OCCASIONAL PAPER

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An *ex ante* appraisal

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Executive summary

The Brazilian Forest Code (FC), created in 1965, requires all private rural properties to maintain a fixed proportion of their area in natural (managed or unmanaged) vegetation as a "legal reserve", with the required share that must be maintained differentiated by biome (ranging from 20% in Atlantic Forest to 80% in the forests of the Amazon biome). Landowners have often ignored the law, which has been difficult to enforce. Regaining full compliance would require potentially costly restoration in areas already converted for agriculture. Recent changes to the FC through new forest legislation in 2012 provide the opportunity for landowners who, as of 22 July 2008 did not meet the area-based conservation requirements of the law, to instead "compensate" for their legal reserve shortages by purchasing surplus compliance obligations from properties that would then maintain native vegetation in excess of the minimum legal reserve requirements. The latter properties would either already have more forested area than required at the time of this "compensation", or have approved plans to restore sites that would permit them to exceed the minimum legal requirements in the future.

This paper discusses critical policy issues to inform the implementation of this compensation instrument, termed the environmental reserve quota or *cota de reservaambiental* (CRA). We examine the prospects for a CRA market in terms of its relative effectiveness for conservation and development, efficiency in the use of resources and social justice, as well as potential implementation hurdles that must be overcome for the instrument to operate at scale. The economic logic behind this instrument comes from differential opportunity costs for land with different profitability in different land uses, making it less costly to conserve or restore forests in areas with less agricultural returns while pursuing agriculture in areas with higher agricultural value. Allowing for compensation with off-site conservation can potentially enable more efficient and less fragmented agricultural production, as well as cheaper and less fragmented forest conservation, compared to the default legal case where each property has to maintain vegetation up to the legal limits on a property-specific basis.

While including CRA as compensation has great intuitive appeal as a way of achieving greater compliance with the statute at lower cost, controversy exists about the potential results that may be anticipated from its implementation. In this paper, we identify key issues to achieve an environmentally effective, economically efficient and social equitable CRA market. We review international experience with similar economic instruments, as well as Brazilian studies simulating the potential results of the CRA. Interviews with leading actors about the instrument complement the literature review. We finish with a synthetic assessment of what our results mean for policy implementation.

The study begins by providing an overview of the parameters set by the original FC and the flexibility options introduced by the new forest legislation (Law No. 12,651/2012). Although modifications introduced in prior years had permitted compensation of the legal reserve deficit on one property with surplus reserves from another, the measure was rarely applied. The application of this flexibility mechanism was hampered principally due to lack of enforcement of the overall FC, making it unnecessary for landowners to comply with their legal obligation either on or off-site. The application of the compensation mechanism was further constrained by the limited scope for trading, as the law required any trades to be done in the same watershed, thus reducing the opportunities for mutually beneficial exchanges. The new FC provides for the establishment

of a georeferenced environmental registry that will license properties' compliance and is anticipated to enable more rigorous enforcement. State plans and clearinghouses for trades are intended to regulate and track trading of surplus reserves between landowners, while commercial exchanges are arising to grease the wheels of the trading mechanism.

Experience in other countries, notably the United States, with economic instruments such as tradable development rights (TDR) and "conservation banking" suggest broad lessons that can inform the process of implementing the CRA, as the latter can be considered a special case of TDR. The literature on TDR usually refers to properties in areas with "undeveloped" land (e.g. surplus forest) that enter into trades as "sending" areas with areas seeking to buy additional development rights (e.g. those lacking in forest conservation) referred to as the "receiving" areas. Landowners in receiving areas compensate those in sending areas so as to qualify for a zoning density variance that allows them to intensify development, or to comply with legal conservation restrictions. A chief distinction of CRA compared to generic TDR programs is the fact that CRA is only an instrument to assist with compliance of historic (rather than future) deficits. Another distinguishing feature of the CRA mechanism in the current legislation is that smaller landowners can contribute to the supply of CRA, but will not contribute to the demand side, since the current FC exempts them from compensating deficits prior to the 2008 baseline.

Our review of the pertinent literature suggests that TDR instruments rely on a prior regulatory setting within which property rights are well established, and in which land-use restrictions are rigorously enforced. Hence, the following should be considered preconditions for the CRA to perform both economically and environmentally: (i) secure land tenure for both sending and receiving areas; (ii) robust monitoring and effective enforcement on areas demarcated for protection; and (iii) reasonably low transaction costs of running the trading system.

Out of these three factors, land tenure security (i) would also be a major obstacle, especially in localities where the new rural environmental cadaster (CAR) system is progressing only slowly, such as in parts of the Amazon. Slow progress with CAR as well as insecure land tenure will endanger participation in CRA, as both CAR and legal land title are requirements for issuing CRAs.

Second, in spite of recent progress, the requirement of effective monitoring and enforcement of development restrictions (ii)is arguably the most critical bottleneck for making a CRA system work at the national scale: if in the past a simple traditional command-and-control protection system failed to be consistently enforced, why would a sophisticated system with trade-dependent, landowner-customized caps in land use(that are harder to monitor) fare any better? What are the administrative changes and infrastructural investments needed to empower such a system, and is their respective provision currently feasible within a realistic time horizon? Advances in remote sensing technology have increasingly improved the feasibility of monitoring, but will need to be expanded to biomes beyond the Amazon, to enable a truly nationwide system. Furthermore, increased registration in the CAR is a promising development that will need to be accelerated to enable monitoring and enforcement of property level obligations. Even if the technological and infrastructure barriers can be overcome, the political will to enforce the law is an open question. Ensuring transparency of information regarding CAR and compliance status could allow greater engagement of civil society in monitoring and creating incentives for compliance. In particular, the interest of private companies in ensuring zero-deforestation agricultural supply chains could create private sector pressure for forest conservation and legislative compliance, as evidence already suggests is occurring to some extent (e.g. Nepstad 2014; Gibbs et al. 2015).

Another set of questions regards how to structure the market to provide a balance between lowering costs of compliance and creating incentives for forest protection and forest restoration. Assuming that a functional CRA monitoring and enforcement system can be implemented in the near future, could it eventually be structured so as to attain its potential to conserve additional forest and environmental services provision? Or would it simply come to legalize hitherto illegally cleared

forestland and trade it for *de facto* unthreatened forests in the remote hinterlands, without promoting any actual forest conservation or forest restoration in the coming decades?

To assure that purchasing CRA results in "additional" forest conservation (i.e. greater environmental benefit than would have otherwise occurred under "business as usual") both sending and receiving areas should be under some degree of pressure. On the one hand, receiving areas should face the prospect of enforcement against illegal land use: without strong enforcement of the forest legislation, it is unlikely that trading will take place (see above). Yet, if sending areas face no real risk of deforestation, the reduced compliance costs for receiving landowners with forest deficits and financial rewards for sending landowners would be matched by potentially zero incremental environmental protection. In this "hot air" scenario, both landowner types would thus gain (although prices paid to senders might be bid down close to zero), but the environment would lose out – compared to a system where at least some landowners have to restore forests in order to legalize their properties and where the trading rules are structured to encourage sales/purchases of CRAs from areas with greater risks of deforestation.

Obviously, how the scenario plays out depends crucially on the design of the system. Experience in TDR in the United States, for example (see Section 2.1), suggests that overly broad trading scope can undermine the local environmental benefits produced by trading, as well as reduce the economic value received by sending area properties due to excess supply of development rights (see above). In Brazil, the legislation allows for trading at a biome scale, i.e. the entire Amazon region. This would involve trading beyond federal state boundaries, should priorities be set for such external sending areas. While ample scope is likely to maximize the total economic gains from trade, overly broad scope will bring in excess unthreatened sending areas that compromise environmental outcomes by largely outcompeting the restoration option as well as more expensive CRAs from forest areas under pressure.

While greater scope of trading maximizes the overall liquidity of the market and overall economic gains, there will be economic winners and losers in more restricted markets. If expanding the market results in net imports of CRAs, prices will fall, benefiting buyers but reducing payments to sellers and lowering incentives for forest conservation locally. Conversely, if expanding the market creates net exports of CRAs, this benefits sellers by increasing demand but also increases prices for buyers within the region by creating more competition.

In principle, one way of balancing environmental and equity problems attributed to excessive scope for trading would be to entirely restrict some types of trades (e.g. across state or biome boundaries). A more targeted option would be to apportion more weight to priority sending areas than non-priority areas to adjust for differential environmental qualities and/or threats. For example, "trading ratios" could be established so that receiving areas could compensate 1 ha of legal reserve deficit with 1 ha of LR surplus from a priority area, but they would need to purchase CRA equivalent to 2 ha of surplus reserves from a non-priority area in order to receive the same conservation credit. However, it is important to preserve relative simplicity (e.g. 2:1 trading from conservation units and across states and 1:1 trading otherwise) as the structuring of arrangements that call for differential weighting, combined with registry and monitoring of compliance could result in greater transactions costs that could endanger the success of the instrument by hindering liquidity. Furthermore, in Brazil, such additional objectives could politically stir resistance from landowner groups who applaud the 1:1 trading option for its expected compliance cost reductions. TDR programs in the United States and other countries surveyed here (see Section 2.1) have been more efficient when they involved pure market transactions between sellers and buyers, but such systems are usually unable to target additional conservation benefits. To overcome this, TDR is in some applied cases being complemented with more focused purchase of development rights (PDR) subprograms, in which higher priority properties receive additional compensation per unit area. Funding for such complementary programs has typically come from the government as well as philanthropic sectors, but could in principle also come from carbon and/or other environmental service markets.

To what extent CRAs become effective is also a political economy question. There has been a widespread sentiment among rural producers in many parts of Brazil that the previous FC was unrealistically restrictive – too environmentally harsh to be taken seriously, providing insufficiently convincing reasons to stay in compliance with it. If introducing the amnesty, CRA and related changes together would alter that general perception and compliance might become a more realistic endeavor for rural landowners. If this politically hoped-for case comes to widely apply, we could also eventually see more environmental compliance, and CRA could become part of such an environmentally effective policy mix. However, one should not discard the opposite option either: once legal constraints have been eased and amnesty has been granted, this can be seen by landholders as a signal that it could also be done again in the future, when land scarcity and political pressure rise sufficiently.

As a final potential policy objective, would a CRA system in its presently envisaged form increase equity in Brazilian land-use policies? The new FC clearly favors the interest of smallholders as a political priority; a CRA system would in addition provide a transfer in favor of landholders who (actively or passively) conserve more than what the law mandates. This may well be seen as a fair reward for a behavior that benefits society. However, we find that the two equity concerns may obstruct each other, if they are not being balanced carefully: when smallholders are both pardoned their past incompliance (which reduces CRA demand) and allowed to become CRA sellers (which increases supply), the net uncorrected result is likely to be a dramatic oversupply when CRA trading prices will be competed down to zero, or close to it. This would cancel out any aimed-for fair reward to *de facto* conservationist landowners (see simulations reported in Section 3).

In conclusion, we find important trade-offs between the economic and environmental objectives related to the CRA. The CRA mechanism primarily serves to produce economic efficiency gains by reducing compliance costs in response to a command-and-control regulation. Yet, some scoping restrictions for trade, other trade regulations (e.g. differential weighting of sending area units in response to differences in deforestation pressures), as well as complementary interventions (e.g. supplemental positive rewards for conservation) could be considered. Nevertheless, some modifying interventions will have to be established in order to create an adequate policy mix, for the TDR mechanism not to lower compliance costs while compensating past noncompliance with "hot air" and providing minimal rewards to landowners who actually protect and restore forests.

Finally, we also identified additional issues that permeate the debate, but remain unaddressed in this report, and are thus flagged for future research:

1. Given the flexibility for state governments to regulate trades within federal guidelines, to what degree could they restrict trades geographically to ensure adequate demand for forest protection and restoration within particular receiving areas?
2. Should lands that possess greater priority for conservation, such as headwaters or corridors, be weighted so as to hold greater market value and attract greater investment?
3. How should private lands that are already legally protected within conservation units, but still require funds to compensate the original owners for their inclusion in such areas, be weighted in a CRA market?
4. How can transactions costs associated with implementation of the instrument be curtailed while ensuring the necessary compliance with the overall strictures of the forest legislation?
5. What additional measures may be needed to ensure that smallholders benefit from CRA trades?
6. Should easements on sending areas require permanent conservation or could temporary easements be more attractive to landowners?
7. What level of monitoring and enforcement (e.g. penalties for noncompliance) would be necessary to maintain the market and how can greater transparency and engagement by civil society support this? What liability and enforcement mechanism exists if CRAs are sold from areas that are later illegally deforested?
8. What complementary instruments would improve the effectiveness of the CRA – greater enforcement or additional positive incentive programs for conservation or restoration?

1 Legislative background in Brazil

Legal requirements governing land use in Brazil date from the 1930s, while the FC was first enacted in 1965 (Law No. 4,771/65). The FC was enacted as a means to protect forest reserves in settled areas so as to ensure supplies of timber and fuelwood to satisfy local needs. In later formulations, the law acquired an environmental protection connotation, providing a way of ensuring the federal Constitution's demand that land serve a social function (CF Art. No. 186). The FC mandated that each property reserve a proportion of its total forest area, with the required share differentiated according to the nation's principal biomes (*Amazonia*, *Cerrado*, Atlantic Forest, *Caatinga* and *Pampa*).[1] The area of forest that is required to be maintained is termed the "legal reserve" (LR). The law also required that riparian areas, steep slopes and hilltops be set-aside in "permanent protection areas" (APP – *Áreasde Proteção Permanente*). All such areas were exempted from the rural land tax (ITR – *imposto territorial rural*), though generally low levels of the tax have so far made the tax exemption a small incentive for landowners to conserve LRs and APPs.

Since its initial passage, the FC has undergone substantial modification, but the fundamental principle that each property should protect its share of native vegetation and ecosystems remains. In 1997, in response to global concern about deforestation, the LR in Amazonia was raised from 50%to 80% by provisional decree (MP No.1605-18, 11 Dec. 1997). The LR was subsequently kept at this level through successive renewal of executive orders. An unpopular measure among landowners, seen as contradicting acquired land-use rights, the FC was scarcely observed not only in the Amazon, but in the country as a whole (Sparovek et al. 2012). Landowners preferred to accumulate liabilities or fines rather than acting to restore deforested or degraded land, even when the law proffered a seemingly infinite time horizon (30 years) in which to comply. Lack of restoration technology or inputs, opportunity costs, and absence of rigorous enforcement of the FC contributed to noncompliance. Enforcement actions to reduce deforestation dramatically increased in the latter half of the past decade, helping to achieve a decline of 75% in Amazon deforestation rates (see Nepstad et al. 2014 for a review). But the ruralist backlash from the strict measures adopted led to insistence on changing the FC (Soares-Filho et al. 2014).

In 2012, after over a decade of noncompliant resistance by agribusiness interests, the ruralist demand for rolling back land-use regulation under the FC partially prevailed. However, important environmental protections were maintained and new mechanisms were introduced that could potentially induce greater compliance. The new Brazilian land-use legislation (Law No. 12,651/2012) maintains the same proportional reserve requirements as the prior legislation, but gave a blanket amnesty to all illegal deforestation on private properties under four "fiscal modules" in size that had occurred prior to 22 July 2008 (Article 67).[2] All lands – small and large properties alike – were also exempted from fines associated with illegal deforestation up to this same date. Nevertheless, the requirement that historical

1 In the Amazon, landowners were initially required to protect 50% of the remaining forest on their properties, while in the *Cerrado*, this was reduced to 35%. The remaining areas of the country were required to protect 20%.

2 The fiscal module (*modulo fiscal*) is defined by the land area conceptually necessary to provide for basic needs of a rural household. In the Amazon region, this module varies in most municipalities between 60 and 100 ha in size; so that four fiscal modules equals as much as 400 ha, not exactly a small holding, but marginal in scale for all but the most intensive agribusiness ventures. This exemption was adopted to favor small farming interests, but could serve as a means to disguise liabilities on larger properties by title aggregation. Such properties could conceivably be divided into smaller titled units under four modules in size, while operating at a larger scale. Regulatory clarification in a May 2014 decree determined that rural establishments as a whole (not individual titled properties) would be subject to regulation.

deficits must be corrected or "regularized" in the future was maintained on properties larger than four fiscal modules.

According to estimates by Soares-Filho (2013), of the approximately 5 million Brazilian farms, 92% have area up to four fiscal modules, although these represent only 30% of the total area. Article 67 of the 2012 FC reduced the LR liability by about 17 million ha, mostly on those properties under four fiscal modules that are no longer required to make up for LR deficits incurred prior to 22 July 2008. In total, the new forest legislation reduced the estimated area of LR deficit by 58% from 50±6 to 21±0.6 million ha. At the same time, the new law reduced APPs by redefinitions of their required width from riverbanks, and exclusion of the requirement that native vegetation be retained on hilltops, accounting for another estimated 6 million ha decline in required forest area.

In an effort to counteract prior difficulties with enforcement, the new legislation creates a rural environmental registry (CAR – *cadastro ambiental rural*) that requires all owners or "possessors"[3] of rural properties to register their lands with the state environmental agency, delineating the georeferenced LR and APP on satellite images. Owners or "possessors" of properties with deficit LR would then be responsible for stipulating how they plan to comply with the environmental law, to serve as the basis for monitoring of compliance. The CAR, LR and other FC requirements apply to all rural properties for environmental compliance purposes (and may be referenced as lending criteria by credit sources or as purchasing criteria by slaughterhouses or other private agricultural commodity buyers). Although CAR is mandatory for all property types, issuance of CRA is only open to titled landowners. The CAR owes its origin to licensing instruments adopted in the states of Mato Grosso and Pará in the Brazilian Amazon as a tool for FC enforcement. These state systems demonstrated promise as a means to legitimate licensing procedures and remote monitoring, though they did not significantly reduce deforestation (Azevedo 2009; Pires 2013). As a result of experience with these trial systems, licensing was adopted nationwide as a central element of the new forest legislation; it also added other instruments to tie the CAR to specific actions by landowners to comply with the legal requirements for LR and APP observance.

Despite the significant reduction in forest liabilities, debate has grown over landowners' ability to comply with the legal requirements for set-aside areas on private lands. Landholders therefore expected government to establish new mechanisms to further reduce the costs of compliance. The new forest legislation sought to stimulate greater compliance through flexibility mechanisms while at the same time exempting small properties from these requirements.

One such flexibility mechanism included in the 2012 law is the option for landowners to "compensate" for any LR deficits on one property that were incurred prior to 22 July 2008 with LR surpluses on other properties, a procedure already permitted by Provisional Measure 2,166–67 of 2001. This compensation could be done directly by purchase of a permanent or temporary forest easements on another property to make up the deficit, or through the acquisition of so-called environmental reserve quotas (CRA – *cotas de reserva ambiental*). The CRA system would permit landowners within the same biome to trade surplus reserves among themselves. Such an instrument had been included in the prior FCas "forest reserve quotas" (*cotas de reserva florestal*). However, its implementation had been limited because trades were only permitted within the same watershed, which severely restricted the scope for trading. To our knowledge, the overall results of the quota system have not been evaluated.[4] Since there had been little real tangible threat of consistent enforcement of the prior FC strictures, few were eager to either restore their properties or compensate their liabilities with lower cost compliance assets available on properties elsewhere.

3 Because title regularization is a complex process in Brazil, many rural landowners do not hold formal deeds to the land they occupy, and are classified as "possessors".

4 Very few landholders brought their properties into compliance through compensation on other properties; for example, between 1999 and 2007, only five such applications were processed by Mato Grosso's environmental agency (Azevedo 2009). The state of Mato Grosso also attempted to establish a fund that landholders could pay into as compensation for excessive forest clearing and that would then be used to defray costs of regularizing private properties in protected areas, but the national Ministry of Environment rejected the creation of this fund (Azevedo 2009, 267).

Under the new forest legislation, the legally "deforestable" surplus is the forest area above the LR requirements (set at 20% to 80%, according to the biome), which the property owner can legally cut. In the Amazon region, some areas have had their LR requirements reduced from 80% to 50% due to the enactment of ecological-economic zoning. Such properties can issue CRA from the area between 50% and 80%. Landowners of properties sized under four fiscal modules with a forest deficit incurred prior to 22 July 2008 are not required to reforest or compensate for these deficits. Yet, such smallholders who had deforested more than the legal limit at the time, but still have forest areas remaining in any part of their properties, cannot legally deforest these remaining areas in the future. At the same time, smallholders are allowed to issue CRA on up to 100% of any remaining forests (outside of APPs). As of 22 July 2008, however, all private properties, large or small, are bound by the legal reserve percentages in their respective biomes. Moreover, after that date, all landowners that reduce(d) native vegetation beyond the legal limits are required to return to compliance by restoring those areas, without having the option to compensate by buying CRA. Thus, the CRA is only an instrument to assist with compliance of historic (rather than future) deficits, and smallholders can contribute to the supply of CRA but will not contribute to the demand for CRA under the current FC.

The CAR environmental registry established through the new forest legislation in Brazil, along with its requirement for development of a state program for environmental regularization (PRA), set the framework within which the CRA scheme is expected to operate. The Rural Environmental Registry System (SICAR), a georeferenced web-based system developed by the Ministry of the Environment and replicated by the states, will enable documentation of over 5 million rural properties, improve transparency and provide a pathway to environmental compliance. The system is operated online and automatically calculates legal liabilities by simply uploading the georeferenced property boundaries and demarcating water bodies and forest patches. This tool is expected to facilitate automated demarcation of potentially tradable areas and will signal land-use changes, thus reducing the costs of monitoring and enforcement. It is expected that SICAR will thus also facilitate the market for CRA. Although numerous uncertainties still exist about the registry procedures for CRA titles, a federal regulatory decree (Decree No. 7,803/2012) and normative instrument of the Ministry of the Environment (Normative Instrument 2, 5 May 2014) have clarified the procedures; some states have already passed complementary legislation to implement the statute including the procedures for registry and trading.[5] However, there is a key question of timing: when would such a property cadaster be sufficiently advanced to serve as a (preconditioned) instrument for at-scale CRA implementation? The speed of CAR implementation is uneven across federal states; in some potential sending areas of the Amazon, unclear land tenure is likely to inhibit participation in CRA – just as it inhibits the implementation of other area-based land management tools, such as payments for environmental services (PES) (Börner et al. 2010).

1.1 Potential benefits of CRA

Economic instruments such as the CRA require certain preconditions to be met in order to work effectively. Secure and well-demarcated land tenure is one of them. But perhaps the foremost question for broad-based implementation is whether the level of land-use enforcement – that directly stimulates the incentives for CRA – and hence the opportunity for trading will be sufficient to stimulate a market.

Geographical constraints on transactions (or lack of same) will be a crucial aspect of the effectiveness of this instrument. In most parts of the Amazon and Cerrado regions, for example, there is still a large amount of intact forest beyond the restrictions embodied in the forest legislation. Much of this forest area, especially in less accessible areas, may not be under imminent threat of being deforested. This has the potential to create what some have termed "hot air" in the potential CRA market, meaning that landowners could avoid a liability to restore land with a LR deficit by buying a CRA from lands that, while legally clearable, are not likely to be deforested in practice. Such "hot air" will also increase the supply, and thus the price of CRA will decline – in the worst case, to practically zero. In this way, "hot air" will conceivably deflate both the potential market value and the ecological effectiveness of the CRA mechanism (Soares-Filho et al. 2014).

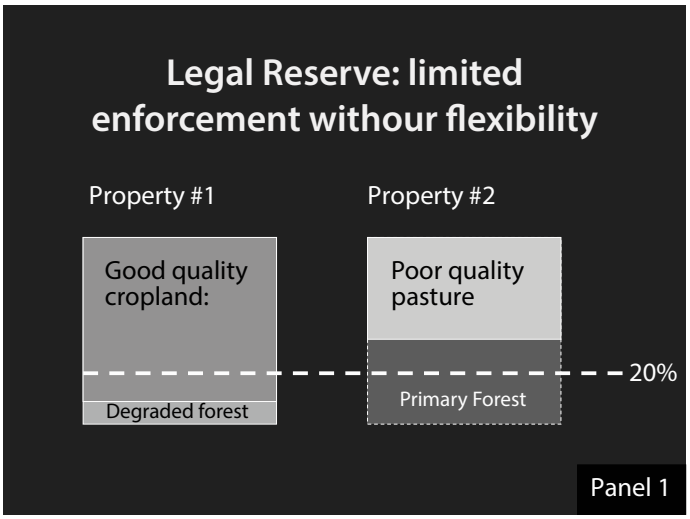
5 The state of Mato Grosso do Sul recently passed a decree regulating the new forest legislation, establishing the basis for creating titles to permit CRA trading (BVRio 2014).

The new FC legislation provides that CRA can also be issued to regularize public property over protected areas (i.e. "conservation units"). Owners of private lands within areas that the government has designated as conservation units are in theory supposed to receive compensation for their loss, but this process has been slow to be completed. The potential to sell CRA from these formerly private lands could generate revenues to enable the government to clear its debts related to these lands and regularize their status as part of conservation units. Although potentially helpful in bolstering the conservation status of publicly protected areas and thus beneficial to biodiversity conservation over the long run, the possibility of issuing CRA from within publicly protected areas would further widen the scope for trading, and thus put downward pressure on the market value of reserve quotas.

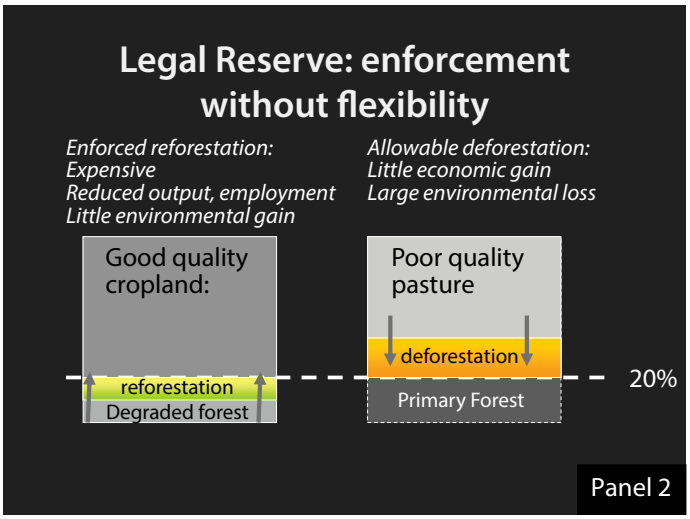
If one were to consider the sole objective as being one of achieving lower compliance costs for "receiving" landowners, added supply of forest surpluses would be welcome. The compliance cost-reduction objective of CRA thus displays important trade-offs with environmental goals if the latter are not clearly defined. The pivotal issue for national policymaking may thus be one of attaining an appropriate balance between demand and supply of quotas, so that trading may become part of the solution to achieving conservation goals as well as cost-reduction objectives in an integrated manner.

Another critical aspect of the CRA instrument is the institutional complexity of the rules that are laid out for registration of lands available for trades, which could add multiple layers of transactions costs that could easily stifle the instrument. However, government is intent upon introducing an incentive toward compliance with the new legislation, and although the CRA brings no net monetary gain for landowners taken as a whole (the transactions between CRA senders and receivers represents a zero-sum game), it represents one such opportunity by reducing compliance costs for those in deficit, and provides positive incentives for those that had practiced conservation – whether by deliberate intention or by default. It may, however, be necessary to complement CRA with other incentives (e.g. credit, PES, etc.) to provide a stronger stimulus for conservation. The CRA mechanism in theory serves to produce economic efficiency gains by reducing compliance costs while achieving a fixed or potentially even greater target level of environmental benefits. However, for this to work in practice, certain trade restrictions have to be put in place to avoid the mechanism achieving its cost-reduction benefit at an elevated cost by weakening the environmental results. Additional interventions may also be needed if the goal is to enhance participation and benefits accruing to smallholders, who may otherwise have difficulty accessing the market, despite their special dispensations under the revised FC.

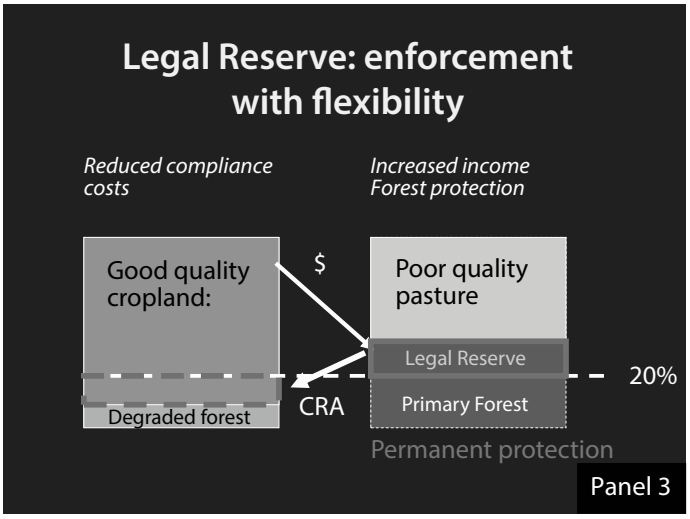
In the following, we describe the origins of the CRA mechanism and its roots in the family of tradable development rights (TDR) instruments. Such TDR instruments were widely adopted by local governments in the United States and in other countries. In this context, broad lessons are described that apply universally to this type of instrument, which may be suitably applied in the Brazilian context. We then summarize the recent research on the potential functioning of CRA-like instruments in Brazil with respect to their relative effectiveness for conservation and development, efficiency in the use of resources and social justice, as well as the potential implementation hurdles that will have to be surmounted to operate at a suitable scale and reasonable cost. Figure 1 presents the concept of LR trading in hypothetical terms, applicable to the Brazilian setting (Chomitz 2004).



Properties in different parts of the same biome are differentiated by soil fertility and market access, among other factors, affecting their opportunity costs for conservation. In the case without flexibility and with limited enforcement (panel 1), things stay pretty much as they have been in the past: economically marginal properties continue to have surplus forests without compensation, and good quality lands for agriculture are maintained as cropland or degraded forest regardless of violating the legal reserve requirement (e.g. 20%).



With strong enforcement but without flexibility (panel 2), degraded and illegally deforested lands are required by law to be restored while the remaining surplus forest on the economically marginal property could become threatened with legal deforestation, if there is economic pressure to expand production area to make up for the loss of agricultural land. This "leakage" effect will not generally result in loss of all forests subject to legal deforestation, but some proportion would be lost. The result: some landowners lose productive area; society loses some conservation and ecosystem services.



Under strong enforcement plus a flexible trading scenario (panel 3), potential improvements occur: the landowner with high opportunity costs could compensate the marginal landowner for the surplus forest land she needs to make up for her deficit, so she no longer has to pay a fine or face other penalties. As long as the opportunity cost difference between them is high enough and transactions costs are not too high, there are grounds for trade. But for this to work there must be a credible enforcement and monitoring system in place. Furthermore, to improve environmental quality, trading should take into account different environmental values between properties, including differences in the chance of becoming deforested or degraded in the future due to leakage or other economic pressures.

Figure 1.Hypothetical TDR function in the Brazilian forest legislation context.

Source: Kenneth Chomitz (personal communication, based on Chomitz et al. 2004), and own elaboration

2 TDR experience in land-use management

2.1 Origin of TDRs for managing urban development

The CRA is usually associated with international experiences with tradable development rights (TDR), (also sometimes known as "transfer of development rights"). TDRs emerged as a means to preserve historical landmarks and prime agricultural land in cities and suburbs of the United States, beginning with New York City's creation of the notion of tradable "air rights" in its 1911 zoning ordinance. In this instrument, property owners who wished to increase the height of buildings were allowed to purchase development rights from historic landmarks, churches and other properties, compensating owners of these properties for use restrictions that avoided their conversion to skyscrapers. The value of air rights has increased substantially, with the value of New York real estate, and commanded an average price of about USD 200/ft^2 (USD 2150/m^2) throughout much of the last decade, despite the last financial crisis (Morris2014).

According to the broad municipal enabling legislation enacted in the late 1960s:

> The purpose of providing for transfer of development rights shall be to protect the natural, scenic or agricultural qualities of open lands, or to enhance sites and areas of special character or special historical, cultural, aesthetic or economic interest or value and to enable and encourage flexibility of design and careful management of land in recognition of land as a basic and valuable natural resource. (General City Law § 20-f(2) *in* Cuomo and Perales 2011)

Of particular interest for the creation of financial instruments is the separation of the property rights over the soil from the development rights, which enabled the air rights to be sold or saved ("banked") independently, as a basis for land-use planning and management in New York and other areas.[6] In effect, title to the air or development rights became a separate marketable property, while the land to which they pertained could be transacted separately, retaining the preexisting use restrictions serving as a permanent easement to the bundle of use rights attributable to the property.

Translating this tentatively into the Brazilian forest legislation case, the CRA would become a separate transacted property, able to be applied by the same or another landowner to expand productive area beyond the strictures of the legislation in areas designated by law or regulation (e.g. within the same state and/or biome).

In the TDR formulation, the areas with land use restricted for conservation purposes, serving as a basis for generating tradable rights, are termed "**sending areas**" (supply side), while those which obtain such rights to expand land use are called "**receiving areas**" (demand side). Sending sites are typically nature reserves, upper watersheds, environmentally sensitive areas, active farms, trails and other historic, recreational and cultural resources, as well as open space with subprime value of economic use. Receiving areas in most countries that have adopted this instrument are primarily residential or commercial development projects that seek permission to increase density or extension. Such an approach has come to be widely used both in developed and developing countries where open space and peri-urban agricultural land are the objects of speculation

6 This separation owed itself initially to legal decisions, which came to permit lease or sale of air rights separate from land beginning with such air rights sale over the area occupied by Grand Central Station in New York City (Wright1968).

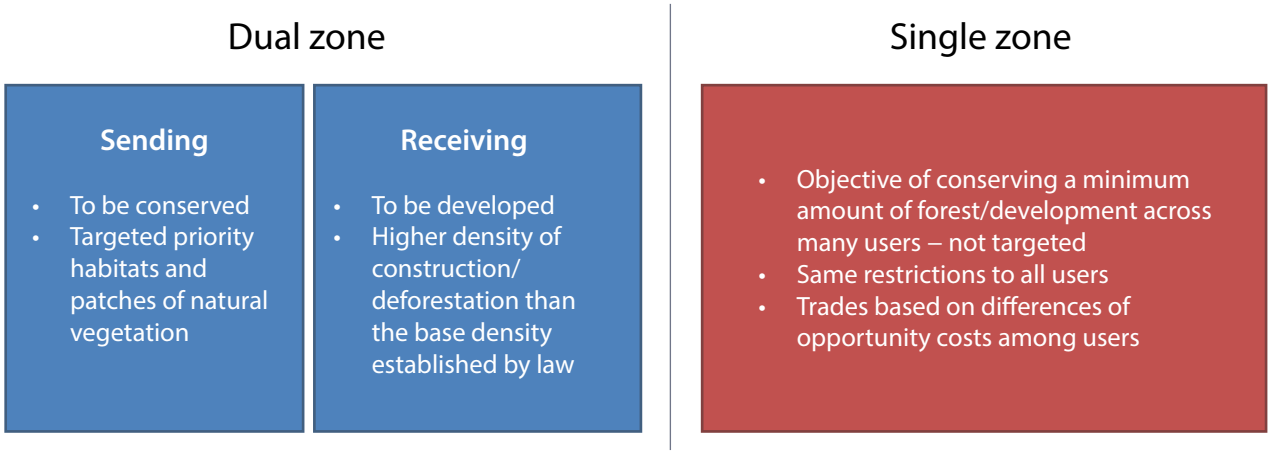


Figure 2.Comparison of single and dual zone TDR schemes and their respective advantages.

and leapfrog development.[7] However, in recent years, TDRs have also begun to be adapted to broader landscape management (Johnston and Madison 1997).

It is important to distinguish between TDR systems operating with single or dual-zone transfers. The cases described in general have two separate zones (sending and receiving), in which use restrictions are differentiated, thus serving as the basis for the trade. In a single-zone scheme, trades occur on an equivalent basis among landowners within the same restriction context, very much like fishing licenses or pollution allowances applying within the same geographic region. Rights are allocated according to a license to use the property according to legal requirements. Given differences in land fertility and other characteristics, opportunity costs differ. Hence, landowners may wish to expand their use rights by purchasing those from other land users who agree to maintain conservation areas intact. This type of system is appropriate for conserving a minimum amount of forest across many users, similar to the approach described in Figure 1, in which an overall conservation target (e.g. 20% of total property area conserved) is set on a geographic basis and trading is permitted between properties to achieve that overall goal.

A dual-zone TDR scheme is more appropriate for targeting specific conservation objectives, such as protection of particular contiguous blocks of habitat, within a specific geographic area (Johnston and Madison 1997). A summary comparison of the two types of TDR schemes is provided in Figure 2. The Brazilian CRA instrument resembles a single-zone system, without clear targeting of sending areas; its effectiveness for achieving some particular conservation objectives may be limited and require adoption of complementary instruments to reinforce and target conservation benefits.

Brazil could consider using a differentiated zone strategy as a means of reinforcing conservation benefits from trading in development rights from priority areas, establishing different weights for distinct targets, rather than weighting each hectare in both sending and receiving properties on the same basis.[8]For example, policymakers could encourage more or less CRA purchases from conservation units or from areas in the same biome in other states, depending on whether or not other in-state demand and supply are sufficient to achieve conservation objectives within the state at reasonable costs.

The value of development rights varies, but may be defined as the difference between agricultural or conservation use (depending on what is the favored land-use option being targeted) and full development value. Values of development rights under most schemes reviewed are subject to external appraisal.

7 TDR systems are common in Canada, Australia, Mexico and India. In China, "Interestingly, the practices of land development rights (LDR) transferring and trading have been booming in China over the past decade. As a reaction to the constraints imposed by China's state-planned land-use system on local urban and industrial development, some coastal provinces in the country have carried out a series of innovative reforms in the area of LDR transferring and trading (Wang et al. 2009).

8 The new forest legislation indicates that trades should target contiguous forest corridors and other priority areas, but provides no specific means to accomplish this in the law.

Due to lack of immediate demand for additional density rights in some contexts, laws now provide for the saving or "banking" of development rights by a municipal authority for use in future opportunities. In effect, rather than having to assure the simultaneous availability of a buyer and a seller of TDR, the conservation of the sending areas may be compensated using public funds or grants, thus ensuring their protection– while the development rights are "stored" for future commercialization when a developer requires increased density rights. The value of tradable rights may thus be enhanced by artificially increasing their scarcity through public or nonprofit purchase and retention from the market, or the use of such rights to create conservation easements at a future time.[9] Such additional interventions may be a useful complement to the private CRA market in Brazil, as we will further discuss.

Voluntary programs allow landowners to choose between developing their properties or selling those development rights. Another mechanism used in some cases is to prohibit the use of development rights in sending areas by increasing zoning restrictions, requiring landowners sell those rights to designated receiving areas if they wish to derive additional revenue from their properties. In all cases, TDRs are set up within the context of prior environmental impact assessment and land-use planning to define those areas desirable for conservation and for intensification (Kaplowitz et al. 2008). In Brazil, unlike other cases of TDRs that have been formulated at a much smaller scale, the CRA did not benefit from prior environmental assessment to define criteria for improving its potential effectiveness.

TDR has been brought into play for prime agricultural land and ecosystem protection throughout the United States. TDR programs have contributed toward the preservation of more than 400,000 acres (162,000 ha) of land whose development was restricted through such trades and associated zoning and easements, and are now used in over 200 cities, towns and counties across the country (NJ Future 2010). Twenty-three states have been identified as authorizing jurisdictions to use TDR to implement land-use goals. The largest TDR programs include: Puget Sound, Washington (surrounding Seattle); Montgomery County, Maryland (and other Maryland suburbs of Washington, DC.); the Lake Tahoe area in California, as well as the New Jersey Pinelands and the pioneering Long Island Pine Barrens.

An interesting aspect of the New Jersey (NJ) Pinelands TDR (see Annex 1) is that it enabled communities to allocate residential growth into less environmentally sensitive areas under a threshold of total housing units (176,000) that was deemed to be the carrying capacity of the region, thus preserving endangered wetlands and highland resources. Another feature of interest is the nearly exclusive recourse to market negotiations for credits, rather than reliance on a credit bank, which carried out only two public auctions since its creation, and only pays 80% of the going market price for credits so as to avoid undermining the open market. Nevertheless, the credit bank was responsible for certifying transactions and properties in the public interest.

2.1.1 Lessons learned from conservation banking

In the United States, another major conservation application of TDRs[10] has been the creation of "conservation banks". Conservation banking developed as an alternative to in-lieu fees, which required developers who negatively impact a habitat or species to put a designated amount into a fund that supports research or conservation activities (Jakle 2013). Conservation banks instead are repositories of conservation lands that allow developers to purchase credits from setting aside lands with high conservation value, as a means to compensate for losses in such habitat on a development site. The principal types of conservation banking are wetland mitigation banking and endangered species habitat banking.

9 The USDA Natural Resource Conservation Service (NRCS) provides funding under its Agricultural and Conservation Easement Program (ACEP), for 50–75% of easement purchase in areas to be desirably retained as cropland, grasslands, unprotected forests and wetlands (such wetlands may include areas that can be feasibly restored to wetland status). To enroll land through agricultural land easements, NRCS enters into cooperative agreements with eligible partners, including nonprofit organizations. Each easement is required to have an agricultural land easement plan that promotes the long-term viability of the land. See: http://www.nrcs.usda.gov/wps/portal/nrcs/main/ky/programs/easements/acep/.

10 Mitigation and conservation banking are more like transferable development *obligations* than transferable development rights, because they are requirements that a landowner must fulfill to obtain the right to develop (Solimar Research Group 2003).

The concept of "banking" land for conservation and compensation first gained impetus with wetlands mitigation banking in the 1970s, which then spread across the US[11] and was well regulated by the 1990s (Santos et al. 2011). The legal basis for wetlands mitigation banking arose from Section 404 of the Clean Water Act that requires compensatory mitigation for unavoidable impacts to wetlands, streams or other aquatic resources (US-EPA 2014). The US-EPA (2014) defines a mitigation bank as a "wetland, stream, or other aquatic resource area that has been restored, established, enhanced, or (in certain circumstances) preserved for the purpose of providing compensation for unavoidable impacts to aquatic resources permitted under Section 404 or a similar state or local wetland regulation." A developer may not offset wetland impacts by making payments to a research fund or by any other indirect method (Ecosystem Marketplace 2014).

The number of credits generated at a bank site is related to the area of the wetland and the ecological value of the area (US-EPA 2014). It is not uncommon for fewer credits in acre terms to be available for sale than the number of acres restored (Ecosystem Marketplace 2014). Additionally, wetland mitigation banking involves a mitigation ratio, or a multiplier, which means that a credit buyer is required to purchase more credits than acres destroyed. In general, for each acre of wetland destroyed, 1 to 3 acres of restored wetland credits must be purchased, although this ratio can be as high as 1:10 (Ecosystem Marketplace 2014). As of 2013, there were 935 wetland and stream banks in the US (Jakle 2013) and the market was worth an estimated USD 1.3–2.2 billion per year in 2008, with tens of thousands of acres involved (Ecosystem Marketplace 2014).

An endangered species conservation bank is "a parcel of land containing natural resource values that are conserved and managed in perpetuity, through a conservation easement held by an entity responsible for enforcing the terms of the easement, for specified listed species and used to offset impacts occurring elsewhere to the same resource values on non-bank lands"(US-FWS 2003). Endangered species habitat banking is very similar to wetland mitigation banking, but focuses on protecting threatened and endangered species and their habitat (rather than only protecting aquatic resources). Regulatory requirements for such conservation banking arise from the Endangered Species Act, Sections 7 and 10, which require federal agencies to consult with the US Fish and Wildlife Service (US-FWS) regarding potential impact to threatened endangered species and require developers to obtain a permit if their actions may cause incidental take of listed species (Ecosystem Marketplace 2012).[12] Traded units are either an acre of habitat for terrestrial species, a linear foot of riparian habitat for aquatic species, or depending on the ecology of the species, the unit may be a breeding pair (Ecosystem Marketplace 2012). Similar to wetlands mitigation banking, there is often a mitigation ratio, requiring developers to purchase more credits than acres of land affected. Private, tribal, state and local government lands (and with special consideration, federal lands) are eligible to become conservation banks, and US-FWS species recovery plans are used as guides for determining the most desirable locations for conservation banks (US-FWS 2012).

Conservation banking for endangered species began in California in the 1990s and became widespread in the US in the 2000s, following the publication of the first comprehensive federal guidelines on conservation banking by the US-FWS in 2003.As of 2011, there were 90 active, 17 inactive and 19 sold-out banks in the US, with prices ranging from USD 3000–125,000 per acre (Ecosystem Marketplace 2012). As of late 2009, over 80,000 acres of land are under conservation easements due to endangered species credit trading (Ecosystem Marketplace 2012) and protect more than 22 species (Fox and Nino-Murcia 2005). Variants of conservation banking with the aim of further protecting endangered species have recently been developed under the name of "habitat exchange", which incorporates weighting based on performance and additional conditions associated with relative habitat functionality (see Annex 1 for further details).

11 This spread was fueled by the US Fish and Wildlife Service's support of establishment of banks in 1983 and further buoyed by the uniform guidance on wetland mitigation banking published by the US Army Corps of Engineers, the US-EPA, the US-FWS and other federal agencies.

12 The USFWS is the principal agency that administers the ESA with respect to terrestrial and freshwater species, while the National Marine Fisheries Service is the lead agency with respect to marine and anadromous species(Ecosystem Marketplace 2012).

2.1.2 Assessment of experience

The common characteristics of the TDR programs are their primary recourse to the creation of markets to manage voluntary transactions. Although transactions are voluntary, they are subject to public regulation, registry and monitoring for compliance with agreed land-use restraints. They rely on a prior regulatory setting within which property rights are well established, and in which land-use restrictions are rigorously enforced. TDRs often include the incorporation of permanent conservation easements in the sending property title. Factors that promoted greatest success included a strong impetus for regional development coupled with strict control over land-use restrictions in sending areas. Other important features have been the creation of credit banks to enhance liquidity and the simultaneous implementation of purchase of development rights (PDR) schemes (without requiring trades) to supplement market transactions. Efforts to reduce transactions costs and streamline the time needed to transfer rights have also been frequently cited in the literature as important factors for successful TDR outcomes (McConnell and Walls 2009).

Among problems cited in the literature, the most serious is that the TDR credit may not attract sufficient demand to attain a value superior to the use of the existing development rights in the sending area (i.e. opportunity cost) (McConnell and Walls 2009; Pruetz and Standridge 2009). The experience shows that creation of use restrictions beyond those generally required in a given locality are essential if additional conservation benefits are to be obtained. A related approach to promote conservation benefits and help assure "additional" conservation is achieved overall has been to establish trading or mitigation ratios to require more than one unit of land area conserved as compensation for each unit of land area developed. However, the value of a credit used for compensation should be sufficiently high to cover the opportunity costs of supplying the conservation benefits. If credit values are below or only marginally superior to opportunity costs and transactions costs are significant, landowners are likely to keep potential conservation lands out of the market. Where uncertainties reign, trading is thin. These factors establish the rationale for restrictions on trades, as well as public purchase of rights, to direct conservation towards priority sites.

Some inherent TDR scheme characteristics influence their effectiveness for environmental services provision and biodiversity conservation. If low-cost supply is plentiful relative to demand, prices will be too low to attract lands of greatest threat of loss for conservation (e.g. those closer to human settlements) to the TDR credit market, since these typically also have higher opportunity costs than less threatened areas. Since most schemes work on a voluntary basis, development rights are normally first sold by those sites that are least likely to become developed; thereby revealing an "adverse selection" of the sending zone sites vis à vis incremental conservation benefits (i.e. the least desirable or non-"additional" sites from a conservation perspective are the ones most likely to be offered into the program). This problem arises when areas not subject to development pressure offer themselves for compensation, when they would not likely succumb to such pressures in any case and thus have relatively low costs of conservation. Moreover, differences in the conservation potential of sending site parcels are usually neglected. The wetlands and conservation banking experiences in the US have required trading ratios that require more than 1:1 compensation, but this will raise costs, and not necessarily eliminate non-additional trades or account for other differences in conservation values. Habitat markets based on demonstrated improvements in habitat quality are still in the development phases.

TDR schemes are also deemed by reviewers of the instrument (Santos et al. 2011) to increase equity in land-use regulation, as development restrictions for property owners in sending zones are compensated by the return on sale of TDR credits, whereas developers in receiving zones have to pay for additional development exceeding prior existing legal limits. Most sending zone residents on agricultural lands tend to have lower incomes than those who are benefited by density enhancements in receiving zones. In a single zone scheme such as that envisaged in Brazil, more intensive use in receiving areas by wealthier landowners would compensate poorer landowners on marginal lands who (deliberately or by default) maintain forests intact.

It is necessary to consider the extent to which procedural equity has been observed in the design of TDR schemes, since some restrictions may be

mandatory, forcing trades to occur at a lower than market value. Opportunities for participation in TDR policymaking and program development as well as promises made to sending area landowners and receiving area residents, all need to be taken into consideration in appraising the equity results. Nevertheless, there could in the Brazilian case be a fundamental transfer of resources through CRA from those who have not complied (i.e. deforested in excess) to those who are above compliance limits (i.e. have deforested by less than the legal limit). In principle, this might be perceived as a fair policy: it rewards those who have historically protected forests. However, what may somewhat blur this basic principle of fairness are the changes that have been made over the years in compliance rules, such as the reduction in LR from 80% to 50% in some parts of the Amazon, or the recent amnesty provided to excessively deforesting, incompliant smallholders. In the latter case, at least past incompliance is being tolerated (but not rewarded) by the FC. However, at least we can say that, at the margin of the history of Brazilian land-use regulations, the proposed CRA system provides a step in the direction of more equitable rewards for landowners who are inclined to conserve their forests.

2.2 Instrument mixes in TDR

TDR schemes require as a point of entry the existence of a prior regulatory framework that establishes strict land-use restrictions over both sending and receiving properties (in Brazil, the national FC and the new forest legislation; in the USA and other countries, land-use zoning, primarily enacted at the local level, as well as the federal Clean Water and Endangered Species Acts in the wetlands and conservation banking cases in the USA, respectively).

A mix of instruments complementary with TDR can overcome their ineffectiveness for conservation purposes. For example, the purchase of development rights (PDR) programs typically involve an assessment of different sites and their ecological features, importance and underlying threat of development. Such PDR credits may involve external participants such as conservation organizations that purchase such credits on behalf of the broader beneficiary community, or to preserve natural values. Owners of such high conservation valued sites would then be offered preferential pricing over and above that prevalent in a TDR scheme. These programs thus often achieve higher conservation results though they may be preserving less overall area. Many TDR programs are therefore complemented by a PDR subprogram that is directed towards acquiring development rights from ecologically important sites, e.g. buffer zones or corridor parcels that are highly threatened by development (Santos et al. 2011). Another option would be to combine different types of TDR (such as habitat or wetland banking systems), or to combine TDR with a payment for environmental services (PES) scheme that provides economic incentives for carbon storage or other services.

PDR and TDR programs are seen as complementary, for example, using one program to target preservation in one geographical area, while using the other to target additional areas. Typically, however, there is a trade-off between assessing a sending site's characteristics in order to adjust permit price (e.g. in PDR-programs or by assigning a special transfer ratio in the TDR scheme itself) and the transaction costs associated with a TDR-scheme. Complex trading schemes, involving individual assessment of sending sites, were found to have substantially lower numbers of transactions, program participation and hence conservation effect (Machemer et al. 1999). Restricting trades to fewer properties on larger tracts may be one way to reduce transactions costs (Chomitz 2004). This occurs because the sheer number of transactions can impede effectiveness of trading which government must intermediate on a case-by-case basis. Furthermore, the costs of monitoring and enforcement are also increased when there are many smaller properties, which may require higher resolution imagery to track compliance.

In summary, voluntary, market-based TDR schemes have been found overall to be more effective in achieving conservation than either PDR or more complex rights purchase approaches, but less effective for biodiversity conservation. The two development rights strategies are most effective when adopted in combination. The introduction of a competitive bidding or auction mechanism is also a potentially interesting approach for selling PDRs. This feature can help reduce information asymmetry, mainly by encouraging landowners to reveal their true opportunity costs for conservation, and thus saving costs to the regulator.

Concluding this section, our review of TDR experience indicates that the following attributes should be considered to act as prerequisites for functional trading schemes:

- Secure, well-demarcated, non-overlapping land tenure;
- Areas demarcated for protection subject to compliance monitoring;
- Strong regulatory institutions that enforce land-use restrictions in both sending and receiving areas and effectively sanction non-compliant landholders;
- Reasonable transactions costs of setting up and running the system are either incorporated into market prices, or assumed by other stakeholders.

Of these prerequisites, in the case of CRA in Brazil, it is clear that without strong enforcement of the underlying land-use regulation, it is unlikely that trading (or any other form of legal compliance) will take place. Receiving areas should be under pressure of law enforcement to restore forests to the LR limits, or there will be no demand for compliance, and hence for buying CRA. At the same time, to assure additionality (i.e. greater environmental benefit than is expected from a "business as usual" scenario without the environmental regulation), targeted sending areas should be under some degree of pressure of degrading land-use change and consequent loss of environmental values in order for the mechanism to deliver an environmental improvement in the absence of additional complementary policy tools. In the next section, we review studies simulating the potential results of Brazil's CRA mechanism at national and state levels.

3 Simulation of TDR in Brazil's forest legislation

3.1 Introduction

Policy simulations in Brazil have focused on the implementation of the CRA between properties with forest in excess of the biome-specific legal requirement, and those with a deficit, in order to achieve overall compliance and potential co-benefits such as those derived from forest contiguity and conservation of critically endangered species at a bioregional or landscape scale.

Instead of reviewing actual experience with TDR instruments in Brazil, which remains embryonic and undocumented, we here summarize the principal preexisting empirical simulations of tradable LR quotas carried out at a national or subnational level. We selected nine studies, giving preference to those that had a wider scope and were more recent in realization, with special attention to those conducted within the framework of the new forest legislation (2012). However, some studies that conducted simulations before the new requirements passed into law were also included. Five had national coverage, three had state coverage (including the states of Mato Grosso, São Paulo and Minas Gerais) and one had a sub-state and local coverage (forest area of Mato Grosso and Xingu watershed in Mato Grosso). (See Table 1 for a summary of the simulations and their respective assumptions).

For each study we reviewed its objectives, key assumptions, geographic coverage, its main results, and their overall contributions toward our understanding about the potential for CRA in Brazil in terms of:

- effectiveness (for targeting areas valuable for biodiversity conservation);
- efficiency (in terms of their potential for compensating opportunity costs and minimizing transactions costs);
- equity(distributional impacts and the potential role for smallholders in the market).

In conclusion, we include a brief discussion of the results and highlight common stances as contributions to the debate.

3.2 National simulations

Sparovek et al. (2010) assessed the compliance of Brazilian agriculture with the prior FC legislation (Law nº 4.771/1965 and Provisional Measure Nº 2,166-67/2001) and identified associated challenges for agricultural development. The study applied the AgLUE model covering the entire Brazilian continental territory, based on high-resolution raster files. The model considered as private all rural land outside state and federal protected areas and Indian reservations.[13]

At this scale, Sparovek et al. (2010) estimate the total deficit of LRs at 36 million ha. The deficit varied among regions, ranging from about 8% in the southeast to 24% in the north, as well as between biomes. The Legal Amazon region as a whole has the largest deficit (about 27%)but ranges from only 1% in the Pantanal to 34% (22 million ha) in the Amazon forest biome. The authors estimated that the total national area of natural vegetation lacking legal protection (92 million ha) corresponds to almost twice the area occupied by the four principal Brazilian crops (soybean, corn, sugarcane, beans) or 1.4 times the total agricultural area excluding pastures (64 million ha).

13 The analysis was conducted with a breakdown by regions (N, NW, CW, SE, S) and biomes outside the Legal Amazon (Amazon, Caatinga, Savanna, Atlantic Forest, Pampas and Pantanal) and within the Legal Amazon (Amazon, Savanna and Pantanal).

Table 1. CRA in Brazil's Forest Code (FC): simulation model scope and assumptions

		Total assessed area of CRA demand (million ha)							Total assessed area of CRA supply (million ha)							Estimated average value for CRA (BRL/ha)	Area expected to be traded (million ha)	Total market value (Billion BRL)			
	Scenarios/ *Assumptions	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampas	Pantanal	Total Brazil	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampas	Pantanal	Total Brazil			Amazon	Atlantic Forest	Cerrado	Total
Sparovek 2010	* prepared before 2012 change in FC	22.5	0.6	3.8	8.2	0.5	0.1	35.7	7.3	23.9	41.2	9.4	2.9	7.4	92.1	--		--	--	--	--
Biofilica/ ICONE2012	Across states + PA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.8	10.3	1.9	**13**
	Restricted to states, no PA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10.2	0	4.4	**14.7**
	Restricted to states +PA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11.9	7.8	4.6	**24.2**
Soares-Filho et al.2014	*evaluated impact of FC revision	7.2	0.33	3.7	4.8	0.287	0.037	16.3	8.6	25.8	39.9	3.4	3.0	7.3	88 ± 6	--	--	--	--	--	--
Rajão and Soares-Filho 2014	1,2 - Restricted to states (+critical areas or not)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4,751 ± 1,235	4.17 (89%)	--	--	--	**19.8 ± 5.2**
	3 -Restricted to states +priority areas	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3,729 ± 908	4.67	--	--	--	**17.8 ± 4.2**
	4 - Restricted to states +PA +settlements	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,263 ± 356	4.67	--	--	--	**10.5 ± 1.6**

continued on next page

Table 1. Continued

		Total assessed area of CRA demand (million ha)							Total assessed area of CRA supply (million ha)							Estimated average value for CRA (BRL/ha)	Area expected to be traded (million ha)	Total market value (Billion BRL)			
	Scenarios/ *Assumptions	**Amazon**	**Caatinga**	**Cerrado**	**Atlantic Forest**	**Pampas**	**Pantanal**	**Total Brazil**	**Amazon**	**Caatinga**	**Cerrado**	**Atlantic Forest**	**Pampas**	**Pantanal**	**Total Brazil**			**Amazon**	**Atlantic Forest**	**Cerrado**	**Total**
Rajão and Soares-Filho 2014	5 - Across states +critical areas	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,553 ± 534	4.66	--	--	--	**11.9 ± 2.4**
	6 - Across states +PA +settlements	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,984 ± 317	4.66	--	--	--	**9.2 ± 1.4**
	7 - Restricted to states, CRA 5 years	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,917 ± 143	1.5	--	--	--	**2.8 ± 0.22**
	Total	**--**	**--**	**--**	**--**	**--**	**--**	**4.7**	**--**	**--**	**--**	**--**	**--**	**--**	**129**	**1,900 to 4,751**	**1.6 to 4.2**	**--**	**--**	**--**	**2.9 to 20**

Note: -- indicates no values were calculated by the referenced source for these columns.

Sources: Compiled from simulations reviewed (see references). PA = protected areas

According to the results, achieving full compliance with the prior version of the FC: "would have required drastic changes in agricultural land use, large areas being taken out of production and converted or permitted to revert back to natural vegetation" Sparovek et al. (2010, 6046). Full compliance with the FC might not be satisfactory in terms of either economic efficiency or environmental effectiveness due to leakage, because primary vegetation in unprotected areas is lost to agricultural production while current agricultural areas must be reconverted to protected natural vegetation (see graphic presentation in panel 1 of Figure 1). An analysis of LR compensation based on the TDR approach permitted under the prior FC (i.e. trading within small watersheds) was conducted to assess its potential to correct for this problem (see discussion under Effectiveness).

In a follow-up article, **Sparovek et al. (2012)** discuss weaknesses of what were then proposed revisions to the FC and made suggestions for improvements to the draft legislation (Substitute Bill No. 1,876/1999 reported by then Federal Deputy Aldo Rebelo), in particular to avoid the significant reduction in LR contained in the bill. Although the compensation mechanism had so far proven difficult to apply and was not frequently used by farmers, Sparovek et al. (2012) propose that compensation can promote agricultural development. They argue that through compensation, producers could make best use of current agricultural land while contributing to protection of natural vegetation on other properties. The instrument could stimulate increased conservation, agricultural development, and provide a way for Brazilian farmers to escape illegal land use.

Sparovek et al (2012) suggested amendments in the draft legislation to ensure that the LR requirements be maintained at a level that would stimulate demand for reserve compensation. If this were done, they felt actors would find it attractive to set-aside areas for nature protection promoting establishment and growth of the CRA market. Furthermore, they proposed that a suitable spatial scale for protection compensation be required so as to stimulate protection in regions where there is more conversion pressure on the vegetation.

In the same year, **Biofílica and ICONE (2012)** simulated the direction of the CRA market among Brazilian states and biomes, to focus corporate operations in key segments of the agribusiness sector. The AgLUE model and database they ran (in partnership with Sparovek's lab), considered only two market agents: cattle ranchers (with low willingness to pay for compliance) and soybean farmers (with high willingness to pay). Also, the land sales prices were considered to reflect willingness to pay and opportunity cost.[14]

Biofílica and ICONE (2012) examined the use of CRA as a means to compensate private landowners whose land had not been expropriated when public protected areas (PA) were created, a measure specifically provided for in the new forest legislation. They assumed that such trading in PA would be 20% more expensive than trading with private areas, owing to increased transactions costs from negotiations between public and private actors. However, they also estimated that 27% of the area of Pasin Brazil exhibits specific tenure problems that could be solved using CRAs. Sales of CRAs from these properties within protected areas could help solve these problems by providing finance that could be used to compensate private landowners and consolidate the status of these properties within the conservation units. The compliance options considered by Biofilica and ICONE (2012) were: first, no trading, and LR recuperation using natural regeneration (considered to have zero implementation cost, but full opportunity cost) and second, the purchase of CRA. Three CRA trading scenarios were defined: (i) trade within the states (with trades in PA); (ii) trade within the states (without PA) and; (iii) trade within biomes (with trades in PA). Market values are assumed determined at the equilibrium of the estimated supply and demand.

In the biome wide market (including PA), the Atlantic Forest emerged as the largest CRA market by value (BRL 10.2 billion) because already consolidated economic activities and low supply of marginal lands pressed the CRA value upward. In the Amazon, the presence of only a few states with potential demand (Rondônia and Pará) and the high volume of supply from other states (e.g. Amazonas) results in a low potential market value for CRA, leading to a potential market of only BRL 0.8 billion. The Cerradois is similar to the Amazon, with a total value of BRL 1.9 billion. When the market is restricted to federal states (without trades

14 Only summary data was available from a presentation made from this study, the results being proprietary, and there are no estimates provided of the area potentially brought under trades, only their gross value is provided.

in PAs), the value in the Amazon and Cerrado markets rises to BRL 10.3 billion and BRL 4.4 billion, respectively, due to tighter supplies and higher prices. When CRA from PA are included, the potential market value rises about 16% in the Amazon and 3% in the Cerrado. The potential market value in the Atlantic Forest is dependent on inclusion of PA compensation, which had not been included as available for trading. The potential value in the Atlantic Forest rose from zero to BRL 7.8 billion (with PA trading) in the state-level scenario. No area estimates were provided in the study, but were presumably compatible with those generated in Sparovek's model since they relied on the same database.

Soares-Filho (2013) quantified the change in area to be conserved or restored due to the new forest legislation (Law No. 12,651/2012), estimating the efforts needed to achieve compliance and seeking to improve its implementation so as to best reconcile agricultural production and forest conservation. Micro-watersheds (Order 12) were used as the unit of analysis, from the National Water Agency (ANA) database (166,000 units, averaging 5000 ha). Net LR and APP areas were combined and calculated for each watershed unit, not considering APPs on hilltops and steep slopes, assumed as LR.

Soares-Filho (2013) estimated total LR surplus over the new legislation's requirements at 99±6 million ha. Most of this surplus is distributed in the interior of the country, such as in the Caatinga where it is estimated at 26±1.5 million ha, and in the Cerrado, which has the largest surplus, at 40±2 million ha. There is also a concentration in the Pantanal and Pampas but this is occupied by native pastures not forests. The estimated surplus of around 20±1 million ha may be due to the prevalence of lands still in the public domain (*terras devolutas*). The surplus in the Atlantic Forest (4±0.3 million ha) corresponds to only 3% of the biome's original extension, showing its critical need for restoration.

The LR deficit was reduced by 58% with the new FC provisions, dropping from 50±6 to 21±0,6 million ha. The states that experienced the largest reduction were: Mato Grosso, Pará, Minas Gerais and Bahia. The resulting deficit is concentrated along the Amazon border, throughout the entire Atlantic Forest region and in the south of the Cerrado. The biomes with the greatest remaining deficit are the Amazon (8 million ha), Atlantic Forest (6 million ha) and Cerrado (5 million ha). The analysis confirms the potential viability of a market for CRA, showing areas which would act as a source of forest surplus and showing that is possible to reduce up to 55% of the deficits of LR (16±0.5 million ha) using surpluses from the same biome and state.

Soares-Filho et al. (2014) confirms the previously calculated (Soares-Filho 2013) impacts of the FCrevision on forest conservation in Brazil and the magnitude of the effort required to fully implement the new law. The same database from ANA with 166,000 units with a mean area of 3683 ha was used for this simulation, although admittedly, the use of micro-watersheds as a proxy for rural properties generated some degree of scaling error.[15]

The new legislation maintained the same proportional LR by biome; however, it drastically reduced the areas that needed to be restored in both LR and APP. The total area to be restored declined from 50±6 to 21±1 million ha, of which 78% encompasses LR, and the remainder APP. The authors argue that these reductions may have a large impact on biodiversity conservation and forest restoration programs, especially in the Atlantic Forest. In addition, both the FC and the new forest legislation would allow an additional 88±6 million ha of legal deforestation on private properties, with the potential to emit 18±4 $GtCO_2e$.

Soares-Filho et al. (2014) highlight the potential of the CRA market, which according to the simulation could abate an estimated 56% of the LR deficit. Forest restoration as part of the effort to comply with the new legislation could sequester up to 9±2 $GtCO_2e$. CRA and PES would be essential in the Cerrado, the most coveted biome for agribusiness expansion, given its 40±3 million ha of LR surplus. Strengthening and integrating efforts across the myriad state and federal agencies responsible for implementing the law, establishing clear land tenure, granting environmental licenses and supporting agricultural production are all needed. To function, the authors argue, this integrated system must be transparent and harnessed to economic incentives for conservation; otherwise, it might only encourage landowners to exercise rights to deforest.

15 The degree of uncertainty associated with using micro-watersheds to represent rural properties is inversely proportional to the number of properties contained within that microwatershed and directly proportional to the micro-watershed size.

3.3 State and sub-state simulations

Although somewhat dated, the **Chomitz (2004)** study expresses key insights to the potential for TDR-like instruments, examining the economic and environmental impact of alternative trade scenarios in the state of Minas Gerais, based on the regulatory provisions of the FC as applied up to 2012. A simple, geographically explicit simulation model, using aggregate municipal-level data on land use by size class of agricultural properties (756 municipalities and 14 size classes), uses a similarly simplified specification of land-use dynamics. In the model, receiving area landholders can achieve compliance either through abandonment of agricultural land to regrowth, through purchase of forest allowances (i.e. TDRs) from sellers (sending areas), or a combination of these two options. However, no restoration expenses are assumed, nor are APPs considered. Four scenarios were defined:(i) Statewide, (ii) Cerrado only, (iii) Cerradolarge-holders (only properties above 1000ha), and (iv) forests only. The scope of the TDR was limited to establishments above 100 ha as it was assumed that inclusion of smaller properties would exacerbate transaction costs.

Chomitz (2004) estimated forest cover in Minas Geraisas 13.9% of total land area, although the FC requires at least 20% in the Atlantic Forest biome and Cerrado. The great bulk of remaining forest is found in establishments of over 100ha. Surplus LR area beyond the 20% requirement represents only a small fraction of total area for all but the largest size classes. Indeed, only for the very largest size class does the surplus forest area exceed the amount of "deficit" area. In aggregate, the observation units have about 934,000 ha of surplus forest and 3 million ha of deficit area. Deficit areas are mainly found in the more favorable agricultural areas in the west and south, closer to population centers and areas favorable to agriculture. Surplus areas are found in the drier, more sparsely populated areas to the north. In the scenarios restricted by biomes, the supply would exceed demand in the Cerrado. Restriction to larger properties (above 1000 ha) curtails demand much more than it does supply, since the largest size classes hold the greatest proportional surplus. Consequently, the price drops by two-thirds, to BRL 12 per ha, but the quantity drops by less than one-third. The study concludes that trading among large properties, without biome restrictions, would promote more efficient results in terms of areas protected and reduced cost through TDR.

Bernasconi (2013) discusses LR compensation through TDR through a case study in São Paulo (SP) to evaluate the potential effects of the TDR on conservation outcomes considering both opportunity costs and ecological results as compared to a command-and-control scenario without trade. Different scope alternatives for the LR market in SP were simulated using the optimization software Marxan with zones, and their relative cost-effectiveness was evaluated. The database used was derived from the rural census (IEA-LUPA)[16], including 320,000 units of agricultural production (UPA), aggregated using a hexagonal grid of 500 ha each, totaling 50,600 hexagons. Wetland vegetation and riparian areas were added to total natural vegetation and together treated as LR. Three scenarios for compliance with LR requirements were compared: (i) command and control (no trade), (ii) trade within biomes and(iii) trade only with priority areas (sending areas prioritized by potential to improve connectivity between fragments). The Marxan software simulated LR allocation, with land sales prices being used in the model as a proxy for opportunity costs.

Bernasconi's (2013) simulation estimated that remnants of natural vegetation comprised 13.3% of all private rural areas in SP. The farm-level analysis estimated a total of 928,000 ha of natural vegetation on properties with "surplus", of which 762,000 ha of Atlantic Forest and 166,000 ha of Cerrado. There was a total of 2.3 million ha of natural vegetation on properties with "deficit", (1.49 million ha in Atlantic Forest and 801,000 ha in Cerrado). Given the legal requirement to restore deficit areas and greater costs for doing so than trading with surplus properties, there would be a basis for trade. However, opportunity costs are high: in the Atlantic Forest, with around 1 million ha of LR deficit in areas with an opportunity cost ≥BRL 10,000/ha. In the Cerrado, around 700,000 ha would ask the same or an even greater price. Comparing the scenarios, the average opportunity cost per ha of compliance in the "no trade" scenario was BRL 16,000, if "trade within the biome" is permitted, the cost is BRL 3800 and in that permitting "trade only in priority areas", it is BRL 7500. Targeting can thus reduce implementation costs.

16 For details about the database please check: http://www.cati.sp.gov.br/projetolupa/sobreolupa.php

Besides having the greatest cost and the least efficient result in targeting priority areas, the scenario without trade in São Paulo has the further disadvantage of leaving 762,000 and 166,000 ha of Atlantic Forest and Cerrado remnants, respectively, without protection by law. These areas are usually marginal lands, with very low opportunity cost and are of limited interest for clearing for other purposes. But such lands remain very important for biodiversity and ecological functions. Without trading, landowners would need to reforest extensive areas in other parts of the biome to achieve compliance. The agricultural land displaced for such compliance would result in areas already under forest coming to suffer increased pressure for deforestation (leakage).

The analysis by **Stickler et al. (2013)** aimed to: "understand the patterns of regulatory compliance over time and across changes in land-use policy, and the implications of these compliance patterns for the perceived costs to landholders and environmental performance of agricultural landscapes in the state of Mato Grosso" (Stickler et al. 2013,1). The study conducted an analysis of the FC at two levels: the forested area of Mato Grosso using micro-watersheds as units, and in the Xingu River headwaters (180,000 km^2) using registered properties as units.

The authors concluded that the FC regulations are limited in their purpose to defend public interests in private lands. In a scenario of full compliance, the change in the LR requirement from 50 to 80% imposes USD 2 to 3 billion in forgone potential present and future rents on landowners, assuming all land eligible for legal deforestation would be converted to agriculture. Furthermore, they found no success in government attempts to create procedures through which landholders who wished to comply with the law could easily do so, nor were positive incentives offered to landholders who wished to comply with the FC. The authors estimated that full FC compliance would impose a cost of USD 3–5.6 billion (in net present value of the land) for soybean and beef producers.

The study found no evidence that making the FC more restrictive (increase from 50% to 80% LR in the Amazon) had been effective in reducing deforestation. Compliance with the FC as defined in 1989 was moderate (50%) until shortly after the decree establishing the new LR at 80%(1996 ruling), whereupon compliance had declined to 10% by 2009. Compliance with such environmental regulation is highest when:"(i) the process by which landholders can achieve compliance is clear and practical, (ii) the probability of non-compliant landholders being identified is high, (iii) the probability of apprehended landholders being punished (i.e. by paying fines or facing imprisonment) is high, (iv) the costs of compliance are low and (v) there are added positive incentives for compliance. In sum, compliance is highest when noncompliance is expectedly very expensive and/or when compliance brings tangible benefits." (Stickler et al. 2013,8)

The study by **Micol et al. (2013)** simulates the potential of a CRA market in Mato Grosso based on analysis of empirical data, using an existing database of registered properties (SIMLAM/LAU[17] + CAR + agrarian reform settlements). In the remaining private rural areas of the state (excluding PA, indigenous lands, urban areas and water bodies) hypothetical property borders were derived considering the average size of the properties in each municipality. This resulted in a database with 203,000land units.

Micol et al. (2013) applied the revised FC rules pertaining to the LR using three criteria: i) size of property; ii) biome and iii) deforestation as measured up to 2001, 2008 and 2012. These three deforestation dates correspond to define FC compliance based on rules defined at different moments. In 2001, the LR requirement in forest areas of the Amazon biome changed from 50% to 80% (Medida Provisória No 2.166/2001). Only deforestation that had occurred before 2008 (according to Decreto No. 6.514/2008) could be compensated under that legal framework, while 2012 reflects most recent deforestation measured at the time of the study. Two scenarios were defined: with or without the flexibility of socioeconomic-ecological zoning (ZSEE) in the forest areas of the state, whose enactment can reduce the required LR from 80% to 50% for the purposes of restoration or compensation. Protected areas were not included in the simulation of potential CRA.

17 The SIMLAM/LAU rural environmental licensing system adopted in the late 1990s was the predecessor in Mato Grosso to the CAR as established under the revised FC.

Based on Micol et al. (2013) modeling results, in forest areas,[18] the amount of potential supply and demand for CRA are roughly equal in area terms, with 8.8 million ha of supply and 8.6 million ha of demand. In the Cerrado, the potential legally eligible supply of 8.6 million ha, far exceeds the potential compensation demand of 1.9 million ha, by a ratio of 4.5 to 1. Of the total potential supply, in forest areas only 1.7 million ha (19%) are areas subject to legal deforestation under the 80% rule, while in the Cerrado these areas represent 6.7 million ha (78%). The deficit of areas deforested illegally after 2008, which should be compulsorily recovered, is relatively small (totaling 0.3 million ha) compared to the total in both biomes. The ZSEE can potentially reduce demand for CRA in forest areas from to 8.7 to 3.6 million ha, a reduction of 60%. The potential surplus would thereby increase by about 10%, resulting in an imbalance between potential supply and potential demand. This study however only considers potential physical areas of supply and demand as a first approximation, without analyzing the economics of this potential supply and demand.

In the following sections, we appraise the potential for environmental effectiveness, economic efficiency and social equity that we see in the CRA mechanism.

18 The state of Mato Grosso is divided among three vegetation regimes, Forest – including both Amazon and areas in southern parts of the state, which exhibit tropical forest characteristics but do not lie within the Amazon biome; Cerrado and transitional Cerrado areas, and the Pantanal.

4 Considerations for effectiveness, efficiency and equity of CRA

4.1 Environmental effectiveness of CRA

An economic instrument assures greater environmental effectiveness if it ensures greater protection and/or restoration of natural resources than other options. In the case of CRA, an appropriate environmental objective would be to ensure that protected forest cover is greater than would have been the case without CRA – particularly in areas with high biodiversity and importance for provision of ecosystem services. To the extent that use of CRA is a compliance alternative for obligations to restore forests, the reduction in restoration obligations would need to be compared against the gain in forest protection along with the savings in compliance costs and other benefits from enhanced agricultural production. Biodiversity objectives could be further promoted by considering issues such as connectivity, diversity and uniqueness in CRA design. Other environmental objectives might also be included such as retention of carbon stocks or watershed protection, establishing multiple priorities. This would affect the scope of permissible trading, and would hence affect the geographical location and total area that might become sending properties, as we have seen in the use of other TDR instruments outside Brazil. Although such additional objectives may not be easily adopted in the current political processes, experimentation by state governments may demonstrate greater effectiveness, leading the way to legislative improvement.

The environmental effectiveness of TDR could vary with the spatial extent of trading. How far away from their own land should farmers be permitted to compensate their LR deficit, shopping for the cheapest available offer? If cost is the only criterion, broad scope for trading could ensure all of the least environmentally additional parcels enter the market first, since these will tend to have the lowest costs (the phenomenon of "adverse selection"). If the criterion for trading relies only on the presence of unprotected native vegetation, farmers could invest in surplus forests on sending sites far from their own land, hence greatly reducing overall provision of environmental services in a receiving area, where pressures for forest conversion will likely be higher. For example, unrestricted trading could end up leaving an entire watershed without any natural vegetation outside of diminished riparian areas because it exhibits higher opportunity costs. It may be necessary to define a minimum legal reserve limit in receiving areas, and relate this to indicators such as connectivity. If trading targets even higher environmental values or lower opportunity cost in other areas, there can also be a trade-off to be considered between local and overall national environmental benefits. From this perspective, the prior FC's uniform proportional reserve requirement within biomes (without trading) may be considered environmentally ineffective for two reasons: it does not prioritize forest cover in areas where there is a high degree of endemicity of species and ecological communities; and it tends to result in fragmented forests (Chomitz 2004). This also threatens species that require large contiguous habitat areas to support viable populations. Loss of some of these species, especially seed dispersers, pollinators and predators, can disrupt the ecosystem as a whole and threaten its long-term survival. In addition, fragmentation greatly increases the forest perimeter exposed to edge effects. Since surplus areas will most likely be found on larger properties where commensurately large fragments are prevalent, Chomitz expected that trading would permit greater connectivity to be maintained, since most surplus areas in his study of Minas Gerais were found on large properties. In the Amazon biome, a LR of 80% often implies that agricultural activities rather than forests may end up being fragmented, with adverse economic implications. These two examples denote the need for a regulatory approach that considers the entire land-use mosaic.

While trading over a larger area can ensure greater opportunities for such connectivity, Sparovek (2010) stated that large scope LR trading fails to address problems related to water and natural vegetation conservation in areas having a severe LR deficit. For instance, the unprotected native Cerrado vegetation outside the Legal Amazon (27 million ha) is much larger than the LR deficit Sparovek (2010) estimates in the same biome (2 million ha), implying that if only the farmers in this area are allowed to compensate for their deficit by protecting native Cerrado vegetation, less than 10% of the presently unprotected vegetation could become protected by this means. Allowing farmers in biomes such as the Atlantic Forest, where significant unmet deficits exist, to trade with Cerrado properties could increase protection, but investments in protection far from the sending area would not address problems related to water and natural vegetation requirements in receiving areas with a continued, yet then legalized LR deficit.[19]

Sparovek (2012) further argued that although the revised legislation may solve farmers' illegality problem, it is not effective in promoting conservation that is "additional" to what would have otherwise occurred. Under the current situation, with rampant disrespect for the FC, relatively few areas in lands with a high opportunity cost for production remain under forest. There is a risk that, given the prospect for broad trading and widespread reduction in liabilities, achieving compliance with the new legislation would be low-cost, allowing low-productivity agriculture (e.g. extensive cattle ranching) to continue to expand while promoting little restoration and real forest conservation. We could come to see a picture where, since CRA supply potentially exceeds demand by a factor of 8:1, high-value crop sectors (e.g. soybean, sugarcane) seek CRA compensation, but far from their origin of intensively cropped areas with the greatest deficits.

Under a contrasting scenario where the FC in its prior formulation (without reduction in liabilities) is effectively enforced, Chomitz (2004) argues that broadening the geographic scope for trading can substantially increase the potential for forest conservation. The incentive for and benefits of trading require differences in both forest cover and land values. Traders would be able to find properties with greater contiguous forests to fulfill their deficit more easily and cheaply if they have a greater scope for trading. While there will be some local variation in these factors, larger gains from trade may be obtained over greater distances. His analysis showed that substantial scope for trade could arise even under the extreme assumption that intra-establishment and intra-municipality trading arrangements had been maximally exploited. Because surplus and deficit areas tend to be distant from one another, restricting the sphere of trading to small administrative districts would probably restrict this potential, as in the extreme case of the prior FC limiting trades to micro-watersheds. Smaller territories would also increase the homogeneity or substitutability of the forest areas involved, but fewer trades would occur.

Simulation results for São Paulo confirm this hypothesis, indicating that adoption of a constraint for trading only within biomes within the state would produce an outcome which does not fully reflect ecological priorities, since the scope for trading would be overly restrictive (Bernasconi 2013). A complementary problem arises with targeting for environmental assets. Only 16% of the areas selected for LR in a biodiversity-targeted trading scenario in São Paulo coincided with those selected as lowest in cost, meaning that the priority areas for conservation would not be selected by the market when the criterion is solely economic (Bernasconi 2013).

The feasibility of monitoring and enforcement between distant trading units was called into question (personal communication from B Soares-Filho, 2014), as a factor that could undermine the environmental effectiveness of the instrument. A buyer of CRA may have no contact or knowledge of the surplus area that is the object of trading, and will likely rely on the state government in the sending location to ensure that the proprietor of the reserve maintains it. Once he receives the payment, the owner of the sending area (or the state government of that area) will have no further incentive to protect the area that is the object of the trade unless the land-use restrictions established in the PRA are effectively monitored and enforced. One could imagine a system where the seller would be forced to replace a CRA that

19 It is conceivable that part of these requirements could be met by the legislation's requirements for APP conservation, even where LR requirements are met through compensation. There is no treatment in the legislation for the minimum requirements for natural vegetation maintenance within receiving areas. Such thresholds would need to be addressed on a case-by-case basis by state environmental agencies.

is invalidated, potentially with a penalty ("buyer liability" is also a possibility in principle but this is not how responsibility is assigned in the FC). In any event, strong monitoring and enforcement will be crucial for the environmental effectiveness of the CRA program and for creating incentives to ensure forest protection in sending areas. Soares-Filho further affirms the undesirability of trading with other states if this would transfer the burden of monitoring elsewhere, with little or no control from the receiving zone.

The basic tools for monitoring and enforcement are in place through the SICAR and state-developed GIS where these have been adopted (personal communication from G Sparovek, 2014). If these are put in the public domain and both civil society and government enabled to monitor compliance and permanence, distance from the source of a trade would not necessarily impede effectiveness. The matter seems to depend on what type of institutional arrangement is chosen to administer the CRA trades, monitoring and compliance – and how robust it is to large-scale dimensions that transcend the borders of federal states.

4.2 Economic efficiency

Economic efficiency is the centerpiece of any TDR type of mechanism. While all authors thus agree with Chomitz (2004) that TDR represents an economically more efficient solution for an overall conservation target in the landscape to a fixed LR requirement without trading (assuming sending areas represent equivalent conservation), it is also evident that TDR programs generally suffer from high transaction costs (Stavins 1995). Transferring TDR credits requires considerable administrative and legal effort. Perhaps most importantly, there are significant monitoring and enforcement costs. For the program to be effective, it is necessary to ensure that property owners are in compliance and that TDR units are genuine and used without duplication. This requires a system for property inspection, a TDR registry, and an effective set of legal sanctions. Too much restriction in scope for trade would reduce cost heterogeneity and the possibilities of arbitrage, including the margins necessary to sustain intermediaries necessary to make a trading system work.

The CAR environmental registry established through the new forest legislation in Brazil, along with its requirement for development of a state program for environmental regularization (PRA) set the framework within which the CRA system is expected to operate. The possibility that such a system could be automated, facilitating demarcation of tradable areas and signaling land-use changes, could reduce the costs of monitoring and enforcement. The sophistication of the initial SICAR system is limited, but its potential for serving as a basis for trades is considerable, requiring further capacity building at a state level. Notably, the set-up of a system might take time. If trading is allowed to happen in this early stage, and trades are approved where landholders have submitted transactions with overlapping boundaries (to be expected especially in the less developed part of the country), the resulting inconsistencies and conflicts may be hard to resolve *ex post*.

Transactions costs were not estimated in any of the Brazilian simulations reviewed, although a number of cost estimates for registry under the CAR have been performed (e.g. Azevedo et al. 2013). In the TDR experience in the United States, high transaction costs as well as administrative and legal costs have been documented, despite efforts to facilitate market creation (Reid 2007). Despite this caution, the CRA option has already attracted market actors seeking to reduce the costs implicit in matching deficit demand with surplus supply. The *Bolsa Verde* of Rio de Janeiro (BVRio), a nonprofit environmental asset trading advisor operates a web-based platform that permits market actors to identify suitable partners for CRA transactions, providing greater transparency.[20] According to the managers of BVRio, all the market requires to operate well is an appropriate regulatory framework, with minimal red tape. In this case, the effective implementation of the state CAR registries and their respective plans for compliance under the PRA should be sufficient. They cite market interference by regulators as a factor that had limited the efficiency of other environmental trading schemes, such as the carbon market (personal communication from P and M Moura Costa, 2014). But market creation requires a regulatory and administrative structure in place. Roles and responsibilities for the PRA and CAR have been left to the states that also would assume the burden of monitoring and enforcement. It is not clear where the additional revenues required to manage this demanding task will come from.

20 www.bvrio.org.br; see Figure 3.

Figure 3.Website of BVTrade, an online platform for trading in CRA and other environmental assets.
Source: http://www.bvtrade.org/

The geographical scope of trading is another important area for efficiency improvement. While Sparovek et al. (2012) found fault with the previous version of the FC, through which compensation was applicable only if the area assigned for protection were located in the watershed where the LR deficit occurred, they asserted that biome-wide trading could be excessively ample. There is a trade-off between restricted trading to optimize local ecosystem services and potentially reduce monitoring and enforcement costs, and broad compensation to make up for the absence of forest land eligible for compensation protection where the deficits occur. Trading restrictions will create scarcity and increase costs to buyers, but can maintain ecosystem service provision in areas close to receiving zones. Under a biome-wide scheme, farmers would be able to cheaply compensate landowners in areas covered with natural vegetation in remote regions with low suitability for agriculture and low risk of becoming subject to deforestation or other degradation. Regions experiencing agricultural expansion are likely to have higher opportunity costs, so more restricted opportunities for trade will apply. As noted above, much of the forest areas used for compensation would come from areas where the conversion pressure is low, and little would come from regions experiencing agriculture expansion where the sale of CRA would more effectively contribute to nature protection.

Restricting trades, however, would come at the expense of reducing potential efficiencies in terms of optimizing the location of both agricultural production and nature conservation. In contrast to Sparovek's opposition to large-scope trading, Bernasconi (2013) found that trading at the biome level, within the state of São Paulo, would provide for greater cost heterogeneity among LR protection options while ensuring lower overall cost of compliance than a no-trade option. The inclusion of the TDR allowing trades within the biome reduced the compliance costs for an equivalent area of new LR protected by 76% compared with the scenario without trade. Although the inclusion of a new constraint targeting priority areas for biodiversity almost doubled the cost (+95%) compared with the scenario of trade constrained only by biome, it was still 50% less costly than the scenario without trade, under which landowners would have to engage in costly reforestation or somewhat less costly regeneration. This is because the opportunity costs of land

in receiving areas was considerably higher, so gains from trade were obtained even when the trading areas were restricted to priority areas for biodiversity protection. The study shows that the implementation of the CRA could reduce costs without neglecting conservation of priority areas.

Another factor that may affect efficiency is the provision in the new forest legislation that trading can also be conducted to regularize public property over protected areas. Biofílica/ICONE (2013) found that using areas of PAs within states to generate CRA and the potential to trade outside one's state significantly increased the scale of the market. In the Atlantic Forest, where the market is thin because of insufficient LR surplus, the PAs alone could play the role of suppliers. Although this approach may be one way out of the problem of missing opportunities for trade in critical watersheds identified by Sparovek (2012), it may be of questionable efficiency if the objective of the legislation is to ensure natural vegetation is maintained within private land areas subject to agricultural conversion pressure. If the market for CRA was dominated by trades from PA it would have low additionality, in the sense that those areas are already legally protected, and would be used to replace areas that potentially could be restored. There is an enormous backlog of uncompensated private lands within areas later demarcated as parks or reserves. If the CRA were to contribute funding to offset this backlog, it could be of broad social benefit, easing long-term conflicts.

The market with a narrower scope (within states – even when including PA) may be reduced in potential trading value (in the Biofílica/ICONE simulation it dropped by nearly a half from a total of BRL 24.2 billion to BRL 13 billion), However, some states may prefer this option. According to São Paulo's environmental administrator (personal communication from H Carrascosa, 2014), trading to PA would not be as desirable as identifying priority areas within agricultural landscapes where opportunity costs are higher, and promoting degraded land restoration. Both she and Marcio Santilli (personal communication) cited cases in which PA were created by landowners on marginal lands in São Paulo as a means of ridding themselves of environmental liabilities, but then placed the burden for maintenance on local governments. They did this to avoid the costs of permanent easements and associated protection requirements on their own properties, externalizing these costs to the public through protected area creation.

Several interviewees were concerned that the considerably higher costs of forest restoration combined with opportunity costs of land would result in abandonment of this option in favor of cheaper CRA trades. In the Atlantic Forest, native species in regeneration cannot be managed for forest products, while exotics can be planted and put under management, making the former approach undesirable to landowners. Soares-Filho et al.(2014)suggests that, at least with respect to land availability, the concern that forest restoration competes with agricultural production is unfounded. They suggested that pasturelands unsuitable for agriculture (with a lower opportunity cost) would be preferable as targets for restoration. If this were done, only about 550,000 ha of required restoration would remain on arable lands. Planted forest species may also become a source of revenue, making restoration more attractive.

In looking at the Amazon region, two simulation studies done in Mato Grosso agree on several aspects. Micol et al. (2013) make an important distinction between the LR surplus that is subject to legal deforestation and the part of the LR that is protected by law (up to the legally restricted proportion). In Mato Grosso, deforestation on areas affected by the increase in the LR from 50% to 80% in 1997 was considered illegal, imposing what many farmers considered an unfair burden. Stickler et al. (2013) estimated that the change in the law through the increase in the LR requirement represented an opportunity cost of foregone rights to clear forest of up to USD 3 billion in potential rents from soybean farming or cattle ranching if all the lands would be converted. The opportunity costs of conserving the remaining forests declined over time as landholders illegally cleared their private forest lands, leaving fewer forests to be conserved. Whereas under the prior FC, these illegally deforested areas were treated as environmental liabilities, the new legislation exempted farmers from much of the restoration burden throughout Mato Grosso's forest biome by 12,000–18,000 km^2. The cost savings over the previous regulations would be about USD 2.5–3 billion in restoration expenditures, nearly equivalent to the opportunity cost attributed to the former environmental restrictions.

In addition, the provision for trading further reduced the opportunity costs of remaining restoration requirements by allowing farmers to purchase CRA from properties in the state with

surplus LR area. Purchasing the deforestation rights in lieu of reforesting on-farm could lead to an overall savings of USD 1 billion or more.[21] This however could undermine the potential that the law may act as an incentive to increase forest cover. Some areas subject to legal deforestation have opportunity costs significantly higher than other areas that remain under conservation. The lands remaining to be legally cleared under the new legislation have potential for soybean or beef production of approximately USD 370 million in net present value terms, and will very likely be converted for these purposes. The prospect that such areas would be purchased for conservation is negligible, given the availability of lower cost properties at the forest frontier. If such areas are used for compensation instead of on-site restoration, the overall impact in terms of increasing forest cover will be reduced, relative to the case without trading.

In summary, efficiency in CRA implementation will be related to the scale at which trades are permitted, the inclusion of protected areas and the relationship of opportunity costs of potential sellers to the restoration costs of potential buyers. High transactions and monitoring costs imply friction that may impede efficiency and restrict trading.

4.3 Equity concerns

The new forest legislation (paragraph §4 of Article 44, Law No. 12,651/2012) stipulates that smallholdings (up to four fiscal modules) can also issue CRA titles. Regulation of the CRA under this paragraph still depends on implementation of specific legislation by each Brazilian state. Although small properties could play a key role in the CRA market, only 17% of their area has been registered as fully titled property (Soares-Filho et al. 2014). This implies a major challenge to ensure the participation of small properties in the CRA market (besides that associated with transactions costs), given the requirement that issuers of CRA hold regularized property rights as titled landowners.

The interviewees agreed that the blanket amnesty on requirements to restore prior illegal deforestation for properties smaller than four fiscal modules was responsible for most of the reduction in the potential CRA demand. At the same time, the possibility of issuing CRA using all remaining vegetation on such properties – rather than only the LR based on the current biome-specific limits – was responsible for a substantial share of the increase of potential CRA supply. Smaller tracts now have no historic liabilities, but they are still subject to the rules governing future land-use change, and are enabled to trade any area remaining on their properties going forward. Micol et al. (2013), for example, highlight that agrarian reform settlements and small farms on up to four fiscal modules have a total of 6.7 million ha in potential supply of CRA in Mato Grosso alone, representing 54% of the total supply in forest areas[22] and 28% in the Cerrado. Of this total, 1.4 million ha (21%) would be permitted to deforest, since they exceed the requirements of the new FC.

Furthermore, while under the prior FC, the surplus supply could only be used to resolve up to 50% of the deficit in receiving areas, under the new forest legislation, CRA can compensate for as much as 92% of the LR deficit, according to a quantitative estimate based on the legal provisions (personal communication from Soares-Filho, 2014). This means that very little restoration will be needed to achieve compliance, depending on the costs of CRA. So, allowing for broader use of CRA, a move thought initially to address an equity issue since liabilities of smaller properties were removed, could result in reduced total economic value of the CRA market due to the heavily increased volume of supply, as well as the eliminated demand from smallholders. Low CRA values in turn mean low compensation for landowners who have maintained standing forests in excess of legal obligations. The fairness concern to favor smallholders thus comes to trade off against another fairness concern to adequately favor historically conservationist landholders.

Having clear land tenure rights is a fundamental requirement to issuing CRA, which could lead to the exclusion of small landowners since so few of them have clear land tenure. Tenure insecurity will also affect larger properties in regions such

21 In 2009, the surplus area remaining under forest in LR able to be legally cleared and, therefore, available for such a trade was 8646 km^2. Under the 2012 legislation, this trade would reduce the restoration burden to approximately 75,000–68,000 km^2. This would reduce the direct costs of restoration (i.e. outplanting) by approximately USD 8 million. The opportunity cost could be reduced by approximately USD 585 million (Stickler et al. 2013).

22 This refers to forest areas of Mato Grosso, which are defined as those in the Amazon biome, transitional ecotones and other forests surrounding the Pantanal.

as the Amazon. The rules for registration in the CAR permit untitled properties to initiate their regularization, as a first step in full property rights recognition. The CRA, however, does not permit trading until the area to which quotas apply is delimited within a legally registered property title (§1 of Art.45 of Law 12.651/2012). The law further defines that any additional deforestation that occurs within the area so delimited is a liability of the seller, not the buyer.

Furthermore, the sheer number of small properties creates a challenge for bringing these properties to market at low transactions costs. One possibility foreseen by several interviewees to overcome transactions costs is for private groups (representing investors) or public agencies (e.g. local governments) to act as "aggregators", in order to provide technical assistance and promote scale. In the state of Espírito Santo, where nearly all properties are under four fiscal modules, the state legislation determines that each property must register its LR and enjoys technical assistance from the state government, but this is an exception to the rule (personal communication from R del Valle, 2014).

Chomitz (2004) considers that creation of a TDR system in Minas Gerais will tend to generate rents for properties that are very large in area but are far from being the wealthiest, since they are generally in areas of poor and unproductive soil or remote access, serving primarily as a "reserve of value." This group accounts for less than 20% of Minas Gerais' landholders, but more than three-quarters of the total area. If only large landholders participate due to transactions costs, this only slightly reduces the estimated amount of forest placed under protection. Further attention is warranted for the distributional implications of such a situation, however.

4.4 Complementary instruments in the policy mix

Micol et al. (2013) found that the effectiveness of the potential demand for LR trading in Mato Grosso will depend upon enforcement of the legislative requirements by the government (through command and control), by the supply chain (imposing restricted access to markets) and by the financial sector (imposing requirements to access credits). This observation can be generalized to Brazil.

Market instruments such as TDR require that demand be stimulated by regulatory imposition of a cap or minimum reserve requirement (Barton et al. 2011). The environmental protection provided by such a system lies in the cap (Vatn et al. 2011), so they are only feasible in contexts where direct regulation is in place and is adequately enforced. In the Brazilian case of CRA, this is an essential issue since this instrument has never been fully implemented due to lack of demand. Although improvements in command-and-control environmental enforcement over the last decade can take credit for the drastic reduction in new Brazilian deforestation since 2004 (e.g. Börner et al. 2014), the deficient enforcement of the prior FC has made accumulation of non-compliant liabilities more of the norm than compliance. The new legislation brought with it the expectation of a clean slate for an increased enforcement of the law, and has thereby led to increased interest in compliance. This makes more urgent the need for a better design for implementation of the instrument. The possibility to link this market to the emerging REDD+ mechanism and to PES, which could provide increased sources of demand for forest protection, also merits closer consideration, given the guarantees offered by the CRA registry for permanence of standing forests (personal communication from Rdel Valle, 2014).

The addition of the CRA to the existing command and control apparatus could represent a weakening of that structure, as it leads to the possibility that critical areas for restoration of degraded forests are compensated cheaply with CRA that may not deliver the same environmental benefit. First, CRA may come from unthreatened lands far from the areas where such coverage is most needed. This suggests the need for complementary incentive policies along with certain well-designed restrictions on trading – so as to target trades to priority areas for conservation as well as assure that at least part of the deficit is made up through receiving area restoration – while at the same time maintaining sufficient liquidity for the CRA market to function. Even if compensation occurs with CRA from lands under threat of deforestation, ensuring sufficient monitoring and enforcement so these areas indeed remain protected is another critical concern.

Financial incentives could also be brought to bear to increase the provision of forest conservation and restoration benefits through a well-targeted purchase of development rights and/or PES system,

for example. Financial incentives could also be used to ensure more complete compliance, and possibly create a more equitable distribution of costs of compliance and foregone development options (Börner et al. 2015). The costs of completing CAR registries, structuring CRA titles and trading all imply additional transactions. Since trades are voluntary, the financing of CRA purchases and/or restoration costs by the banking system represents an important prerequisite to compliance. The very structuring of the CRA market remains disputed territory, with some states such as São Paulo, seeking to establish trading platforms through the stock and commodities exchange BOVESPA, while the federal government insists on a single titling system through the Central Bank.

Certification systems that regulate agricultural production aimed for specific markets can also contribute positively by increasing demand for compliance and environmental effectiveness. However, the risk of leakage effects following from strict implementation of rules, in the absence of corresponding agricultural intensification on already-cleared areas, needs to be considered; under the prior FC, full compliance could have resulted in presently unprotected natural ecosystems becoming converted to farmland in order to compensate for lost agriculture production. Leakage is an equally valid concern in relation to certification systems, depending on the size of the geographic region under consideration. Finally, certified production may not be an option for producers who lack the capacity to meet the requirements (on some aspects of the production and for monitoring, accounting and reporting).

The federal government should provide better general criteria to be applied at a national level. States and their environmental agencies must assume their roles as organizers, regulators and monitoring agencies of the TDR. Some states have already developed local level systems of property database management that have shown to be a key in subsidizing land-use and conservation planning, to ensure that the transaction costs for private actors for the CRA will not be prohibitive.

Soares-Filho et al. (2014) asserts that the first crucial challenge is to convince the agribusiness sector of their potential gains from the new forest legislation. Although law enforcement activities have intensified in recent years, the agribusiness constituency has always taken advantage of the government's relatively weak enforcement of environmental laws. One particular strategic question is how the cattle ranching sector will react to the new law, given that pastureland by far outnumbers cropland in Brazil and the bulk of production is for the domestic market. An amnesty afforded by the new forest legislation could lead to the perception that illegal deforesters are unlikely to be prosecuted, and may even be exonerated again in future legal reforms. To meet this challenge, Brazil must continue to invest in its monitoring and enforcement capabilities. Satellite-based deforestation monitoring systems maintained by the National Institute for Space Research (INPE) need to be expanded to other Brazilian biomes and adapted to detect subtler land-use changes, including forest degradation and deforestation in savannahs, riparian forests, and small remnants of the Atlantic Forest.

5 Summary and conclusions

Based on our review of experience with TDR instruments in the United States, it is clear that the strength of such environmental markets is dependent on the scope of tradable land rights and the existence of sufficient demand for land-use quotas. If the local market for trades is soft, or confined to an overly restricted area, prices may need to be stimulated through banking or complementary purchases of development rights. Overall, the most important factor is the existence of enforceable zoning codes in both sending and receiving areas that make trade necessary to achieve landowners' development objectives. It may be necessary to establish thresholds on growth in sending areas so as to increase the value of TDRs for receiving area proprietors. The presence of a TDR "bank" or depository involving public purchase of development rights and later release to the market when demand materializes represents another potential component in the success of TDR systems.

Most of the studies on the potential of CRA in Brazil concur with international experience that the ecological effectiveness and the economic viability of the mechanism are strongly associated with the scope of the market. Studies that compare different scenarios conclude that the wider the scope, the greater the possibilities for trade. Also, the costs for buyers will be lower and the total volume of the market will be higher. Wider biome-wide trading could reduce prices and overall market value in the aggregate (Biofílica/ICONE 2013). In addition, as Sparovek (2012) cautions, too broad a scope for CRA trades will result in loss of ecosystem functions.

Since Brazil is an immense country, as are the biomes it covers, allowing the market to span an entire biome can result in concentration of conservation in areas where there is low risk of deforestation due to the low suitability for agriculture or large distance from market. Protection of these already passively protected areas would imply zero environmental additionality ("hot air"). Also, there are many different typologies and ecosystems within the same biome that could end up being underrepresented. The prospect of targeting trades to better respond both to opportunity cost variations and environmental criteria should be contemplated within the realm of states' priority-setting, as defined by the complementary regulations issued in May 2014. Modeling of deforestation threat associated with the presence of roads and the influence of slaughterhouses applied in scenarios constructed by Soares-Filho et al. (2014), should become part of such a strategy.

Studies show that when the trading scope is heavily restricted– as in the current law which permits trading within biomes but sets priorities for trading beyond state lines– some biomes and states such as those in the Atlantic Forest and Caatinga have low prospects for environmentally effective trades. This is either because there is lack of supply of surplus forest areas, eliminating the potential for trading, or there is a substantial excess of supply, relative to the demand. An excess of low-cost supply in the market could result in low prices for CRA from these forested areas, reducing incentives and failing to discourage legal deforestation.

This implies that there is a trade-off between a wider scope with lower opportunity costs and greater volume of transactions, enabling the market in some locations, and a narrower scope with more local ecological effectiveness in other locations and greater potential for targeting of priority areas for conservation. The trading system will probably need a 'helping hand' from regulators to achieve a balanced set of objectives. Pre-trade simulations and live trial-and-error adjustments of the system can help to inform the process. Creation of a complementary federal "bank" or purchase of development rights program to help manage interstate transfers is another possibility.

Another important point raised by the studies is the differentiation between the "surplus" that can be legally deforested and that which cannot but can still be sold as CRA due to different rules for properties under four fiscal modules in size and to the presence of ecological-economic zoning under the new legislation. By definition, these have different opportunity costs. In a market with excess supply from non-additional areas, this difference means that part of the surplus that can be legally deforested will be converted, in the absence of strong additional conservation incentives. In this case, the market for CRA will play the role of compensating some landholders for giving up the option to cut down part of their forest, but it will probably not avoid all new deforestation. Besides this, the Atlantic Forest biome presents opportunity costs that are differentiated from those in other parts of Brazil, as the Atlantic Forest Law[23]places a total ban on deforestation there.

The potential impact of the instrument in terms of effectiveness for conservation may have been further diluted with the decree of 5 May 2014,[24] expanding the concept of "priority area" that could be used for compensation outside a given state. This resulted in an additional increase in the potential supply that, summed with the large reduction in potential demand (caused by the 2012 legislation), can reduce the ecological effectiveness of the CRA. This increases the likelihood that CRA will be issued only in very marginal lands with low opportunity costs and threats of deforestation.

Following the same argument, if the market were to be dominated by CRA from protected areas, as simulated by Biofílica/ICONE (2013), it would also fail to lead to new additional protection because those areas are already protected and will be used to reduce requirements to restore lands in other areas. To balance this, states should consider devising their environmental regularization programs (PRA) with a selection of priority areas within the state. This will be important to guarantee that surplus forested areas within the state will be valued and reduce the risk that they will face deforestation.

When discussing the efficiency of the instrument, the studies and interviews point out that the implementation of a market for CRA can add monetary value to native vegetation conserved on private properties. But none of the simulations calculate the transactions costs involved. Most recognize the literature that states that such costs are high and sometimes prohibitive, but this aspect still demands more empirical research. Publicly supported credit banks could be another option to enhance liquidity, as in some US-TDR cases. The only hypothesis discussed (but not tested) is that the wider the geographical scope of the market, the greater the costs of monitoring areas and enforcing the functioning of the system when buyers and sellers are far away from each other, e.g. in two different states.

Most interviewees agreed that the value of CRA would be insufficient to cover the opportunity costs of crop production, although it may compensate for natural regeneration in marginal pastures with low productivity. So the sale of CRA from sending areas may act more like a consolation prize for those who preserved more than what was required by law, as well as those smallholders who did not clear all of their forests. Some interviewees (Carrascosa, Valle) mentioned the duration of the contracts as a key variable for economic efficiency. Some landholders were more interested in temporary rather than permanent easements, due to the possibility of changing the status of the area later if the value of the CRA was no longer of financial interest. Although such easements were not often created under the prior FC due to insufficient threat of enforcement, this option may become more popular under the current legislation.

A few of the studies addressed the distributional and equity aspects of the CRA market. Transaction costs can exclude much of the smaller properties from the market. Although the law specifically requires states to provide technical assistance to small farmers in registering in the CAR and issuing CRA, there is much more to be done to ensure that these properties will be able to participate in the market and receive financial compensation for their forest areas. Because most small landowners lack formally titled land tenure, they would be unable to issue a CRA. One possibility foreseen to support their participation is to stimulate agents to work as "aggregators" to provide technical assistance and promote scale.

23 Law No. 11,428/2008.

24 Article 16, Decree 8,235/2014

Two points mentioned in Chomitz (2004) have a bearing on equity. First, a market restricted to larger properties tends to have lower average transaction costs because such landowners have greater ease in dealing with the bureaucratic vagaries of such a market and their lower number represents a reduced administrative effort for public authorities. Second, a restriction to large properties could be more effective for conservation because those properties concentrate most of the surplus area (especially larger fragments) and also usually reckon with supply chain pressure on the demand side. These factors would thus have to be weighed against the concerns over smallholder participation.

The new forest legislation changed the rules for surplus calculation in order to address distributional implications of the LR requirements and give more advantages to small and medium properties (up to four fiscal modules). Some studies show that smallholders and settlers could strongly participate in the supply of CRA (and no participation in demand, by definition). However, this prospect is as yet untested in practice.

Ultimately, one point often cited in the studies is the institutional feasibility of monitoring and enforcement of such systems. The CRA market, as any TDR system, requires a robust registry system and also a well-functioning monitoring process in order to operate. This is particularly the case where there are different states and different systems that must be integrated. The importance of enforcement is crucial: without pressure from government, banks and the supply chain to push the landholders into LR compliance there won't be any demand and therefore no market. The credibility of monitoring and sanctions of incompliance is thus a vital precondition for whether the system will work or not.

In conclusion, what the studies and interviews show is that, despite the high expectations that are being placed on the CRA in the context of the new forest legislation, the potential of the market to create meaningful conservation incentives has been undermined by amnesty, reduction in liabilities and, at least in some regions, the permission for interstate trading. The CRA is by no means a panacea that will solve all of the problems of forest conservation on private lands in Brazil. To become effective, CRA must be used in combination with other instruments, not replace them. In fact, other instruments to compensate landowners for adopting better practices and protecting remaining forests, such as differentiated credit or payment for environmental services may be more environmentally effective than the CRA – an instrument at present more designed to reduce the cost of legal compliance – although there might be important synergies among all these instruments in the future. Above all, the effectiveness of the CRA will depend on the effective monitoring and enforcement of the land-use restrictions in the forest legislation, alongside continued efforts to motivate restoration of degraded sites in the productive landscape.

5.1 Considerations for further research

Our review of the potential concerns and opportunities associated with implementation of the market for CRA in Brazil does not exhaust the issues stimulated by this debate. To provide a more complete assessment, a number of matters have emerged as deserving further research, which we enumerate as follows.

1. How could trading ratios afforded to those who invest in CRA derived from areas with different deforestation pressures be adjusted, as a means to target results of trading to enhance forest conservation? How could such trading ratios be adjusted, as a means to target results of trading to enhance biodiversity conservation? How might an environmental benefits index (such as adopted in the conservation reserve program in the US) perform in this context?
2. To what extent will permission of CRA trading to protected areas and/or across states affect the potential for forest conservation, restoration and associated environmental values?
3. What positive incentives are required and/or what complementary restrictions need to be set on trading (e.g. different weights of sending vs. receiving area units), so as to assure that at least part of the deficit is made up through receiving area restoration
4. Should differentiation of environmental values not be politically or technically viable, the opportunities to establish restrictions by state and type of properties should be considered. What would be the cost and market scale implications of such restrictions for buyers and sellers, and their effectiveness, efficiency and equity implications?

5. What level of enforcement and penalties for noncompliance are needed to ensure adequate demand for compliance, including via CRA?
6. What prospects exist to link CRA compensation to the emerging REDD+ implementation strategy and to payments for carbon and other environmental services?
7. What are interactions of CRA with voluntary corporate supply-chain governance initiatives for zero-deforestation agricultural commodities as well as broader industry initiatives such as the soybean moratorium and the zero-deforestation cattle agreements?
8. How might the option for temporary easements for CRA trading affect the permanence of standing forests or their restoration? What would be the cost implications of such restrictions for buyers and sellers?

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Annex 1. Description of US TDR programs

TDR has been used effectively to allow density increases in residential developments, so as to allow prime farmland and conservation areas to be preserved. TDR was used notably since 1993 in the Long Island pine barrens of New York State (NYS). Trades occurred from 52,200 acres [12,133 ha] (principal sending areas) and adjacent 47,500 acres [19,223 ha] of compatible growth areas (less restrictive sending areas), to protect a regionally important aquifer serving 1.8 million people. Three townships in Suffolk County, NY (Brookhaven, Riverhead and Southampton) are involved in the plan, which registered 737 parcels as perpetual conservation easements, and established a pine barren credit (PBC) clearing house to transact these instruments through auction. Receiving areas were designated through townships' comprehensive zoning plans. By NYS law, receiving areas must also show municipal services capacity to absorb the additional residential density. By 2013, 745 transactions had occurred, and the PBC value (averaging 2.5 ac [1.01 ha]/parcel) had risen to nearly USD 65,000, for a total value over USD 33 million.[25]

A similar TDR scheme was created in New Jersey's (NJ) Pineland National Preserve in 1985, in four counties overlying the critical Cohansey aquifer that covers 1 million acres (nearly 405,000 ha). Landowners in downzoned areas were offered the opportunity to market Pineland development credits, and to restrain use to agriculture, forestry, fish and wildlife management, and low intensity recreation. Each credit represents 39 acres (15.8 ha) of upland agricultural land (or 2/10 credit for 39 acres of wetlands), each credit being tradable for one additional residential unit in receiving areas in less restricted areas of the pineland region. A Pinelands development credit bank – DCB was created to register and facilitate transaction of these credits,[26] and one municipality created a local development credit exchange, permitting credits to be received anywhere in the Pinelands region from exchanges in Burlington county. A total of nearly 51,700 acres (20,923 ha) were transacted by 2013 at an average PDC value by the mid-2000s of USD 30,000 (Pinelands DCB 2013), stimulating the creation of a statewide TDR enabling legislation in 2004. However, due to cumbersome planning requirements and ability to demonstrate additional density capacity, no additional areas had been protected through TDRs in the state as of 2010 (NJ Future, 2010).

The TDR-program in Montgomery County, Maryland is held to be one of the most successful schemes. By 2008 it had preserved over 50,000 acres (20,235 ha) of prime agricultural land and open spaces in the densely-developed Baltimore/Washington, DC corridor by transferring more than 8000 development rights, accounting for 75% of all preserved agricultural land in the county (Pruetz and Standridge 2009).

Introduction of habitat exchange

The habitat exchange is conceived as the next generation of conservation (endangered species) banking. Like conservation banking, habitat exchange is a form of compensatory mitigation based on Sections 7 and 10 of the Endangered Species Act. Unlike conservation banking, habitat exchange is a performance, or outcome-based market, rather than a practice-based market. Performance-based markets generally have lower administrative and conservation costs while

25 For regular updates on the program and its documentation, see http://www.pb.state.ny.us/chart_pbc_main_page.htm#Plan_and_Handbook.

26 For this certification, the Pinelands Development Credit Bank requires the following property documentation: an application, the deed, a 60-year title search, a 20-year upper and lower court search of liens and judgments, a copy of the tax map showing the property in question, a letter from any mortgage holder indicating that they understand the land will be encumbered with a deed restriction, and a signed deed restriction appropriate for the location of the property.

addressing the concern that not all species habitat is created equal,[27] issues that arose in conventional conservation banking. Whereas conservation banking credits are usually measured in acres, habitat exchange credits are measured in *functional* acres. Credits arising from a parcel of land take into account the site quantity (acres) as well as the site quality, which is a measure of the habitat quality on site and the quality of the surrounding landscape. The quality of the acres is determined by measuring specific habitat characteristics relevant to the species of interest.

Developers whose activities would negatively impact habitat must purchase habitat exchange credits based on the difference in functional acres of the impacted land before and after their projects. Landowners can create credits by restoring or protecting land (e.g. by placement of a permanent conservation easement)—however, to ensure additionality, the only credits that may be entered into the market are those that arise from the difference in the functional acres of the land before and after habitat improvement (i.e. if a landowner had 100 acres of 40% habitat quality—or 40 functional acres—and plants native species, removes damaging landscape features, etc. to raise the quality of the habitat to 100%, the landowner's land is now 100 functional acres, of which 60 may be entered into the market).Additionally, like other conservation banking, habitat exchanges involve a mitigation ratio to ensure net habitat gain for the species of concern (or at least no net loss) or to offset uncertainties. The mitigation ratio varies by species. The habitat exchange market is still in the development and design phase but should be launched by the end of 2014 for the lesser prairie chicken, and shortly thereafter for the greater sage grouse (more information available at http://www.thehabitatexchange.org/).

27 The concept behind this is that the habitat exchange is similar to an appraisal of a house—two houses may both have the same area but have different values.

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The Brazilian Forest Code (FC) requires all private rural properties to maintain a fixed proportion of their area in natural vegetation as a "legal reserve" whose proportions are differentiated by biome. Landowners have often ignored the law. Regaining full compliance would require costly restoration in areas converted. Recent changes to the FC provide that landowners may "compensate" their legal reserve shortages by purchasing surplus compliance obligations from other properties. This paper discusses critical policy issues regarding Environmental Reserve Quotas or *Cotas de Reserva Ambiental* (CRA). We examine the relative environmental effectiveness of the CRA, its efficiency in resource use and social justice, as well as potential implementation hurdles. Allowing for compensation with off-site conservation can enable both more efficient, and less fragmented agricultural production, as well as forest conservation, compared to the default on-farm conservation proposition. CRA as a means for compensation has great intuitive appeal, yet controversy exists regarding its implementation. We review international experience with similar economic instruments, as well as Brazilian studies simulating the potential results of the CRA. Interviews with leading actors regarding the instrument complement the literature review. We finish with a synthetic assessment of the implications of our results for policy implementation.

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