THAIS MUNIZ OTTONI SANTIAGO

IMPACTOS DO NOVO CÓDIGO FLORESTAL BRASILEIRO, LEI FEDERAL Nº 12.651/2012

LAVRAS - MG
2016

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Tese apresentada à Universidade Federal de Lavras, como parte das exigências do Programa de Pós-Graduação em Ciências Florestais, área de concentração em Manejo Florestal, para a obtenção do título de Doutor.

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THAIS MUNIZ OTTONI SANTIAGO

IMPACTOS DO NOVO CÓDIGO FLORESTAL BRASILEIRO, LEI FEDERAL Nº 12.651/2012

IMPACTS OF THE NEW BRAZILIAN FOREST CODE, FEDERAL LAW Nº 12,651/2012

Tese apresentada à Universidade Federal de Lavras, como parte das exigências do Programa de Pós-Graduação em Ciências Florestais, área de concentração em Manejo Florestal, para a obtenção do título de Doutor.

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RESUMO

O Código Florestal (CF) é a ferramenta central da legislação que regula o uso do solo em imóveis rurais do país. A lei exige que Áreas de Preservação Permanente (APP) sejam mantidas para preservar recursos hídricos e evitar erosão e que entre 20% a 80% da área dos imóveis rurais seja conservada como Reserva Legal (RL). No entanto, tais exigências têm sido historicamente ignoradas. Na Amazônia, bioma com a maior biodiversidade do planeta e um enorme estoque de carbono, o pouco impacto do CF pode levar a prejuízos globais. Em 2012, revisões do CF incluíram novos mecanismos para facilitar cumprimento da lei e evitar novos desmatamentos ilegais. Esse trabalho investigou as respostas de produtores rurais da Amazônia ao novo contexto legal e analisou os potenciais impactos do CF de 2012. Inicialmente, investigou-se a hipótese de ruptura do processo de construção da RL como instrumento de conservação ambiental a partir do CF de 2012. A pesquisa, delineada por métodos bibliográficos e documentais, dedicou-se a analisar o formato jurídico da RL ao longo do tempo. Concluiu-se que, ao buscar solucionar o pouco impacto de ambiciosas exigências do passado, o novo CF flexibilizou ou retirou a exigência de manutenção de RL, rompendo o processo histórico de sua afirmação como instrumento de conservação. Embora ele facilite o cumprimento da lei, os resultados indicam que essa estratégia pode não ser suficiente para inibir a formação de novos passivos ambientais. O segundo artigo analisou a probabilidade de pequenos produtores rurais de Rondônia adotarem planos para a recuperação de APP e a extensão desses planos uma vez que a decisão é tomada. Os dados utilizados incluíram questionários aplicados a produtores rurais, suplementados por dados georeferenciados de imóveis rurais. Concluiu-se que o acesso aos agentes de extensão rural e outras regulações ambientais, tais como licenciamento ambiental, tiveram impacto significativo sobre o desenvolvimento desses planos, sugerindo que o CF de 2012 tem potencial para impactar decisões futuras sobre o uso do solo. Por fim, o último artigo investigou a probabilidade de proprietários de terras de Rondônia desejarem participar do novo mercado de Cotas de Reserva Ambiental (CRA). Dados utilizados nessa análise vieram dos registros georeferenciados inseridos no Cadastro Ambiental Rural (CAR), incluindo respostas ao questionário aplicado durante o cadastramento. Adicionalmente, foram utilizados dados socioeconômicos municipais disponibilizados pelo IBGE. Concluiu-se que médios e grandes proprietários rurais tendem a conduzir o comércio de CRA, sendo aqueles com maiores custos de oportunidade do uso do solo os potenciais compradores de CRA. Não houve indícios de que pequenos produtores se disponham a participar desse mercado, o que pode ser ambientalmente benéfico se a ausência de oferta de cotas favorecer outras medidas de regularização que promovam o aumento da cobertura vegetal. Por outro lado, incentivos positivos

adicionais para a conservação de eventuais remanescentes vegetais nesses imóveis parecem necessários. Este trabalho, portanto, sugere que esforços reais e políticas complementares, capazes de apoiar a aplicação da nova lei, serão essenciais para o sucesso do CF de 2012.

Palavras-chave: Área de Preservação Permanente. Reserva Legal. Cadastro Ambiental Rural. Conformidade ambiental. Amazônia.

ABSTRACT

The Forest Code (CF) is the main tool of the legislation that regulates land use on private properties in Brazil. The law requires that Areas of Permanent Preservation (APP) are set aside to preserve water resources and prevent erosion and that between 20% and 80% of the rural property area is conserved as Legal Reserve (RL). However, these requirements have historically been ignored. In the Amazon, the most biodiverse biome in the world, with an enormous stock of carbon, the little impact of the Forest Code can lead to global losses. In 2012, revisions to the law included new mechanisms to facilitate law compliance and inhibit new illegal deforestation. This work investigated the responses of Amazon farmers to the new legal context and analyzed the potential impacts of the 2012 CF. First, it was investigated the possibility of rupture of the RL construction as an instrument for environmental conservation after the new CF. The research, outlined by bibliographic and documentary methods, was dedicated to analyze the legal format of RL over time. It was concluded that the new CF made flexible or removed the requirement of RL maintenance, breaking the historical process of its affirmation as a conservation tool. Although it facilitates compliance with the law, the results have indicated that this strategy may not be enough to inhibit the formation of new environmental liabilities. The second paper analyzed the probability of land owners adopt plans for recovering the APP and the extension of these plans, once the decision is made. The data used included a survey applied to land owners, supplemented with georeferenced data of rural properties. It was concluded that the access to rural extension agents and other environmental regulations, such as environmental licensing, have had a significant impact on the development of these plans, suggesting that the 2012 CF has the potential to impact future decisions about land use. Finally, the third paper investigated the probability of landowners in Rondônia wanting to participate in the new Environmental Reserve Quota (CRA) market. The data used in this analysis came from georeferenced data inserted in the Rural Environmental Register (CAR), including responses to the questionnaire applied during the registration process. In addition, socioeconomic data of counties, provided by the IBGE, were used. It was concluded that medium and large rural landowners are likely to drive the CRA trades and the ones with higher opportunity costs of land use are the potential buyers of CRA. There was no evidence that small land owners are willing to participate in this market, which can be environmentally beneficial if the absence of quota offers favors other measures of regularization that promote the increase of forest cover. On the other hand, additional positive incentives for encouraging the conservation of any remaining vegetation on these properties seem to be needed. This work, therefore, suggests that effective efforts and complementary policy,

able to support the implementation of the new law, will be essential to the success of the 2012 FC.

Keywords: Permanent Preservation Areas. Legal Reserve. Environmental Rural Registry. Environmental Compliance. Amazon.

SUMÁRIO

PRIMEIRA PARTE

INTRODUÇÃO

O Código Florestal (CF) é a principal lei que regula o uso do solo em propriedades privadas do Brasil, estabelecendo padrões de conservação ambiental. Criado em 1934, foi revisado em 1965 e transformado em uma lei ambiental, de fato, em 2001. O CF exige que áreas ambientalmente sensíveis, como aquelas localizadas ao redor de recursos hídricos, em encostas, topos de morro e altitudes elevadas, sejam protegidas como Áreas de Preservação Permanente (APP) para assegurar a estabilidade do regime hídrico e evitar erosão. Além disso, proprietários devem conservar a vegetação nativa em 20% a 80% da área do imóvel rural a título de Reserva Legal (RL). No entanto, apesar de seu papel fundamental para a manutenção de uma variedade de serviços ecossistêmicos, o CF tem tido pouco impacto, principalmente na Amazônia. Com o aumento das taxas de desmatamento no início dos anos 2000, uma série de medidas foram tomadas para aumentar a eficácia da lei. Essas medidas incluíram melhorias na fiscalização, estabelecimento de multas ambientais e embargos a produtos oriundos de áreas ilegalmente desmatadas da Amazônia. Como consequência, desencadeou-se uma imediata reação do setor do agronegócio visando à reforma do CF. Em 2012, essa reforma foi aprovada e o novo CF foi instituído pela Lei Federal nº12.651.

Dentre os instrumentos adicionados para facilitar o cumprimento do CF, destacam-se: 1) a redução dos requisitos de recuperação ambiental; 2) a criação de um Programa para a Regularização Ambiental do imóvel rural (PRA), que inclui uma cláusula para a suspensão de multas ambientais em troca da apresentação de um plano formal para a recuperação do passivo ambiental; e 3) a criação de um sistema de Cotas de Reserva Ambiental (CRA), que permite que

proprietários rurais negociem áreas com vegetação nativa acima dos limites exigidos pelo CF para compensar o débito de vegetação nativa em RL de outras propriedades. Esses instrumentos devem ser facilitados pelo Cadastro Ambiental Rural (CAR), registro online e autodeclaratório criado para reunir informações georeferenciadas dos imóveis rurais do Brasil. Apesar das perdas ambientais, o novo CF promete promover a regularização ambiental de imóveis rurais do país e encorajar a conservação. O sucesso desse código ainda depende das decisões do produtor rural, que são baseadas nos benefícios percebidos com a aplicação dos novos instrumentos. Esses, por sua vez, aguardam regulamentações em nível federal e estadual para serem implementados. Por essas razões, os resultados do CF de 2012 continuam desconhecidos.

Este trabalho se divide em três artigos com o objetivo comum de investigar os potenciais impactos do novo CF estabelecido pela Lei n^{o}12.651/2012. O primeiro artigo consiste em uma pesquisa qualitativa que analisa a construção histórica da RL no ordenamento jurídico brasileiro e a possibilidade de sua ruptura como instrumento de conservação ambiental após a reforma de 2012. Os demais artigos têm como foco a Amazônia, bioma com maior passivo ambiental do país e uma histórica dificuldade em implementar as exigências do CF e, mais precisamente, o estado de Rondônia, um dos estados mais desmatados da região. O segundo artigo investiga a probabilidade de pequenos produtores rurais adotarem planos para a recuperação de APP e a extensão desses planos uma vez que a decisão é tomada. Trata-se de uma pesquisa quantitativa que utiliza dados derivados de questionários aplicados a produtores rurais na região de Ouro Preto do Oeste, suplementados por dados georeferenciados dos imóveis rurais. Por fim, o último artigo pesquisa a probabilidade de produtores rurais aceitarem comprar ou vender CRA e os fatores determinantes dessa decisão. A análise utiliza dados contidos nos

registros inseridos no CAR de Rondônia além de dados socioeconômicos municipais fornecidos pelo IBGE.

Este estudo, portanto, fornece previsões sobre os efeitos do CF de 2012 a partir da integração de diferentes fontes de dados, incluindo informações inéditas provenientes do CAR. Os resultados apresentam o significado das mudanças legislativas adotadas e indicam fatores determinantes para o sucesso da nova lei.

SEGUNDA PARTE – ARTIGOS

ARTIGO 1

A EVOLUÇÃO DA RESERVA LEGAL: FUNDAMENTOS PARA ANÁLISE E COMPREENSÃO DO INSTRUMENTO

Artigo preparado de acordo com as normas da revista Ciência Rural

“versão preliminar”

RESUMO

O Código Florestal (CF) é a principal lei que regula o uso do solo em propriedades privadas do Brasil, exigindo que uma porção da área do imóvel rural seja mantida com vegetação nativa a título de Reserva Legal (RL). Instituída em 1934, a RL sofreu alterações em sua dimensão e finalidade e afirmou-se no ordenamento jurídico brasileiro como instrumento de conservação ambiental. Esse trabalho investigou a hipótese de ruptura do processo de evolução da LR após revisões feitas ao CF em 2012. Uma pesquisa qualitativa, delineada por métodos bibliográficos e documentais, analisou a construção histórica do instrumento e seu formato jurídico ao longo do tempo. Concluiu-se que, ao flexibilizar e até mesmo retirar a exigência de manutenção de RL em propriedades rurais, a nova legislação rompeu com a tendência de construção da RL como instrumento de conservação ambiental. A história do CF indica que, isoladamente, essa estratégia pode não ser eficaz para inibir a formação de novos passivos ambientais.

Palavras-chave: Código Florestal Brasileiro; Legislação Ambiental; Desmatamento

ABSTRACT

The Forest Code (FC) is the main legislation regulating land use on private properties in Brazil and it requires that a portion of the rural property areas is maintained with native vegetation as Legal Reserve (LR). The LR was established in 1934, it has undergone changes in its requirements and purpose and been consolidated in the Brazilian legal system as an instrument of environmental conservation. This work investigated the possibility of disruption of the RL's evolution process from the revisions made to the FC in 2012. A qualitative research outlined by bibliographic and documentary methods has analyzed the historical construction of RL and its legal format over time. It was concluded that by reducing and even removing the requirement for LR maintenance in rural properties, the legislation disrupted the tendency of the LR's construction process as an instrument of environmental conservation. The FC's history indicates that, in isolation, this strategy may not be effective in inhibiting the formation of new environmental liabilities.

Keywords: Brazilian Forest Code; Environmental Legislation; Deforestation

INTRODUÇÃO

O Código Florestal (CF) é a lei que estabelece padrões de conservação ambiental a propriedades privadas do Brasil. Ele exige que áreas ambientalmente sensíveis sejam protegidas como Áreas de Preservação Permanente (APP) e que, no mínimo, entre 20% a 80% da área dos imóveis rurais seja mantida com vegetação nativa a título de Reserva Legal (RL). Enquanto APPs se destinam, essencialmente, à conservação de recursos hídricos e à estabilidade geológica do terreno, RLs são requeridas para assegurar a sustentabilidade do uso de recursos naturais e proteger a biodiversidade. Apesar da exigência legal, o déficit de vegetação nativa em áreas que deveriam ser protegidas é generalizado, evidenciando o pouco impacto do CF sobre o uso do solo no país (SPAROVEK et al, 2010).

Devido ao seu conceito mais difuso, o cumprimento da RL tem sido encarado por produtores rurais como uma restrição menos aceitável ao uso do solo do que a APP (SPAROVECK et al, 2012). Frequentemente, a RL é apontada como um instrumento inócuo (BACHA, 20005) que impõe barreira ao crescimento econômico e contribui para a perda de competitividade da produção agrícola (VALVERDE, 2010). Ao mesmo tempo, estudos têm apresentado evidências da sua importância na provisão de serviços ecossistêmicos (PARDINI et al. 2010) e no aumento da produtividade agrícola do imóvel rural (CARAVALHEIRO et al., 2011). Apesar do conflito e de constantes mudanças legislativas, a construção da RL tem sido direcionada para a afirmação do caráter conservacionista do instrumento (AHRENS, 2007).

Em 2012, uma reforma buscou aumentar a eficácia do CF e apresentar alternativas às propriedades irregulares. Às custas de grandes perdas ambientais (BRANCALION et al, 2016), o novo CF introduziu mecanismos que oferecem flexibilidade para o cumprimento da lei. Embora tenha reconhecido a

importância da RL e mantido o conceito do instrumento, na prática, o novo regulamento parece romper uma tendência histórica de afirmação da RL como instrumento de conservação ambiental. Essa hipótese é sustentada pelo contexto social em que se deu a reforma do CF: marcado pela valorização do agronegócio, redução nas taxas de desmatamento, vulnerabilidade do Congresso Nacional e por um grande passivo ambiental (CUNHA; MELLO-THERY, 2010; INPE, 2011; SPAROVECK et al, 2010).

Esse trabalho resgata a construção histórica da RL e analisa seu formato jurídico ao longo do tempo, com a finalidade de investigar a hipótese de ruptura do processo de construção ambiental da RL a partir do CF de 2012. Discute-se as principais motivações para as alterações legislativas e as implicações das recentes mudanças. Trata-se de uma pesquisa exploratória, delineada por métodos bibliográficos e documentais (GIL, 2010) que reúne a informação dispersa sobre RL entre diferentes marcos regulatórios. Ao retomar a história da RL, o artigo pretende discutir os fundamentos da RL e indicar oportunidades para aumentar a eficácia do instrumento. Além disso, tem o potencial de fornecer subsídios para a elaboração de hipóteses em estudos posteriores focados em questões relativas ao uso da terra no Brasil.

A Reserva Legal no Código Florestal de 1934

O primeiro CF brasileiro surgiu, em 1934, como uma das tentativas do Estado de controlar setores estratégicos da economia, permitindo e apoiando a industrialização do país. Com o intuito de disciplinar o desmatamento e assegurar a estabilidade de mercados madeireiros, esse CF exigiu a manutenção da quarta parte (25%) da área dos imóveis rurais com matas, localizada a critério da autoridade competente (BRASIL, 1934). Embora não houvessem regras proibindo o uso dessas reservas, o corte raso era explicitamente proibido. A prioridade econômica dessa medida era evidente, pois, a exigência da “quarta

parte" era anulada caso o proprietário desejasse retirar toda a vegetação heterogênea existente para transformá-la em cultivos florestais visando facilitar a exploração industrial. Pequenos imóveis localizados próximos a florestas também eram dispensados da obrigação da "quarta parte" por já contarem com matéria-prima disponível. A própria ideia de "reservar matas" remete-se ao conceito econômico relativo ao ato de assegurar recursos (madeira) para uso futuro.

O CF de 1934 não era claro sobre a possibilidade de computar o montante de floresta que deveria ser preservada no imóvel rural com o objetivo de assegurar o regime das águas e evitar erosão (Florestas Protetoras) no cálculo da "quarta parte" da propriedade que também deveria ser mantida com floresta. No entanto, é evidente que a legislação tratava esses dois dispositivos de forma distinta: ao contrário da "quarta parte" que poderia ser completamente substituída para facilitar a exploração industrial, as Florestas Protetoras, de conservação perene, só poderiam ser utilizadas em caráter excepcional, isto é, em caso de grande vantagem para a fazenda pública e mediante autorização do Ministério da Agricultura.

À medida em que controlava o uso dos recursos naturais, as "reservas florestais" evitavam o esgotamento da matéria-prima florestal do país e, indiretamente, promoviam a conservação ambiental. Mas, as dificuldades para a efetiva execução do CF de 1934, sobretudo, em função da inércia ou mesmo resistência das autoridades estaduais e municipais, motivaram a elaboração de um novo CF para aprimorar e reorganizar a matéria (AHRENS, 2007).

A Reserva Legal no Código Florestal de 1965

O CF de 1965 precisou se adequar ao novo arcabouço legal do país que limitava o direito à propriedade e exigia a conservação dos recursos naturais para assegurar o bem-estar da coletividade (BRASIL, 1964). Assim, seu caráter

protetivo foi ampliado e as Áreas de Preservação Permanente (APP) foram criadas incorporando não só as Florestas Protetoras do código anterior como também outros tipos de vegetação cuja localização e importância demandavam proteção. O percentual exigido como "reserva florestal" passou variar entre imóveis rurais situados nas regiões Norte e norte do Centro-Oeste do país (50%) e nas demais regiões (20%), com exceção dos imóveis localizados a Nordeste do Brasil, para os quais não houve exigência explícita de "reserva florestal" (BRASIL, 1965). Essa ausência legislativa parece ter retardado a adoção do instrumento na região e, em parte, explica a pouca quantidade de área instituída como RL atualmente (BACHA, 2005).

Como no CF anterior, a localização das "reservas florestais" na propriedade era determinada pela autoridade competente. Além disso, já não havia a isenção da obrigação de reservas florestais para imóveis situados próximos a florestas e a inclusão da APP no cálculo do percentual de "reserva florestal" tornou-se explicitamente proibido. O CF de 1965 determinou que a exploração de toda a vegetação nativa não considerada de preservação permanente, dependeria de norma estabelecida em ato do Poder Federal ou Estadual. Contudo, a tardia regulamentação e aplicação dessa norma (BRASIL, 2006) pode ter reduzido os efeitos de um possível controle sobre o remanescente florestal do país.

O CF de 1965 também permitiu que imóveis rurais, localizados fora da região Amazônica e com área entre 20 e 50 hectares, contabilizassem além da cobertura florestal de qualquer natureza, os maciços de porte arbóreo frutícolas, ornamentais ou industriais. Embora não esteja explícito, a norma sugere que não eram exigidas "reservas florestais" em imóveis dessa região com área até 20 hectares. A área destinada a completar as reservas florestais de imóveis da região Amazônica também poderia ser agrupada numa só porção entre os adquirentes.

O CF de 1965 aprimorou a exigência de "reservas florestais", esclarecendo determinados pontos da lei e aumentando o rigor em regiões de interesse. Entretanto, não avançou em mecanismos que pudessem incentivar a manutenção dessas reservas. Ao contrário, continuou permitindo a completa remoção das mesmas quando o produtor, visando a maiores rendimentos econômicos, desejasse estabelecer cultivos florestais homogêneos. Evidente, portanto, a permanência do caráter econômico dessas reservas que continuavam dispensáveis se assegurado o suprimento de matérias-primas e estabilidade do mercado madeireiro.

A partir da Política Nacional do Meio Ambiente (Lei Federal nº 6.938 de 1981) e da Constituição Federal de 1988, nova orientação foi dada às políticas públicas do país, passando essas a reconhecer o meio ambiente como um sistema ecológico integrado, necessário ao bem-estar da população, à segurança nacional e à sustentabilidade do desenvolvimento econômico. Assim, as "reservas florestais" do CF de 1965 assumiram novas funções que não se restringiam apenas à oferta de matéria-prima, mas incluíam também a prestação de serviços ambientais à propriedade rural e à sociedade em geral.

Para adequar o corpo jurídico das "reservas florestais" às suas novas funções, a Lei Federal nº11.284 de 1986 acabou com a possibilidade de corte raso de florestas heterogêneas para o plantio de cultivos florestais, condicionando a exploração florestal ao manejo sustentado e exigindo a reposição com espécies típicas da região (BRASIL, 1986). A Lei Federal nº 7.803 de 1989 contribuiu à essa adequação ao exigir a manutenção de reservas não só em biomas florestais, mas também em áreas de cerrado (20% do imóvel rural), cunhando o termo Reserva Legal (RL) e obrigando proprietários rurais a averbar RL junto ao cartório de registro de imóveis. A mudança da destinação da área tornou-se proibida mesmo nos casos de venda e transmissão da área (BRASIL, 1989). Fixando a localização da RL no imóvel rural, essa lei não só

interrompeu a prática de vendas sucessivas que resultavam no completo desaparecimento dessas reservas (BACHA, 2005), como também facilitou a fiscalização e assegurou a estabilidade necessária para que desempenhassem suas funções ambientais.

No início dos anos 1990, a medida que a fronteira agrícola alcançava os limites de proteção de APP e RL, o CF dava indícios de que, isoladamente, seria incapaz de conter o desmatamento em áreas protegidas (SIQUEIRA; NOGUEIRA, 2004). Já em 1992, o passivo ambiental era evidente com apenas 7,38% dos imóveis registrando possuir RL (OLIVEIRA; BACHA, 2003). A Lei de Política Agrícola (Lei Federal nº 8.171 de 1991) instituiu a primeira das sucessivas exigências de regularização do déficit de RL em imóveis rurais do país, estabelecendo o prazo máximo de 30 anos para que proprietários rurais realizassem a regularização integral da RL. A recuperação da vegetação nativa deveria ocorrer mediante o plantio anual de um trinta avos da área que deveria ser restaurada (BRASIL, 1991).

A Reserva Legal na Medida Provisória nº 2166-67 de 2001

Com as florestas tropicais no centro do emergente debate ambiental, o desmatamento decorrente dos incentivos fiscais que promoviam a ocupação da Amazônia brasileira passou a prejudicar a imagem do país e a restringir o seu acesso ao crédito internacional. Para solucionar a questão, a Medida Provisória nº 1.511/96 aumentou o percentual de RL para imóveis situados em florestas na Amazônia de 50% para 80% (BRASIL, 1996; SIQUEIRA; NOGUEIRA, 2004). A RL, então, foi o instrumento utilizado para alterar o padrão do uso do solo na região e evitar novas conversões de floresta. No entanto, sem alternativas ao modelo de exploração vigente que era baseado na conversão florestal e sem melhorias na aplicação da lei, a mudança legislativa não foi capaz de conter o

avanço do desmatamento da Amazônia (IPEA, 2011; SIQUEIRA; NOGUEIRA, 2004; STICKLER ET AL., 2013).

O rigor da nova exigência de RL, somada ao Decreto Federal nº 3.179 de 1999 que instituiu sanções àqueles que explorassem ou realizassem o corte raso da vegetação nativa em RL (BRASIL, 1999), despertou uma forte reação do setor do agronegócio. Deflagrou-se um processo conflituoso de discussão entre conservacionistas e ruralistas que gerou 67 reedições da medida provisória de 1996, enfim estabelecida, com força de lei, como Medida Provisória nº 2.166-67 de 2001 (BRASIL, 2001). Ao final desse processo, inflamado por pressões do movimento ambientalista (FIGUEIREDO; LEUZINGUER, 2001) e apoiado por evidências sobre a necessidade de reservas de vegetação nativa ao longo da paisagem (AHRENS, 2003; METZGER, 2010), o conceito de RL foi redefinido e seu caráter conservacionista consolidado.

Definiu-se que proprietários rurais da Amazônia Legal deveriam manter RL de acordo com a fitofisionomia predominante no imóvel rural, isto é: 80% da área do imóvel rural se florestas, 35% se cerrado e 20% se campos gerais. Nas demais regiões do país, a RL seria de 20% da área do imóvel. O cômputo da APP no cálculo da RL seria admitido quando a soma dessas áreas ultrapassasse: 1) 80% da área dos imóveis da Amazônia Legal, 2) 50% daqueles situados nas demais regiões do país e 3) 25% dos pequenos imóveis, por sua vez, definidos de acordo com o tipo de exploração, a renda auferida e a área do imóvel. Para os pequenos imóveis rurais também foi assegurada a gratuidade da averbação da RL e o cômputo de espécies exóticas, desde que cultivadas em sistema intercalar ou em consórcio com espécies nativas.

Buscando superar a precária conectividade entre os fragmentos de vegetação, o novo CF expandiu a possibilidade de instituir RL em regime de condomínio para todas as regiões do país e exigiu que a localização da reserva considerasse a proximidade com outras áreas protegidas. A essa altura, os

valores da RL haviam sido expandidos: de um instrumento que buscava assegurar a disponibilidade de matéria-prima florestal, a RL tornou-se um instrumento destinado a assegurar os serviços ecossistêmicos. A demanda, no século XXI, não era mais o abastecimento de mercados florestais, pois, plantios subsidiados por incentivos federais da década de 1960 já apoiavam o desenvolvimento de indústrias de papel, celulose e siderurgia (TOMASELLI, 2013). No auge das discussões sobre desenvolvimento sustentável, interessava atender à opinião pública nacional e internacional (SIQUEIRA; NOGUEIRA, 2004) e fornecer um instrumento capaz de assegurar a qualidade ambiental e o sucesso da produção agrícola.

Proprietários rurais que não cumpriam os requisitos de RL deveriam optar pela recuperação da área desmatada mediante: 1) regeneração natural; 2) recomposição por meio do plantio de espécies nativas no prazo máximo de 30 anos, admitindo-se o uso de exóticas apenas como pioneiras; e 3) compensação do déficit de RL por meio da aquisição de áreas de vegetação nativa localizadas em outros imóveis rurais ou em Unidades de Conservação (UC) pendentes de regularização fundiária e que excedessem aos requisitos do CF (Cotas de Reserva Florestal – CRF). Essas cotas deveriam ser adquiridas no mesmo ecossistema ou, pelo menos, na mesma bacia hidrográfica em que o imóvel rural com déficit de RL estivesse localizado. Para fins de recomposição, o CF também permitiu que o Poder Executivo, desde que indicado pelo Zoneamento Ecológico Econômico (ZEE) e pelo Zoneamento Agrícola, ouvidos o Conselho Nacional do Meio Ambiente, o Ministério do Meio Ambiente e o Ministério da Agricultura e do Abastecimento, reduzisse o percentual de RL de 80% para até 50% da área dos imóveis situados na Amazônia Legal. Assim, em tese, o CF exigiu a recuperação integral da RL desmatada sem comprometer as funções do instrumento e mantendo o espírito da lei.

A Reserva Legal no Código Florestal de 2012

O aumento das taxas de desmatamento da Amazônia no início dos anos 2000 (INPE, 2011) desencadeou novos esforços para aumentar a eficácia do CF. Dentre as medidas adotadas, inclui-se o Decreto Federal nº 6.514 de 22/07/2008 que, revogando o decreto de 1999, aumentou o rigor das multas aplicadas àqueles que não cumpriam as exigências de APP e RL (BRASIL, 2008). Essas medidas provocaram a reação do setor ruralista que, apoiado por futuras quedas nas taxas de desmatamento na Amazônia e pela valorização de commodities agrícolas, obteve sucesso em aprovar a reforma do CF mediante a Lei nº 12.651 de 2012 (BRASIL, 2012).

O CF de 2012 foi elaborado sob o consenso de que as versões anteriores da lei tiveram pouco impacto sobre o uso do solo. Era preciso oferecer uma solução para as áreas em não conformidade e evitar novos passivos ambientais. A nova lei manteve os requisitos de conservação de RL (admitindo a possibilidade de sua redução para 50% nos estados da Amazônia Legal com ZEE aprovado e com mais de 65% do território ocupado por UCs) e criou mecanismos com a promessa de aumentar o cumprimento da lei, tais como: o Cadastro Ambiental Rural (CAR), o Programa de Regularização Ambiental (PRA) e a Cota de Reserva Ambiental (CRA).

O CAR é um registro eletrônico obrigatório, destinado a integrar a informação georeferenciada dos imóveis rurais do Brasil e com potencial de se tornar a principal ferramenta de monitoramento e planejamento ambiental do país. O registro no CAR, contendo a localização de áreas protegidas, dispensa a averbação da RL em cartório e qualifica produtores rurais a computar a APP no cálculo da RL, desde que o benefício não implique em novas conversões para uso do solo e que a área a ser computada esteja conservada ou em recuperação.

Proprietários rurais que, após o registro no CAR, optarem por aderir ao PRA deverão apresentar proposta simplificada com prazos e condições para a

correção do déficit ambiental. Essa adesão deve gerar termo de compromisso que, uma vez assinado, suspenderá infrações relativas à supressão de APP e RL anteriores à 22/07/2008. O cumprimento desse termo é também suficiente para converter tais infrações em serviços de melhoria ambiental. Embora facilite a regularização ambiental, a suspensão de multas ambientais pode significar um desestímulo ao proprietário que respeitou as determinações da lei, contribuindo para a "cultura da esperteza" e da ilegalidade, o que ameaça até mesmo o cumprimento da nova lei. Ainda, apesar do grande potencial do CAR e do PRA, não há previsão para que as informações prestadas, incluindo as propostas para a regularização ambiental, sejam validadas pelo órgão ambiental e comecem a produzir efeitos reais (BRASIL, 2014a; 2014b).

Imóveis rurais com área até quatro módulos fiscais, em 22/07/208, foram dispensados da recuperação da área desmatada em RL. Isso qualifica 90% dos imóveis rurais do país com área entre 20 e 440 hectares, dependendo do município (IBGE, 2006). Demais proprietários que tenham desmatado respeitando os percentuais de RL previstos pela legislação em vigor à época da supressão também foram desobrigados da necessidade de alcançar os limites atuais de RL. No total, estima-se que o CF de 2012 tenha sido responsável pela redução da área a ser restaurada de 50 ± 6 a 21 ± 1 milhões de hectares no país, dos quais 78% correspondem a RLs (SOARES-FILHO et al., 2014). Dessa forma, os benefícios ambientais que a recuperação integral da RL poderia proporcionar (GARCIA ET AL., 2013) foram renunciados, ainda que evidências cientificas tenham afirmado a necessidade de manter a RL com as dimensões da legislação anterior (METZGER, 2010).

Alternativas atuais para correção do déficit de RL incluem: 1) regeneração natural; 2) recomposição mediante plantio, a ser concluída em até 20 anos e admitindo-se a utilização de espécies exóticas em até 50% da área a ser recuperada; e 3) compensação. As possibilidades de ofertar cotas de RL para

fins de compensação foram ampliadas com a criação da Cota de Reserva Ambiental (CRA) em substituição à CRF do código anterior que, por sua vez, não produziu efeitos significativos (MAY et al, 2015). O CF de 2012 permitiu que a CRA seja correspondente não só à vegetação nativa intacta que exceda os requisitos do CF, mas, também à vegetação excedente que esteja em processo de regeneração ou que integre a RL de pequenos imóveis rurais. Trocas de CRA também passaram a ser limitadas pelo bioma onde a propriedade com déficit de RL está localizada. Embora possa reduzir preços de CRA, esse novo recorte geográfico tende a implicar em maiores custos ambientais se não houver equivalência ecológica entre as áreas envolvidas na compensação e se não for assegurado um equilíbrio de reservas ao longo da paisagem (SILVA; RANIERI, 2014).

A oferta de cotas também poderá será ampliada quando o cômputo da APP for suficiente para atender ao percentual de RL e o restante de vegetação nativa no imóvel, que não poderá ser convertida, tornar-se CRA. É evidente que, ao mesmo tempo, a permissão para o cômputo da APP também diminui o déficit de RL, e assim, a possível demanda por CRA. A demanda também diminui com o perdão do déficit da RL de pequenas propriedades (transferidas da categoria de devedoras para credoras de RL). O desequilíbrio entre maior oferta e menor demanda por CRA é previsto como o principal obstáculo para a concretização desse mercado (SPAROVECK ET AL., 2012; MAY ET AL., 2016). Embora o CF de 2012 tenha admitido a possibilidade de uso de outros instrumentos econômicos para estimular a conservação, como o Pagamento por Serviços Ambientais (PSA), sua concretização ainda depende de uma regulamentação abrangente (BRANCALION et al, 2016). Enquanto isso não acontece, remanescentes florestais e áreas protegidas continuam suscetíveis ao desmatamento e dependentes de intensa fiscalização e monitoramento.

As tabelas abaixo resumem o processo de evolução da RL. Apresenta-se o histórico das normas do instrumento (tabela 1), destacando-se as exigências para a regularização do déficit ambiental (tabela 2) e o tratamento diferenciado dispensado aos pequenos imóveis rurais ao longo do tempo (tabela 3). Os resultados indicam que, para superar o pouco impacto das legislações anteriores, rompeu-se a tendência de construção da RL como instrumento de conservação ambiental. Retroceder e flexibilizar a aplicação do instrumento ou até mesmo, permitir seu completo desaparecimento, é parte essencial do pacote de medidas adotados pelo novo CF para corrigir os possíveis erros cometidos no passado. Aparentemente, essa opção renuncia aos benefícios ambientais já conquistados (GARCIA ET AL., 2013) e ignora os pilares ecológicos (METZGER, 2010), jurídicos (AHRENS, 2007) e históricos (CASTRO, 2013) que justificam a RL até os dias atuais.

A história parece indicar que o sucesso do CF depende mais de incentivos que valorizem e estimulem a conservação em áreas privadas do que da redução de áreas protegidas. Embora tenha incluído novas medidas para promover o cumprimento da lei, o sucesso do CF de 2012 em evitar a formação de novos passivos ainda depende do fortalecimento de órgãos ambientais cuja atual deficiência técnica e de recursos atrasam a validação das informações inseridas no CAR (SOARES FILHO et al, 2014), de avanços na fiscalização ambiental (AZEVEDO et al. 2014), de assistência técnica a pequenos produtores rurais, também carentes de acesso à tecnologia e crédito rural (IBGE, 2006), e de programas para o pagamento por serviços ambientais (BRANCALION et al, 2016). Sem esses avanços, o CF de 2012 corre o risco de se limitar à plataforma virtual do CAR e continuar causando pouco impacto sobre o uso do solo, ainda que contando com exigências substancialmente menos rigorosas para a conservação.

CONCLUSÃO

O objetivo e os mecanismos reguladores da RL sofreram alterações ao longo do tempo: partindo de um caráter estritamente econômico, destinado a assegurar a disponibilidade de matérias-primas e a estabilidade do mercado madeireiro, para um caráter conservacionista, em defesa da manutenção de serviços ecossistêmicos. O CF de 2012, no entanto, rompeu a tendência da afirmação da RL como instrumento de conservação ambiental ao retroagir nas exigências de recuperação do passivo ambiental, ampliar o grau e a abrangência das facilidades destinadas à pequena propriedade, suspender multas relativas ao desmatamento ilegal, aumentar a participação de espécies exóticas, permitir a total sobreposição de APP e RL e ameaçar os benefícios ambientais da compensação com a reformulação do mercado de cotas.

Revisões que buscaram aumentar eficácia do CF ao longo do tempo focaram excessivamente no ajuste de parâmetros de conservação e recuperação da RL, sem que outros esforços acompanhassem a aplicação da lei e criassem incentivos para a conservação. A história sugere que reduzir as exigências de RL sem que tais lacunas do passado sejam preenchidas, não é suficiente para impedir a formação de novos passivos ambientais. Embora tenha inovado com mecanismos de grande potencial para o cumprimento do CF com o CAR, esses ainda dependem de regulamentação, grande apoio institucional e ações locais para que possam produzir efeitos reais e positivos. Considerando as evidências sobre a necessidade da RL, a tentativa de regularização de imóveis rurais no país poderia ter apostado mais na valorização do uso sustentado da RL, da geração de renda a partir do restabelecimento da vegetação, da assistência técnica ao produtor rural e da efetivação de programas de pagamentos por serviços ambientais do que da redução das exigências de RL via CF de 2012.

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Tabela 1 - Histórico das exigências de conservação de Reserva Legal no ordenamento jurídico brasileiro.

Características	**Ano**				
	1934	**1965**	**1989**	**2001**	**2012**
Denominação	-	-	Reserva Legal vegetação nativa	Reserva Legal vegetação nativa	Reserva Legal vegetação nativa
Composição	floresta nativa	floresta nativa			
Parâmetros (conforme localização do imóvel e fitofisionomia predominante)	25%	Norte e norte do Centro-Oeste: 50%; demais regiões 20%	Norte e norte do Centro-Oeste: 50% se Floresta, 20% se Cerrado; demais 20%	Amazônia Legal: 80% Floresta, 35% Cerrado, 20% Campos; demais 20%	Amazônia Legal: 80-50% Floresta, 35% Cerrado, 20% campos; demais 20%
Cômputo APP	-	não	não	se APP+RL ≥ 80% Amazônia Legal ou ≥ 50% demais regiões	sim, admitindo-se APP em processo de regeneração
Declaração	-	-	cartório	cartório	Cadastro Ambiental Rural
Uso	permitido (corte raso em caso de substituição por cultivos florestais)	mediante autorização (corte raso em caso de substituição por cultivos florestais)	mediante autorização	Manejo Florestal Sustentável (MFS)	MFS c/ ou s/ propósito comercial
Regime de Condomínio	-	exceto região Amazônica	exceto região Amazônica	sim	sim

Tabela 2 - Histórico das exigências de recuperação do passivo ambiental em área de Reserva Legal.

Características		**1991**	**2001**	**2012**
Exigência de recuperação		integral	integral	exceto aqueles que suprimiram vegetação conforme a legislação vigente à época e pequenas propriedades
Regeneração natural como alternativa		-	sim	sim
Recomposição como alternativa	Prazo (anos)	30	30	20
	Composição	normas do órgão gestor	exóticas como pioneiras	exóticas em até 50% da área a ser recuperada
Compensação como alternativa	Localização	-	mesmo ecossistema, mesmo estado e mesma bacia hidrográfica	mesmo bioma, preferencialmente mesmo estado
	Meios	-	adquirir Cota de Reserva Florestal, arrendar área sob servidão florestal, doar área em UC	adquirir Cota de Reserva Ambiental, arrendar área sob servidão florestal, doar área de UC
Apoio Financeiro		não	não	previsto
Multas		deveriam ser pagas	deveriam ser pagas	serão convertidas em serviços proteção ambiental

Tabela 3 - Histórico do tratamento dispensado pelo Código Florestal especificamente à pequena propriedade rural.

Características	**Ano**				
	1934	**1965**	**1989**	**2001**	**2012**
Conceito	pequenos imóveis, a critério do órgão florestal	imóveis até 50 ha localizados na região Sul, sul do Centro-oeste e Leste meridional do país	imóveis até 50 ha localizados na região Sul, sul do Centro-oeste e Leste meridional do país	imóveis ≤150 ha na Amazônia Legal, ≤50 ha no Polígono das Secas, ≤30ha demais regiões. Exploração familiar e 80% da renda originada de atividade agroflorestal	imóveis 20-440 ha, conforme município. Exploração familiar e renda de atividades econômicas vinculadas ao estabelecimento (% da renda a ser definida pelo Poder Executivo)
Exigência de RL	sim (isentos se isolados e próximos a florestas)	sim (parecem isentos imóveis ≤ 20ha)	sim (parecem isentos imóveis ≤ 20ha))	sim	sim
Cômputo de APP	-	não	não	se APP+RL ≥ 25% da área do imóvel	sim, admitindo-se APP em regeneração
Composição	-	admite-se exóticas	admite-se exóticas	exóticas + nativas	admite-se exóticas
Exigência de recuperação do passivo em RL	-	-	-	sim	não[1]
Oferta da RL como cota para compensação	-	-	-	-	sim

[1] Aplica-se aos imóveis rurais que detinham área de até 4 módulos fiscais em 22/07/2008.

ARTIGO 2

CARROTS, STICKS AND THE BRAZILIAN FOREST CODE: THE PROMISING RESPONSE OF SMALL LANDOWNERS IN THE AMAZON

Artigo preparado de acordo com as normas da Revista Forest Economics

"versão preliminar"

ABSTRACT

The Brazilian Forest Code has been in existence more than 80 years but has largely been ineffective in reducing deforestation in the Amazon due to a lack of adherence and enforcement. Recent revisions to the law reduced the recovery requirements for Areas of Permanent Preservation (APP) and Legal Reserve (LR) and established new tools to facilitate compliance, encourage environmental conservation and strengthen the supervision and monitoring of protected areas. The goal of these changes is to facilitate compliance, encourage environmental conservation, and strengthen the monitoring of protected areas. This paper investigates the probability that a household in Rondônia, Brazil will set aside land for permanent preservation and, once this decision is made, the extent of preservation. Our results suggest that−even in a region that is heavily deforested and under conditions of weak enforcement−households are complying with the law by developing formal plans for preservation. Most important, we find that access to extension agents, existing APP guidelines, and other policy levers (such as environmental licensing) have made a significant impact on the development of these plans suggesting that the 2012 Forest Code has the potential to impact future land use decisions.

JEL Codes: Q23, Q15, Q56

Keywords: Brazilian Forest Code, tropical forests, Brazil, forest protection, forest recovery

Carrots, Sticks and the Brazilian Forest Code

The Promising Response of Small Landowners in the Amazon

1.0 Introduction

The Brazilian Amazon is home to a third of the world's rainforests (FAO, 2011) comprises one of the most biologically diverse biome in the world, (Dirzo and Raven, 2003; Mittermeier et al., 2003) and significantly influences global climate (Cao and Woodward, 1998; Foley et al., 2007; Nepstad et al., 2008). Approximately 47% of the existing native vegetation in this region is protected within national parks and indigenous territories. The remainder of the Amazon forest (with the exception of a few contested public land areas) is privately owned and falls under the protection of the Brazilian Forest Code (BFC), the central piece of legislation designed to protect the public good aspects of forests through the legislation of private property land use (Sparovek et al., 2010). The law requires that landowners in the Legal Amazon set aside 50% to 80% of the property as Legal Reserve (LR), and that environmentally sensitive areas (such as riverside forest buffers and hilltops) be protected as "Areas of Permanent Protection" (APPs). Although ambitious in scope, to date the law has made little impact on land use due to limited adherence and enforcement.

Recent 2012 revisions to the BFC included the addition of "carrots" by reducing the recovery requirements for APP and LR, the introduction of "sticks," a rural land registry (a compulsory, geo-referenced, and self-declaratory database which integrates environmental information with maps of native vegetation), and the establishment of new tools to facilitate compliance, encourage environmental conservation, and strengthen the monitoring of protected areas. The most impressive of these additions is the development of the rural land registry (Portuguese: Cadastro Ambiental Rural; CAR), the most

comprehensive such registry in the world, which when completed will include over 5 million properties.

This paper investigates the expected impact of the 2012 BFC on the rural landowners in
Ouro Preto do Oeste (OPO), Rondônia, a region notorious for noncompliance with this law. We
analyze the probability that a household will set aside land for APP and, if this decision is made,
the extent of preservation. Data used in this analysis include observations from a 2009 household survey that are supplemented with sketch maps of the property (similar to the maps households create digitally for the CAR), GIS data (including biophysical conditions of the property) and remote sensing data (on nine different land cover classifications). This unique data set provides the ability to analyze the potential impact of the 2012 BFC.

2.0 The Brazilian Forest Code

The BFC was established in 1934 when for the first time it was declared that private (and not just public) land was to be formally conserved under the law. This code required the preservation of "protective forests" that, as defined by their location, play an important role in the conservation of hydrological services and the geological stability of the property. In 1965 the BFC was expanded to include (1) a declarative understanding of the ecosystem services provided by forests (2) the introduction of Areas of Permanent Preservation, and (3) an increase in the areas of LR required within the Amazon biome. In 2001 revisions established more concrete terms for forest conservation and the redefinition of the private Legal Reserve.

Despite the long time period the BFC has been law, the protection of areas preserved as APP and LR has been limited (Bacha, 2005; Gibbs et al.,

2015; Soares-Filho et al., 2014; Sparovek et al., 2010; Stickler et al., 2013), especially in the Amazon region containing the greatest amount of forest cover and largest LR deficit (IPEA, 2011). In addition to having little impact on land use in Brazil, requirements and deadlines for the settlement of environmental deficit become habitually and institutionally ignored due to a lack of supervision, ever-changing legal requirements, the lack of options for properties that do not comply, the absence of positive incentives for compliance (Campos and Bacha, 2013; Sparovek et al., 2012; Stickler et al., 2013) and, in the case of Amazon, the argument was made that conservation requirements ignored the impact of these policies on development (Siqueira and Nogueira, 2004). Historical increases in deforestation rates in the early 2000s (INPE, 2011) triggered efforts to improve the enforcement of the BFC. These measures included the establishment of APP and RL fines (Federal Decree. 6,514/2008) and protection regulations (under Resolution no. 3545/2008) that conditioned the granting of rural credit in the Amazon upon compliance with environmental regulations. These changes in turn provoked reaction from the rural sector that combined with a growing agribusiness and future reductions in deforestation rates, contributed to the further revised BFC, eventually approved in 2012.

2.1 The 2012 BFC

The 2012 BFC includes three important modifications: (1) the introduction of new mechanisms to advance forest monitoring and fire management including a rural environmental registry (CAR), (2) the establishment of a system to enable payments for ecosystem services, and (3) the reduction of APP and LR requirements (divided between changes in conservation and recovery requirements). First, participation in the CAR registry is compulsory and enables property owners to (1) receive deforestation amnesty for land clearing before 2008; (2) obtain environmental license for land use; (3)

trade forest quotas; and (4) gain access to rural credit (beginning in 2017). This registry is an institutional innovation from the point of view of environmental and agricultural planners because it provides a digital framework for supporting biodiversity conservation, addressing climate change commitments and advising agriculture development policies.

The second noteworthy modification introduced in the 2012 BFC is the establishment of tradable legal titles of forest (also termed environmental reserve quotas). This system was introduced to allow landowners with intact or regenerating forest in excess of the BFC requirement to trade these rights with property owners that do not meet the BFC standard. Thus, the addition provides cost effective methods for promoting compliance while providing positive incentives to exceed minimum standards. The CRA market has the potential to offset 56% of LR debt within the nation and is expected to commence in 2017 (Soares Filho et al., 2014).

The last modification addressed here is the reduction of APP and LR requirements. Recovery requirements for land in APP require larger forest buffers for wider rivers (in all iterations of the BFC), but these buffers were reduced in size with the 2012 BFC while land use allowances were expanded. For example, according to the old forest code, rivers of 10 or less meters were required to have a buffer of 30 meters from the river edge while rivers of between 50 and 200 meters were required to have a buffer of 100 meters (Table 1). The required river buffers were not changed, but the new forest code allows for "low impact"[1] use within these buffers. The APP recovery requirements were reduced more substantially, from between 50% and 85% lower depending on the size of the small property that have rivers up to 10 meters wide (Table 1). The amount of land preserved in legal reserve decreased from 80% of the property to

[1] Defined to include agroforestry, sustainable forest management and extraction of non-timber forest products by households.

a minimum of 50% and is lower with the inclusion of the APP in this definition (Table 2)[2]. Furthermore, the LR recovery requirements declined substantially with the deforestation amnesty clause: all properties that register with the CAR and are four fiscal modules in size[3] (the equivalent of 240 hectares in Rondônia) do not need to recover their forests. These changes have resulted in a reduction of the Amazonian environmental debt by approximately 59%, reducing the 1.4 million hectares that would have been recovered as APP under the previous BFC to 899,000 and the 11.4 million hectares that would have been recovered in LR to 7.2 million hectares (Soares-Filho, 2014).

To date, an impressive number rural property owners in Rondônia have registered in the CAR. The most recent report estimates that 75.63% of the area subject to the CAR (including 70,169 rural properties from a total of 180,000) has been registered (Inovacar and Conservação Internacional Brasil, 2015). This is in part explained by the blacklisting[4] of five Rondônian municipalities by the Brazilian Ministry of Environment in 2011. These "Priority Municipalities" are subjected to increased monitoring and stricter adherence to deforestation regulations and are the first to receive technical assistance with the registration process (Assunção and Romero, 2014). Municipalities can only be de-listed if

[2] In this case the state governments within the Legal Amazon define the respective state reduction level. The lowest reduction level of 50% can only be approved if the state has an Ecological-Economic Zoning Plan with evidence that 65% of its public area is protected. However, a current senate bill (PL 390/2013) has been drafted to reduce the reduction of LR in Rondônia to 50%. This bill is backed by the argument that more than 56.5% of the state (24.5% in conservation and 32% allocated to indigenous territory) cannot be used for future development or agricultural activities.

[3] The Fiscal Module (FM) is an agrarian measurement expressed in hectares that varies by state. The FM defines the minimum area required for economic viability and is used to define differences between small (area < 4 FM), medium (area > 4 and ≤ 15 FM) and large farms (are >15 FM). The FM = 60ha for all municipalities in Rondônia. For more see Landau et al. (2012).

[4] The municipalities selected for priority monitoring are those with historically and/or more recently high levels of deforestation and a relatively high of deforestation over the last three to five years. Currently, 50 of the 771 municipalities within the Legal Amazon are on this list.

80% of the territory (with the exception of public protected areas and indigenous lands) is registered within the CAR. Rondônia is the only state in the Amazon, and one of four in the nation to institute a "Plan for Environmental Regularization" establishing guidelines for APP and LR recovery (Inovacar and Conservação Internacional Brasil, 2015). Advertising campaigns carried out by the State Environmental Development Secretary (SEDAM) in cooperation with the Department of Agriculture, Institute of Technical Assistance and Rural Extension (EMATER), trade unions, and local governments have provided technical assistance with the registration process (Inovacar and Conservação Internacional Brasil, 2015).

3.0 BFC Compliance as Discrete Choice

The decision to develop a recovery plan (and create APP) is treated as a dichotomous choice. The household chooses to develop a plan based on the utility that is derived from the efforts relative to not developing this plan and chooses the combination of land uses that delivers the maximum utility. Since the decision to develop a recovery plan is not an all or nothing decision, the extent of the plan (as measured by hectares in recovery) is also estimated. Here the utility maximization model is based on the assumption that households choose a set of land use practices based on the resources which are available, knowledge they possess, perceived risk of noncompliance, and constraints that limit these activities. Although the decision to develop a recovery plan is observable, the resulting utility is not. Differences among farmers in the non-observable underlying utility function can be modeled with household and property characteristics and relevant policy levers.

Household utility maximization is based on the non-observable underlying utility function that ranks the preference of the i*th* household according to the chosen land-use plan (Adesina and Zinnah, 1993; Rahm and

Huffman, 1984). The non-observable underlying utility function is represented by: U_{it} (H_i, $L_{i,}$ P_i), where t represents the technology choice, t=0 if a recovery plan is not undertaken and t=1 if a recovery plan is developed. Utility is derived from the observable household characteristics, H, (such as age and education of the household heads), observable property characteristics, L, (such as lot size, slope, soil and water sources), and from the observable variables that serve as policy levers for the forest code, P, (such as the demand for loans, knowledge of environmental fines (or the perceived risk of noncompliance), and exposure to extension agents). Although the utility is unobservable, the relation between the utility derived from a specific plan is a function of the vector of the observed household, property, and policy characteristics included in the utility measurement.

The household chooses between U_{i1} and U_{i2} depending upon the expected utility of a recovery plan. The utility ranking of the chosen plan is estimated from the vector of observable household, property, and policy characteristics (X) as follows:

$$U_{it} = a_i F_i(X_i) + e_{it} \qquad t = 1,2;\ i = 1,.....n \tag{1}$$

where e_{it} is a disturbance term having zero mean.

Equation 1 is not restricted to be linear; rather the distribution of F depends on the distribution of the error term. If u_i is normal, F will have a cumulative normal distribution, and if u_i is uniform F is triangular. For the purpose of this analysis, u_i is assumed to be normal, making the estimation of the probability possible using a probit model. The i*th* household will choose not to develop a recovery plan if $U_{i1} < U_{i2}$, or if the latent variable $Y^* = U_{i2} - U_{i1}$

> 0 and will choose to develop a plan when $U_{i1} > U_{i2,}$ or if the non-observable latent variable $Y^* = U_{i1} - U_{i2} > 0$:

$$Y_i = \begin{cases} 0 \;\; if \; U_{1i} > U_{2i,} & no\; reforestation\; plan\; is\; developed \\ 1 \;\; if \; U_{1i} < U_{2i,} & reforestation\; plan\; is\; developed \end{cases} \tag{2}$$

The probability that the household adopts the recovery plan or that Y_i equals one, is a function of the independent variables:

$$\begin{aligned} P_i &= \Pr(Y_i = 1) = \Pr(U_{i1} < U_{i2}) \\ &= \Pr[\alpha_1 F_i(X_i) + e_{i1} < \alpha_2 F_i(X_i) + e_{i2}] \\ &= \Pr[(e_{i2} - e_{i1}) > F_i(X_i)(\alpha_1 - \alpha_2)] \\ &= \Pr[(\mu_i) > F_i(X_i)\beta)] \\ &= F_i(X_i\beta) \end{aligned} \tag{3}$$

where X is an n x k matrix of explanatory variables, and β is a k x 1 vector of coefficients to be estimated.

The second stage of the model involves the estimation of the extent of the recovery plan once the i*th* household makes the decision to adopt a recovery plan. A Heckman model where u_i is an independently normal distributed error term with a zero mean and constant variance, σ[5], can be used to make this estimation:

$$\begin{aligned} Y_i &= X_i\beta \quad if \quad i^* = X_{2i}\beta_2 + \mu_i > H \\ Y_i &= 0 \quad if \quad i^* = X_{2i}\beta_2 + \mu_i \leq H \end{aligned} \tag{4}$$

Here, H is a non-observable threshold value and X_{2i} represents the independent variables used to explain the extent decision.

[5] Where $u_i = (e_{1i} - e_{2i})$ as is derived in equation 3.

4.0 Study Area

We investigate the possible impact of the 2012 BFC on future land use using data derived from a stratified random sample of households[6] collected in the six municipalities in the greater Ouro Preto do Oeste region of Rondônia, Brazil (Figure 1) (Caviglia, 1999; Caviglia and Kahn, 2001). The study area is located in one of the most heavily deforested states of the Brazilian Amazon, with a history of noncompliance with legal reserve requirements (Caviglia-Harris and Harris, 2005) and a pro-development culture in support of regional growth and the expansion of the cattle industry (Vale and Andrade 2012). Given this historical context, any future compliance with the BFC and recovery efforts represents a worst-case scenario. In other words, if compliance is found in this region it is even more likely to be found in other regions where the government (or culture) is more environmentally friendly.

Deforestation in Brazilian Amazon began in the 1960's with government settlement programs, large infrastructure projects, and investment in industrial agriculture projects (Andersen, 2002, 1996; Barreto et al., 2008). By the 1980s, these programs resulted in a substantial impact on the landscape: deforestation became closely linked to market forces, specifically with the expansion of cattle ranching and soybean operations (Andersen, 1996; Margulis, 2003). Deforestation peaked in 1995 (Figure 2) triggering executive action to include more rigorous protection measures in the BFC. However, deforestation rates rose again in the 2000s with much of the increase attributed to links to agriculture (Arima et al., 2007; Barreto et al., 2008) and beef (Rivero et al., 2009). In 2004, deforestation again peaked, (INPE, 2011; Figure 2) sparking a series of combined actions by government agencies and NGOs (Nepstad et al., 2014). Despite the success of these actions, the land cleared between 2012 and 2013 increased by 28%; largely due to an increase in the global demand for

[6] The samples were stratified according to the rural county populations.

soybeans (Garrett, Lambin, and Naylor 2013) and the advancement of several major infrastructure projects (such as road paving and the construction of hydroelectric dams) (Arima et al. 2014; Benchimol and Peres 2015; Nazareno and Lovejoy 2011).

The study area includes six municipalities within the state of Rondônia representative of those within the "arc of deforestation," or the heavily deforested post-frontier area (INPE, 2011). The occupation of this region was first encouraged with the construction of the interstate highway Porto Velho - Cuiaba (BR 364) and the creation of large rural settlements by INCRA (Pedlowski and Dale, 1992). Migrants (primarily from the south and southeast) were later attracted by the relatively good soil quality and ease of access via the BR-364 (Caviglia, 1999). In the early settlement years, landowners first replaced small areas of native forests with perennial (cocoa, coconut and coffee) and annual (corn, rice, beans and cassava) crops and later converted much of these lands to pasture for livestock (Caviglia, 1999). Similar to other municipalities throughout the state (Browder et al., 2004; Vale and Andrade, 2012), dairy farming became the main industry in the 2000s with over 89% of the households in the study area participating in this market by 2009 (Caviglia-Harris, 2005, 2004). As a result, this region, and the state of Rondônia, experienced notable increases in the cattle herd both in absolute and percentage terms: the total herd increased over 56 percent since 1980 (from 250,000 to over 12 million head); representing an increase from 1% of the national herd in 1980 to more than 15% currently (Vale and Andrade, 2012).

5.0 Data

A household survey was administered in this study area in 1996, 2000, 2005 and 2009. The target population was the same in 1996 and 2000, but was expanded in 2005 and again in 2009 to include new settlements established in

the study region after 2000, to compensate for attrition occurring between waves, and to maintain a representative sample population within the original and newly settled areas. The survey data provide information on demographic characteristics of the household; hectares of land in different land uses (including forest, pasture, annual crops, perennial crops, and agroforestry), total income (based on farm production outputs and inputs, off-farm employment, and government payments); assets (such as ownership of vehicles, durable goods and cattle); and membership in farm associations and cooperatives. The core set of questions were included in each of the survey years and were expanded in 2009 to include (1) updated measures of wealth to reflect new trends; (2) information on environmental fines, extension visits, and environmental licenses; and (3) recovery efforts. In addition, each household completed a sketch map of the property outlining locations of forest, planned recovery, waterways, and physical property (including households, corrals and fences) in existence (Caviglia-Harris et al., 2012). It is from these 2009 data that most of the analysis to follow is drawn.

First, to provide an overview of the recovery efforts, we divide the sample between those households with and without a recovery plan, where the area in the recovery plan is the self-reported previously forested area that has been cleared and currently set aside for regrowth. Survey responses from 2009 suggest that 56% of the properties had recovery plans, with an average of 8 hectares set aside for recovery (Table 3). As noted in Figure 3, approximately 3 hectares of forest had been left in fallow or purposes as regrowth in prior survey years, a marked change in the amount of land set aside in previous years.

We estimate the APP debt along riversides using two different sets of assumptions (Table 3). Survey responses include the amount (hectares) of land in agriculture, forest, secondary forest, pasture and the amount already cleared that is set aside for recovery, but we do not know exactly where these areas are

located on the property (i.e. if they are located along rivers in APP or in LR; a larger forested area) and therefore cannot be certain if the forested area is included in the APP and/or the recovery plan, nor do we know if the recovery plan includes all areas along rivers or if some river-side buffers need to be added to these recovery plans. First, the area that should be in APP is calculated in a GIS as the 5-30 meter buffers located along the rivers identified with a surface hydrology map (IBGE, 1999). To calculate the APP debt, we subtract this number from the amount of land reported in the preservation plan. Positive debt values represent the additional recovery required for compliance. Because we know the amount of forest on the property but not the location, we create lower and upper bounds for this debt using liberal and conservative estimates of the amount of forest that is in APP. The first, and more conservative assumption (creating our lower bound on debt), is that the amount of area already under preservation is equal to the forest on the property (which may or may not be along rivers) and the current area set aside for the recovery plan. The second assumption (and an upper bound on debt) is the amount of area already under preservation is equal to the current area set aside for the recovery plan. In other words, this upper bound does not include the forest on the property in the calculation assuming that all remaining forest is on the back of the property (and not cleared because it is far from the property front and difficult to reach) and not along rivers. We calculate these values under both the old forest code (that was in effect in 2009, but not largely enforced) and the new forest code to provide context for the analysis of the 2009 data and the expected changes that will come with the enforcement of the 2012 law. The difference being that in 2009 these protected buffers were 30 meters and in 2012 these were reduced to 5-20 meters depending on property size (see Table 1).

A sample of 60 property sketch maps was used to test our assumptions (since these were not available for our complete sample). We find our more

liberal assumption used to calculate the upper bound APP debt (of 23-25 hectares according the old forest code and between 1-6 hectares for the new forest code) better matches these property sketches because (1) a majority of the maps located land set aside for regrowth along forest buffers (Figure 4); (2) households with no recovery plan identified forest as being located on the back of the property, but did not note secondary forest or fallow along rivers (Figure 5); and because 96% of the sample (including those with and without recovery plans) indicated that the primary forest was located in the back of the property. According to this sample, 83% of the properties require a recovery plan to be in compliance with the forest code. In comparison, the GIS estimates of APP suggest that 71% of households will need a recovery plan to preserve forested land along river buffers.

Additional data used in the analysis include access to various household characteristics. According to Table 4, 72% of the households in our sample have bank accounts, 46% have bank loans, and 75% would like to acquire a new bank loan. Furthermore, 50% of the households have a river on the property and 22% have other sources of water (mostly man made ponds). Only 4% of the sample has an environmental license, but 32% are considering applying for a license. Finally, 62% of the sample has been visited by extension agents such as representatives from the Ministry of Agrarian Development, Ministry of Social Development, or the Association of Technical Assistance and Rural Extension, Rondônia (EMATER).

Table 5 includes the last set of descriptive statistics, including household (Hi) and property (Li) characteristics expected to impact the choice to develop a recovery plan. The average education level of the household heads is over 4 years; the average number of crops sold is approximately one per household. The average property includes soils that can moderately support agriculture, while the average property is slightly over 53 hectares.

6.0 Results

Using a Heckman selection model we estimate the willingness of a household to set aside land for forest recovery, and for those households that choose the option, the extent to which the household has a recovery plan. We include education of household heads, diversification of agricultural production along with the physical properties of the lot (such as soil type, slope, distance to the citer center, size and the existence of different water sources) along with policy levers and proxies for forest code regulations outlined in Section 3. More specifically, this last group includes experience with (or knowledge of others with) environmental fines, ownership of an environmental license, the need for a bank loan, and visits from extension agents. Estimation results (Table 6) suggest that crop diversity (in comparison to more specialized production choices focused on cattle), property size, slopes and water sources on their lots (including rivers and other man made sources) all significantly and positively impact to the willingness of a household to develop this plan. In addition, households that have had extension agents visit the property, and those with environmental licenses[7] are more likely to have land set aside for recovery. Also interesting is that experience/knowledge with loans and the desire for future loans are not significant. This insignificance may be related to the lack of enforcement of the forest code at that time, (a recovery plan will not be required for the receipt of bank loans until 2017), and because most households experienced a low risk of fines and/or had little experience with this process. Only 0.2% of respondents had an environmental fine, while 22% knew of

[7] The rural property environmental license (Licença Ambiental para a Propriedade Rural – LAPR) authorizes
deforestation, forestry and livestock activities on the property. The BFC requires property owners with environmental debt to obtain a license and create an adjustment term (Termo de Ajustamento de Conduta - TAC)
including a revised commitment to restore APP and LR but these requirements were largely ignored before the 2012 BFC. Property owners can now obtain their environmental license in the CAR.

someone who had a fine. The estimation of recovery extent reveals interesting results mainly due to the lack of significant predictors. The extent of the reforestation plan is only predicted by the size of the property (Table 4). Education of the households head, property characteristics, water sources on the property are all insignificant in determining the amount of land that is set aside for recovery.

These results suggest that even though the forest code was not well enforced during the time period, the planning for the new forest code, information about the expected amnesty and enforcement, and extension efforts all had an impact on land use plans. These results also suggest an awareness of the critical role forest river buffers play in maintaining water quality and quantity that could have been acquired from local experiences with water quality and quantity issues and/or extension visits. The larger lots with more water sources were more likely to have recovery plans; suggesting knowledge of the expectations of the law and the APP requirements. Furthermore, the extent of recovery plans increased for larger lots. Again, suggesting adherence to this part of the law. While knowledge of fines and the demand for banks loans did not impact these plans, this is likely to change as enforcement is increased and the CAR property registry is organized and implemented as an official part of the code. An important take-away is that further outreach can be expected to be effective and likely to increase the participation in these programs.

7.0 Conclusion

The tropical forests of Brazil store vast amounts of carbon. The rapid clearing of this carbon sink has accounted for up to 70% of the nation's greenhouse gas emissions. Brazil's climate pledge put forward for the Paris negotiations is significant: the Rousseff administration has committed to reduce emissions to 43% of 2005 levels by 2030 (United Nations Framework

Convention on Climate Change, 2015). This commitment is largely founded in the reduction of the emissions associated with deforestation and a goal of zero deforestation by 2030, and thus hinges on the enforcement of the forest code.

The Brazilian BFC is the single most ambitious forest protection law in the world protecting 198 ± 5 million hectares of forests (an area roughly the size of Mexico) with requirements to reforest an additional 21-24 million hectares resulting in an additional sequestration of up to 9 ±2 Gt CO2e (Soares-Filho, et al. 2014). While the scope of this law is national, much of the debate on the 2012 revisions was focused on Amazonian forests. The resulting 2012 BFC includes two key measures that have the potential to increase compliance and effectiveness of forest protection laws in this region. First, the "carrot" provides forgiveness for deforestation to occur on small properties (less than 440) prior to 2008 as long as landowners registry their rural properties. Second, the "stick" or the requirements to register properties and develop a recovery plan introduces transparency and increases enforcement ability. To date,63% of the properties subject to the law have been registered in the nation and 76% of the properties subject to the law have been registered in Rondônia.

The success of this new law hinges on the actions of private property owners, many of whom have lived through previous unenforced amendments. This paper investigates the recovery plans of private property owners representative of those targeted by these amendments, in a region with a history of non-enforcement and non-compliance. Our results suggest that property size, slopes (i.e. land areas that should be protected according to the forest code), extension agent visits, and environmental licenses all significantly and positively impact to the willingness of a household to develop this plan. Most remarkable is the sheer number of households to develop these plans (56%) in light of the capricious nature of this law in 2009. These results suggest that−even in a region as heavily deforested as Ouro Preto do Oeste−there appears to be conditions for

which private land owners will create a recovery plan and adhere to the law. In the greater context of the Brazilian policy and climate change commitments, these results suggest that there is at least some justification for expecting these commitments will be upheld. Much of the success of these plans will rely heavily on the continued development of the technology, databases and framework needed to enforce the law. More importantly, our results highlight the critical role extension visits and enforcement efforts will play in fostering compliance. Without these efforts, the CAR could become nothing more than a passport for rural credit. Extension visits and enforcement efforts can provide this critical link between the online world (CAR) where it's easy to say "I will reforest" and the real world thus changing the scenario (and previous culture) of illegality.

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Figure 1 - Study Area.

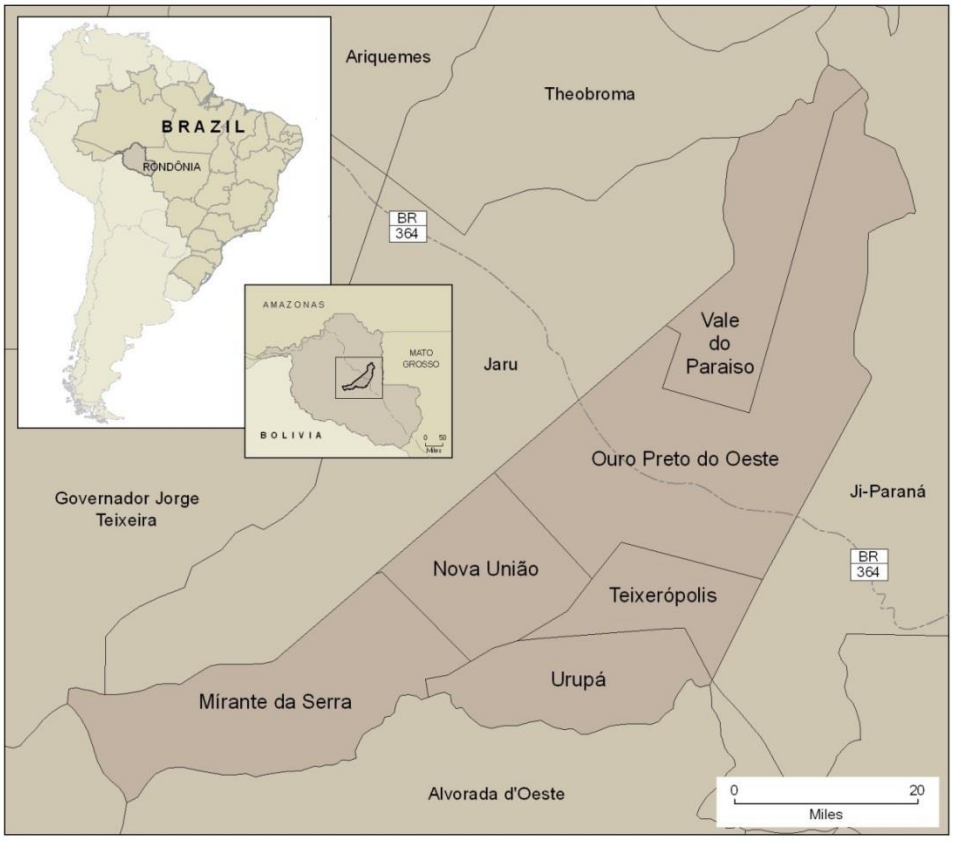


Figure 2 - Deforestation in the Brazilian Amazon (thousands of squared kilometers).

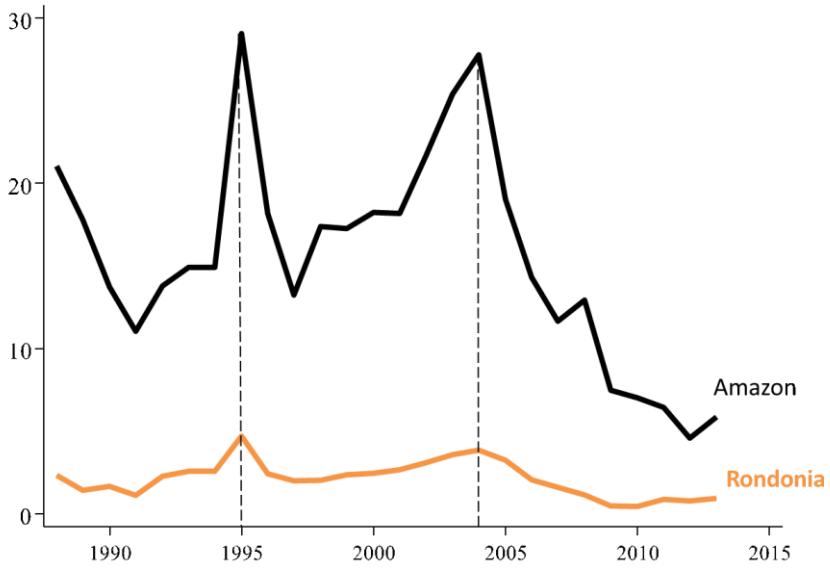


Figure 3 - Land set aside for crops, forest, agroforestry and regrowth over time, hectares.

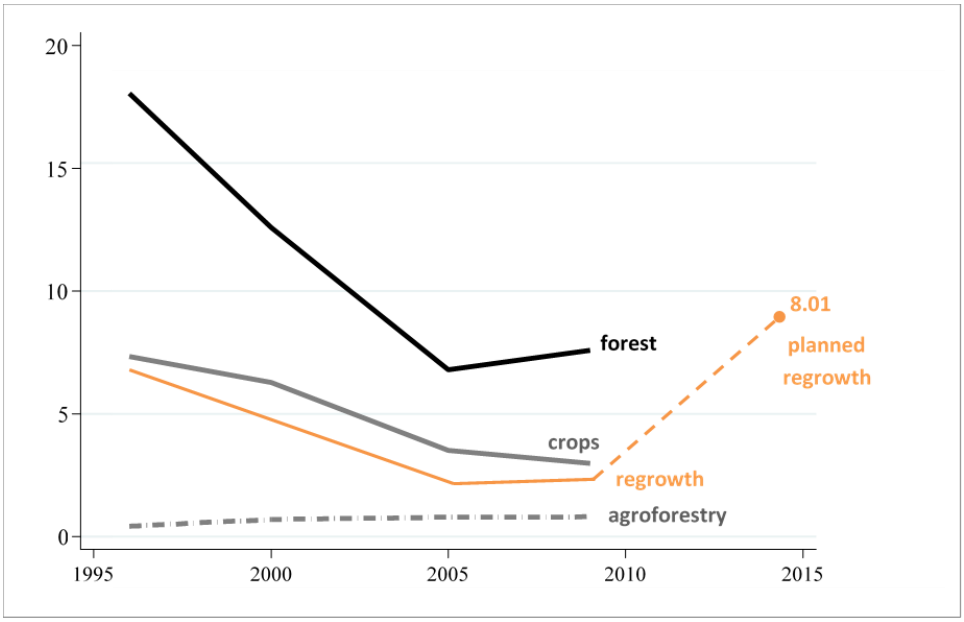
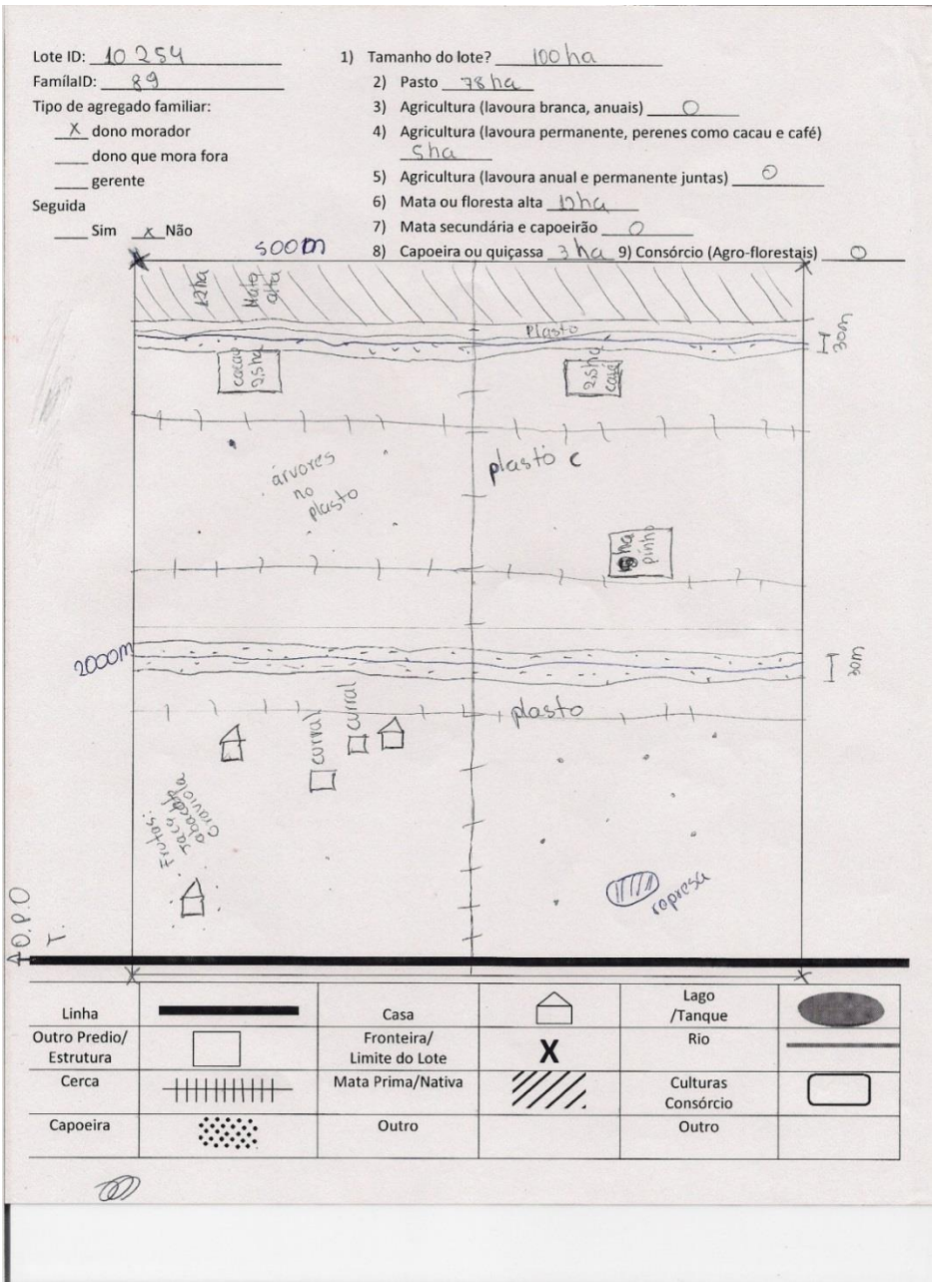
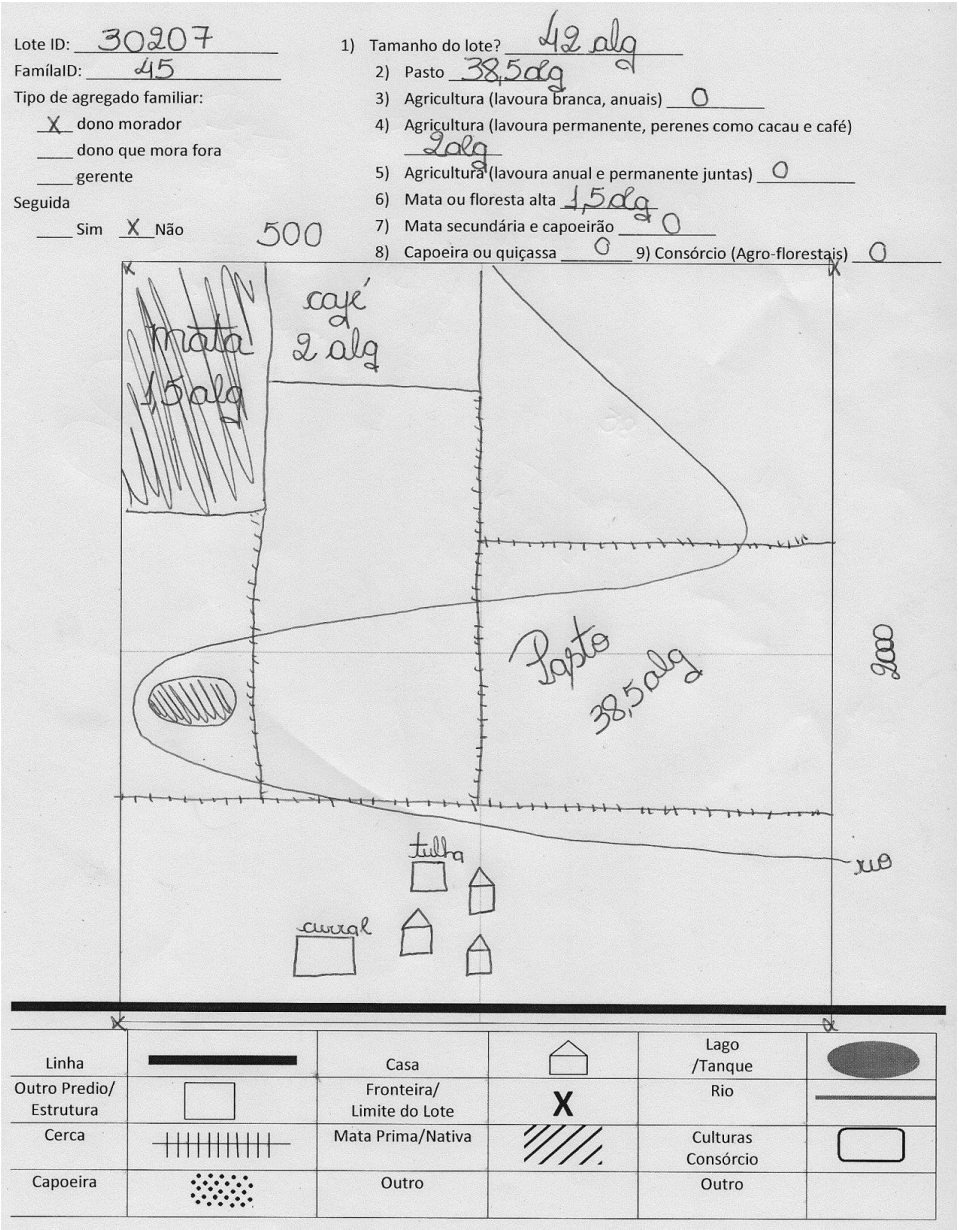


Figure 4 - Sketch map for a representative property with a reforestation plan.



Note the 30meter planned buffer around rivers (area noted with dots) and the primary forest located on the back of the property (area highlighted with hatched lines).

Figure 5 - Sketch map for a representative property without a reforestation plan.



Note the lack of planned buffers around rivers (no areas are noted with dots) and the primary forest on the property (areas highlighted with hatched lines).

Table 1 - Old and New Conservation Requirements for Areas of Permanente Preservation (APP) in the Legal Amazon.

CONSERVATION REQUIREMENTS – RIVER BUFFERS						
Old Forest Code			**New Forest Code**			
Requirement		**Allowed Use**	**Requirement**		**Allowed Use**	
River Width (m)	Required Buffer (m)					
≤10	30	None allowed	Same		Low-impact activities[1] permitted	
10-50	50					
50-200	100					
200-600	200					
>600	500					
RECOVERY REQUIREMENTS – RIVER BUFFERS						
Old Forest Code			**New Forest Code**[2][3]			
Requirement		**Allowed Use**	**Requirement**		**Allowed Use**	
River Width (m)	Required Buffer (m)		Fiscal Module[4]	Rivers Width (m)	Required Buffer (m)	
≤10	30	None allowed	≤1	-	5	Agriculture, forestry, ranching ecotourism, homes
10-50	50		1-2	-	8	
50-200	100		2-4	-	15	
200-600	200		4-10	≤10	20	
>600	500		>10	x	x/2 (20-100)	

[1] Defined by Forest Code; includes agroforestry, sustainable forest management and extraction of non-timber forest products by households.

[2] Rules apply to consolidated rural areas, i.e. portion of the rural area with deforestation (anthropogenic use) prior to 2008, prohibits new conversions to alternative land use.

[3] Recovery requirements do not exceed: 10% of the total property area in property ≤ 2 fiscal modules or 20% in properties with area >2 and ≤4 fiscal modules.

[4] The Fiscal Module (FM) is an agrarian measurement expressed in hectares that varies by state. The FM defines the minimum area required for economic viability and is used to define differences between small (area < 4 FM), medium (area > 4 and ≤ 15 FM) and large farms (are >15 FM). The FM = 60ha for all municipalities in Rondônia. For more see Landau et al. (2012).

Table 2 - Conservation Requirements of Legal Reserve (LR) in the Legal Amazon Under the Old and New Brazilian Forest Code.

CONSERVATION REQUIREMENTS							
		Old Forest Code			**New Forest Code**		
	Requirement	**Exception**	**Use Allowed**	**Inclusion of APP**	**Exception**	**Use Allowed**	**Inclusion of APP**
Forest	80% of property	-	SFM[1]	Allowed if %APP + %LR >80% of farm	50% for municipalities with Ecological-Economic Zoning Plan[2]	SFM with[3] or without[4] market purposes	Allowed if property adheres to the CAR and APP in recovery
Savannah	35% of property	-	SFM	see above	-	see above	see above
Fields	20% of property	-	SFM	see above	-	see above	see above
RECOVERY REQUIREMENTS							
		Old Forest Code			**New Forest Code**		
	Requirement	**Exception**		**Use of the deforested area in LR**	**Requirement**	**Exception**	**Use of the deforested area in LR**
Forest	80% of property	50% for farms designated with Ecological-Economic Zoning Plan		Not allowed	Farms with area ≤ 4 MF not required to recover; same requirements as old forest code for areas > 4 MF	50% for municipalities with > 50% in public conservation areas or indigenous lands	Farms with area ≤4 MF allowed farming; others can use the land except the portion in recovery
Savannah	35% of property	-		Not allowed	see above	-	see above
Fields	20% of property	-		Not allowed	see above	-	see above

[1] Sustainable Forest Management

[2] Municipalities located within a state with an approved Ecological-Economic Zoning Plan and >65% of its territory occupied by public conservation areas or indigenous lands.

[3] Sustainable Forest Management with commercial purpose depends on authorization by the environmental agency.

[4] Sustainable Forest Management without commercial purpose does not depend on authorization and it is limited to 20m^3/ha/year.

Table 3 - Forest and Reforestation by Existence a Reforestation Plan.

	Full Sample	No Reforestation Plan on Property	Reforestation Plan on Property
Area in reforestation plan	4.49	0.00	8.01
	(14.82)	(0.00)	(19.15)
Old Forest Code			
30 meter buffer along rivers (area should be in APP)	28.90	23.17	33.15
	(35.11)	(29.28)	(38.31)
APP debt (lower bound)	16.07	17.16	14.96
	(35.71)	(29.81)	(39.70)
APP debt (upper bound)	24.42	23.17	25.14
	(35.54)	(29.28)	(39.67)
New Forest Code			
5-20 meter buffer along rivers (area should be in APP)	7.96	6.11	9.35
	(13.52)	(10.20)	(15.50)
APP debt (lower bound)	-4.88	0.11	-8.83
	(21.53)	(13.77)	(25.49)
APP debt (upper bound)	3.48	6.11	1.34
	(17.27)	(10.20)	(21.09)
Observations	476	211	265

Table 4 - Forest Code Policy Levers and Requirement Proxies (n=476). (Continua)

Variable	Definition	Mean	Std. Dev.	Min	Max
Savings and Loans					
Bank Account	dummy variable=1 if the household has a bank account; 0 otherwise	0.72	0.45	0	1
Loan	dummy variable=1 if the household has a bank loan; 0 otherwise	0.46	0.50	0	1
Want New Loan	dummy variable=1 if the household wants a loan and currently holds a loan; 0 otherwise	0.75	0.43	0	1
Want Loan	dummy variable=1 if the household wants a loan and does not currently have any other loans; 0 otherwise	0.39	0.49	0	1
Water Sources					
Headwaters	dummy variable=1 if headwaters are located on the property; 0 otherwise	0.29	0.45	0	1
River	dummy variable=1 if a river is located on the property; 0 otherwise	0.50	0.50	0	1
Other Water	dummy variable=1 if another water sources (including lakes and manmade ponds) located on the property; 0 otherwise	0.22	0.42	0	1
Reforestation License					
License	dummy variable=1 if the household has a reforestation license; 0 otherwise	0.04	0.20	0	1
Considering License	dummy variable=1 if the household is considering obtaining a reforestation license; 0 otherwise	0.32	0.47	0	1

Table 4 - Forest Code Policy Levers and Requirement Proxies (n=476). (Conclusão)

Variable	Definition	Mean	Std. Dev.	Min	Max
Visits from Extension Agents and Government Officials					
Extension	dummy variable=1 if and extension agent has been o the property and provided technical assistance; 0 otherwise	0.62	0.49	0	1
Fines	Number of individuals that the household knows that has received an environmental fine including self, neighbors, and relatives)	0.22	0.43	0	2

Table 5 - Descriptive Statistics (n=476).

Variable	Definition	Mean	Std. Dev.
Education	Education level of the household head, years	4.492	3.402
Diversification	Count of fish, honey, different annual crops and a range of perennial crops sold; = 1 for each item sold	0.964	1.128
Soil	soil type on lot, characterized by ability to support agriculture (1-good, 2-moderate, 3-restricted, 4-unsuitable)	2.374	0.723
Slope	Maximum slope gradient on the lot (%)	15.983	10.176
Distance	Distance to the urban center, kilometers	41.266	18.493
Property Size	Lot size, in hectares as reported by household	53.887	49.573

Table 6 - Regression Results.

	Probability will Create a Recovery Plan		**Extent of the Planned Recovery**	
	Coeff.	Stan Err.	Coeff.	Stan Err.
Constant	-1.190***	0.349	-56.891**	28.075
Education	0.008	0.018	-0.003	0.528
Diversification	0.200***	0.058	2.881	2.495
Soil	0.083	0.099	1.842	2.858
Slope	0.011*	0.006	0.262	0.200
Distance	0.000	0.004	0.167	0.105
River	0.348***	0.144	5.514	5.615
Headwaters	0.269*	0.156	5.701	5.317
Other Water	0.448***	0.157	8.140	6.437
Property Size	0.004***	0.002	0.290***	0.051
Extension	0.282***	0.128	0.686	5.008
Want Loan	-0.088	0.141		
License	0.584*	0.349		
Fines	0.144	0.148		
Lambda	32.28***	19.063		
Wald chi2	47.96***			
% correct predictions		65%		
n	476		265	

*, **, *** note significance at the 10, 5 and 1% significance levels respectively

ARTIGO 3

ENVIRONMENTAL RESERVE QUOTA TRADING IN THE BRAZILIAN AMAZON: CAN THIS EMERGING MARKET INCREASE THE EFFECTIVENESS OF THE FOREST CODE?

Artigo preparado de acordo com as normas da Revista Forest Economics

"versão preliminar"

Abstract

The Brazilian Forest Code (CF) is the most ambitious forest preservation law in the world, protecting an estimated 198 (± 5 million) hectares of forest. Yet, due to a lack of adherence and enforcement, this law has largely been ineffective in reducing deforestation in the Amazon. Recent revisions have the potential to increase compliance and reduce illegal deforestation. The most promising action is the establishment of a tradable environmental reserve quota (CRA) system that allows landowners with forest exceeding the BFC requirement to trade these rights with land owners that do not meet the standard. However, impacts of this market will hinge on the choices of landowners and these are still unknown. This paper investigates the probability of landowners from Rondônia, Brazil wanting to purchase or sell a CRA. The results suggest that larger properties are more willing to participate in the CRA market. In this case, levels of deforestation and land-use opportunity costs are likely to influence the desire to purchase and sell a CRA. It seems that there is a large possibility that the 2012 CF is complied. However, the CRA market is more likely to be successful if there are more actions to the law enforcement and market regulations that require law compliance.

JEL Codes: Q23, Q15, Q56

Keywords: Brazilian Forest Code, environmental law, Legal Reserve, forest conservation.

Environmental Reserve Quota trading in the Brazilian Amazon:
can this emerging market increase the effectiveness of the Forest Code**?**

1.0 Introduction

The Brazilian Forest Code (CF) is the main legislation addressed to regulate land use and promote environmental conservation on private properties in Brazil. The law requires that landowners set aside 50-80% of private properties located in the Forest Amazon as Legal Reserve (RL) and protect environmental sensitive areas such as riversides and hilltops as Areas of Permanent Preservation (APP). Yet, due to a lack of adherence and enforcement, this law has largely been ineffective in reducing deforestation in the Amazon (Soares-Filho et al. 2014). The little impact of the CF in one of the most biologically diverse biomes (Mittermeier et al. 2003) and that holds a huge stock of carbon (Nepstad et al. 2008) may, thus, have global consequences.

Recent revisions to the FC made in 2012 have included a new mechanism with the potential to increase law compliance while encourages conservation. It is a tradable environmental reserve quota system (CRA) that allows land owners with forest exceeding the CF requirement to trade these rights with property owners that do not meet the CF standard. This system is expected to be facilitated by a rural land registry (Cadastro Ambiental Rural, CAR) created to gather environmental information of all properties in Brazil and advance in forest monitoring. Because regulation detailing rules for the CRA trades is still pending and participation in this fledgling market will hinges on the decisions of landowners, the impact of the CRA system is unknown.

This paper investigates the 2012 Forest Code impact on landowners in Rondônia, Brazil one of the most heavily deforested states of the Brazilian Amazon. We analyze the probability that a landowner wishes to purchase or sell CRA. To better understand the potential of these trades in Rondônia, we also

estimate the extent of the RL declared by landowners and analyze its determinants. Data were obtained from the CAR registry including georeferenced data of properties and observations from a survey responded by landowners between 2015 and 2016. Data were supplemented with census data from IBGE at county level (IBGE 2016) This dataset provides the ability to analyze the potential impacts of the 2012 CF by investigating a potential component of demand and supply for CRA that is the desire of a land owner in participating in this market.

2.0 The Brazilian Forest Code

The BFC was first established in 1934 with the declaration that private (and not just public) land was to be formally conserved under the law. This code required the preservation of "protective forests" that, as defined by their location, play an important role in the conservation of hydrological services and in the geological stability of the property. The CF was expanded, revised and edited, over more than 80 years, to provide more concrete terms for law compliance. Despite these efforts, the protection of private forested lands has been limited, especially in the Amazon (Bacha 2005; Castro 2013; IPEA 2011; Soares-Filho et al. 2014; Sparovek et al. 2010; Sparovek et al. 2012). Over time, requirements and deadlines for the settlement of environmental debit (the difference between the amount of land to be preserved under law and the amount cleared) became habitually and institutionally ignored due to a lack of supervision, ever-changing legal requirements, and a lack of options for properties that do not comply (Bacha 2005; Sparovek et al. 2012; Stickler et al. 2013). In the case of Amazon, the conservation requirements ignored the impact of these policies on development (Siqueira and Nogueira 2004). Historical increases in deforestation rates in the early 2000s (INPE 2011) triggered efforts to improve the enforcement of the BFC. These measures included APP and RL

fines (Federal Decree. 6,514/2008) and protection regulations (under Resolution no. 3545/2008) that conditioned the guarantee of rural credit in the Amazon upon compliance with environmental regulations. These changes provoked reaction from the rural sector that, combined with a growing agribusiness and future reductions in deforestation rates, contributed to the further revised CF, eventually approved in 2012. The 2012 CF includes three important modifications we will highlight here: (1) the introduction of the rural environmental cadaster (CAR); (2) the reduction of the RL recovery requirements; and 3) the establishment of a system to enable payments for ecosystem services and facilitate the RL compliance, the Environmental Reserve Quota (contributed to the further revised CRA).

2.1 The CAR registry

The CAR is a self-declaratory online registry that integrates the environmental information of an estimated 5 million rural properties in Brazil, among particular and collective properties, such as agrarian reform settlements. This is one of the most comprehensive registries in the world and the first public and transparent mechanism to evaluate the CF compliance. The participation in the CAR registry is compulsory and enables property owners to: (1) receive deforestation amnesty for land clearing before 2008; (2) obtain environmental license for land use; (3) trade environmental quotas; and (4) gain access to rural credit. The CAR emerged as an instrument for land use monitoring and for deforestation combat in Pará state in 2006. In 2008 and 2009, it was adopted by the states of Mato Grosso and Rondônia, respectively. In these states, the georeferenced registry of rural properties was first designed to provide information of the rural property for environmental licensing purposes (Pires 2013). However, the greater pressure for adherence occurred from 2008 on, when CAR became necessary for farmers to get access to bank credit and sell

their products to the agribusiness companies under the soy and meat moratorium agreements (Gibbs et al. 2015; Nepstad et al. 2014). From 2009 on, local governments also had to encourage the CAR adherence for counties to leave the blacklist created by the Ministry of Environment, which imposes credit restrictions to the most deforested municipalities of the Amazon. Previous studies report that in Pará and Mato Grosso, the CAR was successful in terms of adherence and of deforestation reduction in small and medium properties during the first years of implementation, but positive these effects reduced over time, while impacts on large properties were uncertain (Azevedo et al. 2014).

In the case of Rondônia, a massive campaign, performed by counties and the state government to disseminate information about the CAR together with EMATER to provide technical support for small properties, has promoted substantial adherence to the system (Inovacar and Conservação Internacional Brasil 2015). In 2012, the Rondônia digital version of the CAR was launched and a centralized dataset available to the public consultation was created. On May 2015, the system was migrated to the Federal platform that integrates the CAR data from all the Brazilian states (SICAR) and the entries were put in a common format. Deadline to enter into the CAR registry was postponed to 2017 and Rondônia appears to have at least 50% of the state's total properties already inserted into the system (Inovacar and Conservação Internacional Brasil 2015). The system is operated online and automatically calculates the legal liabilities after landowners upload the georeferenced description of the property, containing the polygons of protected areas, if there are any. As the CAR is a self-declaratory registry, data inserted need validation in order to correct eventual inconsistences as those already reported for the Pará registries (Barros, Barcelos and Gallo 2016). An analysis module in SICAR is expected to automate the verification of the reported data, comparing the generated digital map to high-resolution images. However, the lack of human and technical

resources in the environmental state agencies still have to be overcome to assure the quality of field and visual validation (Soares-Filho et al. 2016). In the last stage of the registry, landowners provide objective answers to a survey that investigates their past decisions and future intentions for the land use of the property. This set of answers was used to address the research questioning. The CAR reduces costs of monitoring and enforcement and can facilitate automated demarcation of potentially tradable areas, facilitating the market for CRA (May et al. 2015).

2.2 The RL requirement

The RL emerged when the 1934 CF established that farmers must set aside 25% of the property in order to ensure the availability of raw materials and stability of the timber market (Ahrens 2007). The RL requirement was first increased to 50% of properties in 1965 and, then, to 80% of properties in 1996, as a strategy to stop deforestation in the Amazon. At that time, only 7% of properties in Brazil had set aside area for RL and only 5% in Rondônia (Oliveira and Bacha 2003). The reaction to this increase in the RL requirement triggered a series of acts along 5 years, aiming at revising the CF. In the 2000s, the RL was finally established as 80% of properties in the Amazon, including the APP areas that must be set aside for environmental conservation purposes. Under the Environmental Zoning Plan, landowners from Rondônia were allowed to reduce the RL requirement to 50% for recovery purposes. Table 1 presents the changes in the RL requirements for rural properties in Rondônia over the time. Since its creation, the RL compliance is a major challenge for the Brazilian forest policy (Oliveira and Bacha 2003). The RL purposes related to forest fragments connectivity and carbon storage have not been able to compete with the agricultural benefits of non-compliance (Stickler et al. 2013). Landowners often look at the RL as a constraint to development (Sparovek et al. 2012) or as an

area for future deforestation (Castro 2013). In the Amazon, the attempts to reduce deforestation by ever-changing RL requirements were not successful (Oliveira and Bacha 2003; Siqueira and Nogueira 2004; Stickler et al. 2013) and the biome ended up holding the largest RL debit of the country (IPEA 2011; Soares-Filho et al. 2014; Sparovek et al. 2010).

In 2012, despite the environmental losses (Brancalion et al. 2016; Garcia et al. 2013), an Environmental Compliance Program (PRA) was launched to increase the CF effectiveness. It is a voluntary program whose adherence qualifies landowners to receive forgiveness for pre-2008 deforestation, but requires from landowners a formal plan describing how APP and RL will become compliant. This plan needs to be submitted with Terms of Commitment (a legal document) and validated in the CAR registry (Machado 2016). The PRA implementation still depends on the regulation of the states that will detail the rules and conditions to forest recovery. Rondônia has recently established its state PRA under the Decree 2,0627/2016, largely adopting the federal rule. However, the recovery requirements for RL are still under negotiation with advances and retreats of complementary laws that, over the past two years, have tried to increase these requirements for small properties. The CF doesn't require RL recovery from properties sized up to 4 fiscal modules (240 hectares in Rondônia) with a forest debit incurred prior to 22 July 2008. Medium and large landowners are also exempted of RL recovery if deforestation was done by respecting the limits in effect at the time of deforestation. Overall, the environmental debit was reduced by 58% in Brazil with the new BFC provisions. Approximately 4 million of Brazilian properties still have RL debit and/or cleared (unforested) APP, an area of at least 21 million hectares in Brazil and 316,000 hectares in Rondônia (Soares-Filho et al. 2014).

Landowners must adopt at least one of these alternatives to recover the RL debit: 1) natural regeneration; 2) planting with exotic species in no more

than 50% of the area to be recovered and fully completed in 20 years; and 3) offset the RL debit of the property by acquiring areas with native vegetation from other property that exceeds to the BFC standards. This compensation could be done: 1) directly by purchasing a permanent or temporary forest easements on another property, 2) through the acquisition of a CRA; 3) by donating to the government an area within a Conservation Unit that needs to be expropriated; or 4) by registrying a forested land located on another property with debit. Among the offset alternatives, the CRA trades are highlighted here due to its potential of providing a cost effective way to promote compliance while encourages conservation (Chomitz 2004; Soares-Filho et al. 2016).

2.3 The environmental reserve quotas (CRA) system

The tradable environmental reserve quotas (CRA) system was introduced to allow landowners with intact or regenerating forest exceeding the CF requirement to trade these rights with landowners who do not meet the CF standard. Such instrument had been included in the prior BFC as "Forest Reserve Quotas" (CRF), but it has never been fully implemented and its overall results are still unknown (May et al. 2015). The new CRA market has the potential to offset 56% of RL debit within the nation (Soares-Filho et al. 2014), with benefits derived from differential opportunity costs for land with different profitability in different land uses, making it less costly to conserve or recover forests in areas with less agricultural returns while pursuing agriculture in areas with higher agricultural value (May et al. 2015).

The CRA can be used to offset the RL debit on the property, as long as the CRA provider is located in the same biome, and, preferably, within the same state. The Rondônia PRA has adopted the IBGE biome map that includes 98.8% of the state territory in the Forest Amazon biome (IBGE 2004), allowing trades among almost all the properties within the state. Acquiring areas outside

Rondônia will only be accepted if they are within the Conservation Unit of federal public domain that need expropriation and if they are located in neighboring counties. According to the CF, landowners of properties sized up 4 fiscal modules are not required to reforest and are unlikely to purchase CRA, but they can sell CRAs up to 100% of any remaining forests. The APP that have been converted can neither use compensation to become compliant nor be used as credit towards any CRA. Medium and large landowners of properties over 4 FM have not received this amnesty but can buy or sell quotas correspondent to the forest exceeding contributed to the further revised the BFC standard. Quotas can be issued on areas with existent forest or with vegetation in a process of recovering and this remaining cannot be legally deforested in the future.

The impact of the CRA market will depend on sufficient demand of forest quotas and complementary legislation regulating the market will be essential for it (May et al. 2015; Rajão and Soares-Filho 2015; Sparovek et al. 2012). In the Amazon, the potential supply is estimated to be 55,2 million hectares while effective demand is only 2 million hectares (Soares-Filho et al. 2016). Only Rondônia and Pará may have potential demand for CRA while other states might provide a high volume of supply (Amazonas, for example) (May et al. 2015). Even so, in a regulatory scenario restricted to the biome and state, the Brazilian CRA market has potential to become the largest market for forest certificates in the world by trading 4.2 million hectares with a potential market value of US$ 9.2±2.4 billion. In this case, the Amazon biome has potential to be the largest market for CRA in Brazil, trading 45% of the area traded nationwide. From this amount, 22,168 hectares are expected to be traded only in Rondônia at equilibrium prices corresponding to US$ 1,084±279/ha (Soares-Filho et al. 2016). The strength of this market can be expanded if Environmental Service Programs are integrated to the CRA market system by creating demand for forested areas (Soares-Filho et al. 2016; May et al. 2015).

Even without a regulatory framework fully established, the BVRio (Bolsa Verde do Rio de Janeiro), a nonprofit environmental asset trading company has proposed itself to administrate the CRA trades via a web-based platform (BV Rio 2016). The Bolsa Verde program works similarly to the traditional stock exchange (i.e. with buyers, sellers, and future markets) and landowners throughout Brazil can purchase or sell CRA by temporary (5, 10 or 20 years) or permanent contracts. Current prices in the Amazon, for delivery in a future market, range from R$ 58.78 (in Maranhão) to R$ 550.00 (in Roraima) per hectare per year. In Rondônia, current prices range from R$ 112.41 to R$ 164.87. Nowadays, the market has more than 3,000 participants and 3 million hectares of rural land in potential trade.

3.0 Methods

To determine the land area available to rural land owners for the CRA market, geospatial data within the CAR registry were obtained and linked with survey data describing their willingness to participate in these markets. Geospatial datasets of the state of Rondônia were exported from the SICAR platform and included 90,219 registered properties, as well as the extent of Legal Reserve (RL) and Areas of Permanent Protection (APP) within all the registered properties (Figure 1). The layers were projected to a common planar reference system (i.e., UTM) to enable the calculation of area for individual layers. Each property and all individual units of RL and APP included a unique identifier, enabling the geospatial datasets to be joined at the landowners' level and to the survey response data. The area in Legal Reserve, the percentage of Legal Reserve on the individual lot, the area in Areas of Permanent Preservation and the percentage of APP area on the individual lots were calculated from the CAR registry data. In addition, Legal Reserve areas outside the APP for individual lots were determined at the property level to obtain the percentage of RL outside

the APP areas that the land owner might trade in the CRA market. Two additional geographic measures were calculated for each lot within the CAR registry. Property centroids were generated and Euclidean distances to BR-364 were determined for each lot. These centroids were also used to calculate Euclidean distance to the center of the state capital, Porto Velho.

4.0 Data

The data used in this analysis are derived from all the registries of properties in Rondônia contained in the SICAR platform until August, 2016. Besides, the georeferenced data of the properties, observations from a survey performed with landowners were used. Since there wasn't a survey in the state system, only landowners that have registered their properties directly in the SICAR (from May, 2015 on) provided answers to the questions. These data were provided by the Laboratory of Studies and Projects in Forest Management of the Federal University of Lavras, which is responsible for the SICAR platform operation, upon authorization of the Forest Brazilian Service and the State Department of the Environment of Rondônia. Additional data used in this analysis are census data from IBGE at county level (IBGE 2016).

More than 49,000 landowners who registered in the CAR in Rondônia also completed the survey questions (Table 2). According to these responses, approximately 86% of the landowners are willing to the enroll in the environmental regularization program (PRA). There is RL debit in 30% of the properties and 25% of the landowners plan to address this deficit through natural regeneration and approximately 6% of them, through compensation or replanting. In terms of RL compensation, 6% of landowners plan to use forest quotas while a smaller percentage plan to use rental properties, offsets or donations to address this debit. Approximately 22% of landowners declared that they won't use compensation. Only 3% of them report that they had forest code

infractions prior to 2008. All the landowners report they don't have legal commitment or recovery plan signed with the government. However, 100% of the survey respondents report they have RL surplus in their properties. Only a small percentage of owners plan to do anything with their Legal Reserve surplus: 2% of them plan to institute environmental easement, 3% plan to sell a forest quota, 2% will offset the RL debit in another property owned by themselves, 2% plan to lease their surplus and 7% have other plans. Land owners report that they don't have private natural reserves (RPPN) on their properties and only 2% of the survey respondents own forest quotas instituted under the rules of the previous CF. The responses of the ones with properties equal to or less than 4 FM differ from those with properties over 4 FM, including the compensation plans for RL deficit (26% of the respondents from larger properties and 5% from the smaller properties have these plans; 25% of the respondents from smaller properties plan to allow regeneration while only 15% from larger properties have these plans).

The average property size in the studied sample is 188 ha and 95% of the properties are below four fiscal units; the smaller properties are 53 hectares on average while the larger properties of more than 4 fiscal units – including INCRA settlements - are over 2,600 hectares on average (Table 3). The average property has approximately 21% in Legal Reserve, 6% in Areas of Permanent Preservation and 11% net Legal Reserve. So, the RL surplus reported by all the landowners is likely a reporting error. The average property is approximately 32 kilometers from the state capital and 7 kilometers from the Porto Velho - Cuiabá (BR-364) interstate highway. According to these data, if all the RL of small properties are allowed to become CRA, 20% of these properties can be sold in average. But if it is possible only for the net RL of APP, this amount decreases to 10% of the small properties in average. In addition, if only the small landowners who are abiding the law are qualified to sell forest on RL, they will

need to recover 30% to 40% of their properties to be able to sell it in the market. Thus, it reveals that further regulation detailing rules for CRA are essential contributed to the further revised and may impact the trades.

5.0 Results

The variables of interest are the amount of legal reserve held on the property (as reported in the georeferenced CAR data) and the willingness to participate in the CRA market (as reported in the CAR survey). The willingness to buy and sell quotas to meet the forest code requirements as well as the current ownership of CRF were estimated. There are individual responses for the dependent variable and two independent variables (property size and distance to the BR-364), while the reminder of the explanatory variables are summed at the county level. These county indicators include the amount of area in annual and perennial crops, the cattle herd, gross domestic product, the price of pasture land, literacy, the year the county was founded and the percentage of the county that has been deforested. First, the legal reserve is estimated and, then, the willingness to participate in the CRA market is focused, using the following equation:

$$Y_{ij} = \alpha + \beta_1 H_i + \beta_2 M_j$$

where Y is the independent variable for property (i) county (j), H is a matrix of independent variables available at the property level, and M is a matrix of independent variables summarized for the county.

The Ordinary Least Squared (OLS) estimation of legal reserve explains only 8% of the variation, but suggests that the coefficient on property size (added as a control) is positive and significant as is the county GDP. This fact suggests that, once controlling for size, properties within counties with higher

GDP have significantly more RL. On the other hand, properties within municipalities that have smaller cattle herds, smaller rural populations, lower levels of deforestation and lower land prices are more likely to have higher levels of RL. Finally, properties located in younger municipalities (those with a higher year of founding) are likely to report smaller areas of RL.

After that, in the estimations of the willingness to participate in the CRA market, the models have relatively low explanatory power (pseudo R2=0.3-0.9) again. According to table 4, the willingness to purchase a quota is positively influenced by the property size, the distance from the interstate highway, the area in an annual crop, cattle herd, the year the county was founded and the percentage of the county that has been deforested. On the other hand, the results suggest that larger properties, located in younger counties, farther from the interstate highway, with more area in perennial crops, with higher GDP, higher literacy rate, more rural population and that are more highly valued are those whose owners are more likely to sell quotas. Actually, the probability of a landowner wanting to sell a quota includes many of the same significant determinants; however, many have opposing signs. As an exemplification, annual crops and cattle herd negatively influence the probability of a landowner selling a quota, but positively influence the probability of purchasing a quota. Furthermore, the total amount of deforestation in the county positively influences the probability of a landowner purchasing a quota, but negatively influences the probability of selling a quota. These opposing results suggest that some areas will be net buyers (i.e. those areas with high levels of deforestation) and other areas are more likely to be net sellers (i.e. areas with lower amounts of deforestation). However, participation in the market (as noted by the willingness to sell, buy, or own quotas) is influenced by the age of the county. Landowners in the more recently founded counties are more likely to participate in the market.

Finally, the last estimation of the probability of owning a quota suggests that the distance from the interstate highway (BR 364), the amount of perennial and annual crops in the county, the cattle herd, the rural population, the gross domestic product, the land prices, the literacy rate and the age of the county significantly influence the probability of a landowner holding a quota. It seems that the current level of deforestation in the county influences this decision. Landowners in counties with higher levels of deforestation are more likely to own these forest quotas at the time of the CAR registry.

More research using data at the landowner/property level (most of the independent variables are measured at the county level) need to be conducted in order to increase the explanatory power of the analysis. Even so, there are significant and interesting results to report. First, the results converge to the scenario in which larger properties will drive the CRA market in Brazil (Machado 2016). In fact, small properties are unlikely to purchase CRA since they aren't required to recover their RL debit. Even though an eventual regulation requires this recovery, the majority of the small landowners seems to prefer addressing their debit trough natural regeneration. Moreover, although small landowners are allowed to sell all the remaining forest as quota, the results suggest that they are unlikely to do it. Previous research suggests that the participation of these potential sellers may not materialize due to the high initial costs to obtain a CRA certificate and the requirement of land be properly titled before trading (May et al. 2015; Soares-Filho et al. 2016). The results also suggest that small landowners with lower literacy rate are less willing to sell a quota. Thus, since regulation of the market is pending and CRA prices are not completely defined yet, small owners may have not expressed their desire for selling quota due to the lack of knowledge of the law and the incentives to participate in the market.

Landowners with higher amounts of deforestation and higher costs of opportunities from cattle and annual crops (e.g., soybeans) are unlikely to set aside area in order to sell a quota and seem to perceive the CRA as an alternative more cost effective for RL compliance. Market regulation such as clean supply chain agreements under the soy and beef moratorium (Nepstad et al. 2014) and regulation for credit access (Assunção et al. 2013) may play an important role by requiring law compliance and triggering demand for CRA. Such interventions may also contribute to the high amounts of RL in counties with high GDP. Livestock intensification process may also be associated to the large amounts of RL, since there is evidence that mounting productivity in consolidated and more capitalized areas are associated to lower deforestation (Vale 2015). Therefore, the trade-off between environmental conservation and economic growth may not be so relevant to deforestation in Rondônia (Carvalho et al. 2016).

The results also suggest that landowners from counties with lower amounts of deforestation, lands with lower land-use opportunity cost and little threat of deforestation are responsible for higher amounts of RL and have potential to be the CRA sellers. Previous study has also found that areas that are not likely to be deforested in practice (while legally clearable) may supply the majority of quotas to the market (May et al. 2015). However, the lack of land titles and high initial investments expected to issue a CRA certificate can also represent obstacles to these potential sellers (Soares-Filho et al. 2016). The small properties in younger counties are likely to have lower levels of RL and it may be associated to the lower ability of the government in controlling the actions of pioneer agents, who often have greater impact in deforestation than later immigrants and less aversion to risk of non-compliance (Margulis 2003; Pfaff 1999). Even though, the results suggest that these landowners are not only more willing to purchase CRA but also to sell CRA. More research is needed to understand the current land use dynamic in these counties. The investigation also

needs to be expanded to better understand the influence of other variables in the CRA market such as the prices of pasture land and the distance of properties from the state highway, which are presented as ambiguous results and divergent of the scenario discussed above.

6.0 Conclusion

Private properties in Brazil contain 53% of the native vegetation of the county and store 105 ± 21 billion tons of CO2 equivalents (Soares-Filho et al. 2014). Land use on these areas is regulated by the BFC that establishes environmental conservation patterns to be complied by landowners. However, this law has made little impact in the Amazon, threatening the global climate stability and the maintenance of ecosystem services. Revisions of the CF made in 2012 included new mechanisms that allow landowners with forest exceeding the CF requirement to trade these rights with property owners that do not meet the standard. Therefore, the CRA system has potential to promote conservation while provides a cost effective method for promoting compliance. This research investigates the probability of a landowner from Rondônia wanting to purchase or sell CRA. The results suggest that larger properties will drive the CRA market. In this case, properties with higher level of deforestation, more area in annual crops (such as soybeans) and with more cattle herds are more willing to purchase CRA, while those properties with lower level of deforestation and less intense levels of land use are more willing to sell it. Although these are significant results, the analysis has low explanatory power. So, additional research, able to include data at household/property level, is necessary to confirm the assumptions presented above.

Despite the environmental debit in the state, landowners don't have any commitment signed for environmental restauration purposes and only 3% of them have experienced environmental fines pre-2008, indicating the weak

enforcement of the law in the state. This may have contributed to the little impact made by the quotas system established by the previous BFC. A sheer number of landowners (86%) report desire to adhere to the environmental regularization program (PRA), which suggests an opportunity to promote the law compliance and encourage the participation in the CRA market. However, it is necessary to improve law enforcement so that farmers perceive the CRA system as an alternative to comply the FC, materializing the demand for quotas. The market regulation, such as clean supply chains agreements and credit access conditioned to the law compliance may also play an essential role in ensuring demand to the market. Other positive incentives such as environmental services payment programs are also needed to encourage conservation of the remaining forest higher opportunities costs in small properties unlikely to sell quotas.

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Figure 1 - Spatial extent of registry lots in Rondônia.

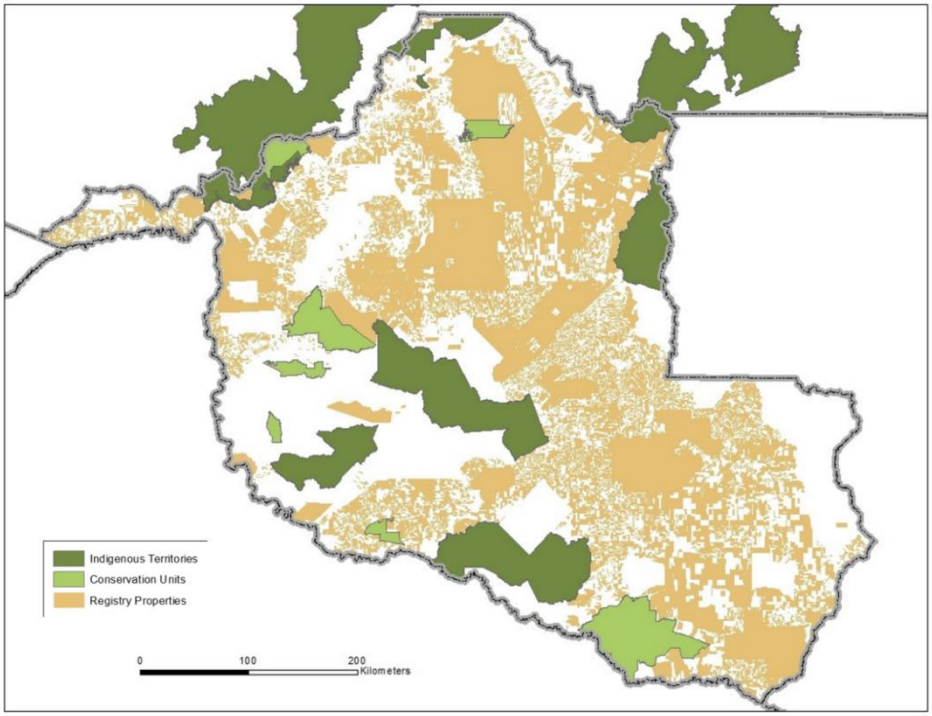

Table 1 – Changes in the Legal Reserve requirements for farms on forest areas of Rondônia

Year	Act	Number	Conservation	Recovery
1934	Federal	Decree 23,792	25%	-
1965	Federal	Law 4,771	50%	-
1991	Federal	Law 8,191	-	50%
1996	Federal	Interim Measure 1,511	80%	-
1997	Federal	Interim Measure 1,511-12	80%	50%, farms ≤ 100ha 80%, farms >100ha
2000	Federal	Interim Measure 1,956-50	80%	-
2000	State	Complementary Law 233 (not implemented)	20%: subzone 1.1[1] 40%: subzone 1.2 70%: subzone 1.3 80%: subzone 1.4 100%: zones 2 and 3	-
2001	Federal	Interim Measure 2,166-67 (adopted as a law)	80%	50% for states with EEZ[2]
2005	State	Complementary Law 312	80%	50%
2006	State	Decree 5,875	-	50%
2012	State	Federal Law 12,651	80%	0%, farms < 240ha 50%, farms > 240ha for states with EEZ
2013	Federal	Senate Bill 390 (under avaliation)	50%	-
2014	State	Complementary Law 784 (not implemeted)	-	10%, farms ≤ 120 ha 20%, farms > 120 and ≤ 240ha 50%, farms > 240ha
2016	State	Complementary Law 872 (revogated)	80%	0%, farms < 240ha 50%, farms > 240 ha for states with EEZ
2016	State	Complementary Law 892 (not implemented)	-	10%, farms ≤ 120 ha 20%, farms > 120 ha and ≤ 240ha 50%, farms > 240ha

[1] Zones according to the Ecological-Economic Zoning Plan of Rondônia
[2] Ecological-Economic Zoning Plan

Table 2 – Descriptive statistics from Rural Cadastral Registry (CAR) survey for Rondônia (it continues)
(n=49,665)

		Properties ≤ 4 Fiscal Modules			**Properties > 4 Fiscal Modules**			**All Properties**		
Variable Name	Definition	Mean	s.d.	n	Mean	s.d.	n	Mean	s.d.	n
PRA	Dummy variable indicating if the household is willingness to participate in the Environmental Regularization Program (PRA); 1=yes; 0=no	0.86	0.34	47,211	0.78	0.41	2,454	0.86	0.35	49,665
deficit	Dummy variable for Legal Reserve (LR) deficit; 1=yes; 0=no	0.30	0.46	47,211	0.33	0.47	2,454	0.31	0.46	49,665
LRdeficitplan-Compensation	Dummy variable for LR deficit plan for compensation; 1=plan to use the offset mechanism, 0=no plan to use the offset mechanism	0.05	0.22	47,211	0.26	0.44	2,454	0.06	0.24	49,665
LRdeficitplan-Regeneration	Dummy variable for LR deficit plan for natural regeneration; 1=plan to allow to regenerate naturally, 0=no plan to allow to regenerate naturally	0.25	0.43	47,211	0.15	0.35	2,454	0.25	0.43	49,665
LRdeficitplan-Replant	Dummy variable for LR deficit plan for investment in replanting; 1=plan to invest in replanting, 0=no plan to invest in replanting	0.06	0.24	47,211	0.10	0.31	2,454	0.06	0.24	49,665
LRdeficitplan-CRA	Dummy variable for LR deficit compensation plan to obtain a forest quota (CRA); 1=plan to acquire a CRA, 0=no plan to acquire a CRA	0.05	0.21	47,211	0.18	0.38	2,454	0.05	0.22	49,665
LRdeficitplan-Offset	Dummy variable for LR deficit compensation plan to offset the deficit with other land owned by respondent; 1=plan to offset with own land, 0=no plan to offset with own land	0.03	0.18	47,211	0.14	0.35	2,454	0.04	0.19	49,665
LRdeficitplan-Donate	Dummy variable for LR deficit compensation plan to offset with donation of land to public lands; 1=plan to offset with donation of land to public lands, 0=no plan to donate land to public lands	0.00	0.07	47,211	0.09	0.29	2,454	0.01	0.09	49,665

Table 2 – Descriptive statistics from Rural Cadastral Registry (CAR) survey for Rondônia (it continues) (n=49,665)

		Properties ≤ 4 Fiscal Modules			Properties > 4 Fiscal Modules			All Properties		
Variable Name	Definition	Mean	s.d.	n	Mean	s.d.	n	Mean	s.d.	n
LRdeficitplan-Rental	Dummy variable for LR deficit compensation plan to offset with rental (or sublease) to LR; 1=plan to offset with LR rental, 0=no plan to offset with LR rental	0.02	0.15	47,211	0.09	0.29	2,454	0.03	0.16	49,665
LRdeficitplan-No Knowledge of Compensation	Dummy variable for no LR deficit compensation plan; 1= no plan to offset, 0=no indication of lacking of plan to offset	0.23	0.42	47,211	0.10	0.29	2,454	0.22	0.41	49,665
TAC	Dummy variable for Termo de Ajuste de Conduta (TAC); 1=yes; 0=no	0.00	0.01	47,211	0.00	0.06	2,454	0.00	0.02	49,665
PRAD	Dummy variable for Plano de Degradação Ambiental (PRAD) or other approved document regarding the regularization; 1=yes; 0=no	0.00	0.02	47,211	0.00	0.07	2,454	0.00	0.03	49,665
Pre-2008_offense	Dummy variable for forest code infractions prior to 2008; 1=yes; 0=no	0.03	0.16	47,211	0.09	0.28	2,454	0.03	0.17	49,665
LRsurplus	Dummy variable for LR surplus; 1=yes; 0=no	1.00	0.00	47,211	0.98	0.13	2,454	1.00	0.03	49,665
LRsurplusplan Easement	Dummy variable for LR surplus plan to institute an environmental easement (Constituir servidão ambiental – to resign permanently or temporarily, in whole or in part, the right to use or remove natural resources on the property); 1=yes, 0=no	0.01	0.11	47,211	0.11	0.31	2,454	0.02	0.13	49,665

Table 2 – Descriptive statistics from Rural Cadastral Registry (CAR) survey for Rondônia (conclusion) (n=49,665)

		Properties ≤ 4 Fiscal Modules			Properties > 4 Fiscal Modules			All Properties		
Variable Name	Definition	Mean	s.d.	n	Mean	s.d.	n	Mean	s.d.	n
LRsurplusplan CRA	Dummy variable for LR surplus plan issue an Envrionmental Reserve Quota; 1=yes, 0=no	0.03	0.18	47,211	0.07	0.25	2,454	0.03	0.18	49,665
LRsurplusplan Offset	Dummy variable for LR surplus plan to use it in another property of the same title that has a remaining deficit of native vegetation, since located in the same biome to comply; 1=yes, 0=no	0.01	0.12	47,211	0.07	0.26	2,454	0.02	0.13	49,665
LRsurplusplan Lease	Dummy variable for LR surplus plan to provide for compensation of Legal Reserve by lease; 1=yes, 0=no	0.02	0.13	47,211	0.08	0.26	2,454	0.02	0.14	49,665
LRsurplusplan Other	Dummy variable for LR surplus plan to use it for another purpose; 1=yes, 0=no	0.07	0.25	47,211	0.11	0.31	2,454	0.07	0.25	49,665
RPPN	Dummy variable for existence of Reserva Particular do Patrimônio Natural - RPPN; 1=yes; 0=no	0.00	0.00	47,211	0.00	0.02	2,454	0.00	0.00	49,665
CRA_own	Dummy variable for ownership of a CRA; 1=yes; 0=no	0.02	0.13	47,211	0.01	0.09	2,454	0.02	0.13	49,665

Table 3 – Descriptive statistics from Rural Cadastral Registry (CAR) geospatial data for Rondônia (n=90,219)

		Properties ≤ 4 Fiscal Modules			**Properties > 4 Fiscal Modules**			**All Properties**		
Variable Name	Definition	Mean	s.d.	n	Mean	s.d.	n	Mean	s.d.	n
Property size	Size of the property, hectares	53.17	45.94	85,497	2620.96	17708.75	4,722	187.57	4091.37	90,219
Legal Reserve	Area of the property in legal reserve (LR), including APP, hectares	12.64	23.03	85,497	511.52	2655.45	4,722	38.75	617.93	90,219
LR percent	Percent of the property in LR including APP	0.20	0.31	85,497	0.42	0.27	4,722	0.21	0.31	90,219
APP	Area of the property in permanent preservation	3.21	4.41	85,497	46.73	136.07	4,722	5.49	32.88	90,219
APP percent	Percent of the property in APP including	0.07	0.07	85,497	0.05	0Á.05	4,722	0.07	0.07	90,219
LR net of APP	Area of the property in legal reserve (LR), that does not include APP, hectares	7.21	18.96	85,497	172.89	927.35	4,722	15.88	216.11	90,219
Net LR percent	Percent of the property in LR that does not contain APP	0.10	0.20	85,497	0.23	0.29	4,722	0.11	0.21	90,219
Distance BR-364	Distance from the property centroid to BR-364, kilometers	6.49	6.05	84,433	8.28	7.15	4,694	6.59	6.12	89,127
Distance Porto Velho	Distance the state capital, Porto Velho, kilometers	31.61	14.31	84,433	31.75	16.96	4,694	31.62	14.46	89,127

Table 4 – Estimations of reported LR and willingness to participate in the CRA market

	OLS **Legal Reserve (hectares)**	**Probit** **LR compensation plan to purchase CRA**	**Probit** **LR surplus plan to sell CRA**	**Probit** **CRA ownership**
Constant	1,436.484**	-24.108***	-13.668***	-41.340***
	(681.115)	(3.143)	(4.879)	(8.530)
Property, hectares	0.066***	0.000***	0.000***	0.000
	(0.001)	(0.000)	(0.000)	(0.000)
Distance to BR-364 from property centroid, kilometers	-0.098	0.016***	0.018***	0.020***
	(0.493)	(0.002)	(0.003)	(0.006)
Annual crops, county total, hectares (2012)	0.000	0.000***	-0.000***	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Perennial crops, county total, hectares (2012)	-0.001	0.000	0.000***	0.000***
	(0.001)	(0.000)	(0.000)	(0.000)
Cattle county herd size (2012)	-0.000***	0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Rural population (2010)	-0.001**	0.000	-0.000**	0.000**
	(0.001)	(0.000)	(0.000)	(0.000)
Gross domestic product (GDP) county total (2012)	0.000**	0.000	0.000**	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
Price of land in pasture (2012)	-0.015***	-0.000***	0.000***	0.000***
	(0.003)	(0.000)	(0.000)	(0.000)
Literacy rate, county average (2012)	303.845	0.573	2.763**	-10.463***
	(220.676)	(1.036)	(1.357)	(2.283)
Year the county was founded	-0.767**	0.011***	0.005*	0.023***
	(0.339)	(0.002)	(0.002)	(0.004)
Percent of the county deforested	-69.212***	0.268***	-0.809***	0.549***
	(15.948)	(0.082)	(0.117)	(0.181)
Adjusted R-squared	0.08	0.03	0.04	0.09
Observations	70,690	38,112	38,112	38,112

Standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%