analysis indicates that the proposed reductions in legal requirements for PPAs and LRAs are so far-reaching in the substitutive FA that off-farm compensation requirements may become essentially zero (Sparovek, 2010; Sparovek et al., 2011). The substitutive FA in addition lacks clear definitions of several important legal mechanisms. Unclear definitions may be helpful for getting the FA approved by the Parliament, but they may impact future enforcement. If approved as it presently stands the substitutive FA may solve the illegality problem but fail in promoting additional conservation. There is a risk that agricultural production will grow based on unnecessary conversion of forests and other natural land to agriculture land.

Some reductions in protection requirements are immediate while others may apply depending on survey results (Agro-ecological Zoning and Water Resource Plans among others). These surveys are to be made by the Federal States and other organizations during a 5-year period when no new deforestation permits will be issued. If the lobby groups in favor of strong reductions in protection requirements are successful during the survey period, and if survey results and interpretation of the suggested legal mechanisms work in the same direction, the following outcome can be expected:

(i) no requirements on small and medium farms to address the existing LRA deficit, which would affect 90% of the farms and 25% of the total area of farmland;
(ii) no requirements at all to address the present PPA deficits, which represent a total of 43 Mha;
(iii) about 20% reduction in requirements to establish PPAs in riparian buffer areas because of changes in the definition concerning buffer strips for small rivers;
(iv) exclusion of the PPA class ''hill tops'', which reduces the conservation requirement by 39 Mha; and
(v) increased possibilities to reduce LRA requirements in non-forest physiognomies in the Legal Amazon Region.

At the same time, possibilities for off-farm compensation of LRA deficits may become much extended in the substitutive FA. In the current version of the FA, compensation is applicable only if the area assigned for protection is located in the watershed where the LRA deficit occurs. This restricts compensation as a market driven mechanism since there is usually a lack of natural land eligible for compensation protection in the watersheds where the deficits occur. In contrast, the substitutive FA suggests that compensation can take place anywhere within the Biome where the farm is located. Given that Brazil is divided into six large Biomes this means that farmers may compensate for LRA deficits by protecting natural land thousands of kilometers away from their farm. Farmer will be able to buy or rent cheaply areas covered with natural vegetation in very remote regions with low suitability for agriculture and low risk of becoming subject to deforestation or other degradation. Buying or renting natural vegetation land located in regions experiencing agricultural expansion will likely cost more due to the higher opportunity cost. As a result, much of the compensation protection would likely become established in areas where the conversion pressure is low, and little would become established in regions experiencing agriculture expansion where compensation protection would more effectively contribute to nature protection.

By lowering the protection requirements and extending the compensation possibilities as described above, the substitutive FA may provide a cheap and easy solution of the illegality problem, but it will not likely be effective in promoting conservation in areas where natural land is presently under highest pressure from agriculture expansion. Neither will it provide much incentive in the agricultural sector for development towards more efficient and productive land use practices. Detailed quantitative information on the effect of the legal mechanisms on conservation is reported in Sparovek et al. (2011).

5. Propositions for a way forward

5.1. *Intensification as an option for combining conservation and agriculture development*

Development of crop production and beef cattle ranching can take place either through intensified production to increase yields or through land expansion. A large part of the crop production in Brazil is already intensive and have high yields (Martinelli et al., 2010b). Drastic yield improvements can hardly be expected for crops such as soy and sugarcane in the short to medium term. Increased production of these crops will therefore require cropland expansion. However, it may not require further conversion of natural lands. Our analyses show that only about 7 Mha of natural vegetation areas are highly suitable for crop production. At the same time, pastures with high or medium suitability for crop production cover about 29 Mha and 32 Mha, respectively – an area almost as large as the present cropland area at 67 Mha.

In total, pastures occupy 211 Mha of land in Brazil and are mostly used for beef cattle production that occupies 158 Mha. A large part of this land is used very extensively. The average stocking rate is 1.1 head/ha and the off-take rate is 22% year, resulting in a slaughter rate of 40 million head per year. By increasing the stocking rates to 1.5 head/ha and off-take to 30% year – in our judgment a modest increase compared to estimated possible intensification – the same slaughter rate of 40 million head per year could be achieved, while releasing 69 Mha of pasture land for other uses.

Extensive cattle production requires that land costs are low and that the pasture areas can be extended to increase the total production. If increased protection of forests and other natural lands leads to reduced opportunities for pasture expansion, and at the same time existing pastures become increasingly considered for crop production, then it can be expected that the beef cattle industry intensifies and also improves the land management so as to avoid unnecessary degradation.

5.2. *Suggestions for changes in the substitutive Forest Act*

A revision of the FA should aim at improving the effectiveness in protecting natural vegetation, especially where the conversion pressure is high. It should also solve the problem of presently existing liabilities, making comprehensive adoption viable. Besides finding the balance between the major pillars in the FA as discussed above, it is crucial that the substitutive FA ensures that future enforcement becomes effective.

Although the technical commission behind the substitutive FA claims this goal is considered, it is our judgment that the existing unbalanced propositions may prevent from reaching this goal. Some key points are proposed for consideration prior to final legal approval:

(i) keep the restoration concept intact for PAAs and re-establish native vegetation on the part of the riparian areas (as defined in the current FA) that is presently used for agricultural production;
(ii) reduce the LRA requirements less than proposed to ensure that there will be a sufficient demand for compensation protection. It is essential that actors find it attractive to set aside areas for nature protection so that this emerging market can become established and grow.
(iii) reconsider the suitable spatial scale for protection compensation. Compensation rules need to be shaped so as to stimulate nature protection in regions where the existing natural vegetation is indeed under conversion pressure.

The needed revisions can be done without substantially changing the legal text, but amendments in threshold values for PPA definitions and LRA requirements are needed to reach a balanced substitutive FA. These amendments need to be based on careful assessments of a wide variety of relevant aspects: it is essential that revisions take into account conditions for agricultural and forestry practices, but also reflect how the Brazilian society understands and prioritize nature conservation and soil/water/biodiversity protection. Targeted research is needed to support setting threshold values for PPA definitions and LRA requirements, and also for shaping effective compensation rules.

Thus, it might be important to extend the 5-year period during which deforestation permits are not issued. Longer commitment to non-deforestation may also be motivated by that more time will be needed for structural changes in sectors that are causing expansion into natural ecosystems, such as extensive beef cattle production, charcoal production for the steel industry, and sawn wood production. A 5-year non-deforestation period is hardly sufficient for these sectors to undergo major changes in their way of operation and there is a risk that deforestation takes off again when this time period ends.

6. Final remarks

Brazil is close to a substantial revision of its main legal nature conservation framework. This revision will influence the prospects for the management of soil and water resources, nature conservation and agriculture production. Further revisions of the substitutive FA are needed to reach clear definitions and also to balance the two options for making the Brazilian agriculture sector legal while avoiding abandonment of large areas of agricultural land. Future development from the present state of the revision process can go in two contrasting directions, either towards finding an adequate balance between conservation and agriculture development or towards promoting spatial agriculture expansion while disregarding nature conservation needs. Much of the outcome will be determined by the parliaments' perception of the relative importance of different objectives and to what extent these objectives are compatible.

The technical commission that drafted the substitutive FA relied little on science-based information. This has – together with the perceived trade-offs between conservation and agricultural expansion – been pointed out as reasons for the legal inaccuracies and the unclear outcome

what regards protection of several hundred Mha of high conservation value areas. In the present situation, science based information is essential – not the least to challenge the perception that Brazil needs to decide between two competing options for the future.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.envsci.2011.10.008.

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