

Four hurdles for conservation on private land: the case of the golden lion tamarin in Brazil's Atlantic Forest

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Many threatened species worldwide rely on patches of remnant vegetation in private landholdings. To establish private reserves that contribute effectively to conservation involves a wide range of complex and interacting ecological, legal, social, and financial factors. These can be seen as a series of successive hurdles, each with multiple bars, which must all be surmounted. The golden lion tamarin, *Leontopithecus rosalia*, is restricted to the Atlantic Forest biome in the state of Rio de Janeiro, Brazil. This forest is largely cleared. There are many small remnant patches on private lands, able to support tamarins. Local NGO's have successfully used limited funds to contribute to tamarin conservation in a highly cost effective way. We examined the mechanisms by analysing documents and interviewing landholders and other stakeholders. We found that the local NGOs successfully identified landholdings where ecological, legal, social, and some financial hurdles had already been crossed, and helped landholders over the final financial hurdle by funding critical cost components. This cost <5% of the price of outright land purchase. This approach is scalable for golden lion tamarin elsewhere within the Atlantic Forest biome, and applicable for other species and ecosystems worldwide.

Keywords: law, economics, finance, social, community, incentive, forest, threatened

Introduction

Practical conservation involves complex social-ecological systems (Karanth and deFries, 2010; Pereira et al., 2010; Perrings et al., 2011; Balmford, 2012; Barnosky et al., 2012; McCarthy et al., 2012; Waldron et al., 2013; Le Saout et al., 2014; Mace, 2014; Pimm et al., 2014; Schwitzer et al., 2014). This applies particularly for conservation on private landholdings, which involves legal, financial, and social interactions between multiple stakeholders (Knight et al., 2010; Bodin et al., 2014; Kamal et al., 2015a).

The significance of private landholdings for landscape-level conservation strategies has been examined extensively, with a global classification of approaches recently proposed by Kamal et al. (2015a). There are recently described examples from Europe (Kamal et al., 2015b), North America (Wallace et al., 2008; Pocewicz et al., 2011; Kamal et al., 2015b); South America (Tecklin and Sepulveda, 2014); Australia (Adams and Moon, 2013; Fitzsimons and Carr, 2014). The most commonly used and heavily studied legal models involve various forms of covenant or easement on land titles (Merenlender et al., 2004; Pocewicz et al., 2011; Adams and Moon, 2013; Rissman, 2013; Fitzsimons and Carr, 2014; Stroman and Kreuter, 2014).

The design of policy instruments to encourage private reserves includes ecological, social, and economic as well as legal considerations (Newburn et al., 2005; Paloniemi and Tikka, 2008; Wallace et al., 2008; Kauneckis and York, 2009; Knight et al., 2010; Raymond and Brown, 2011; Blackmore et al., 2014). One of the principal ecological objectives is the establishment of corridors and connections between existing reserves (Crespin and García-Villalta, 2014), and one of the key economic issues is the opportunity cost of forgoing agricultural development (Phalan et al., 2011). One of the key social mechanisms is through peer exchange and outreach (Kueper et al., 2013), and NGOs may play a critical role in these processes (Pasquini et al., 2011; Stroman and Kreuter, 2014).

Here, we propose a general model for effective practical private conservation, based on four hurdles: ecological, legal, social, and financial. The ecological hurdle is: can a particular parcel of private land contribute significantly to conservation? The legal hurdle is: do mechanisms exist to convert and maintain land use and/or tenure for conservation? The social hurdle is: is conservation an acceptable and defensible land use for landowners and the society in which they are embedded? The financial hurdle is: do landowners have funds and time to cover opportunity, establishment, and management costs for private conservation? Each of these hurdles commonly has multiple components or bars, which set the height of the hurdle.

We derive and illustrate this model using the case of the golden lion tamarin, *Leontopithecus rosalia*, in the largely cleared and privatized Atlantic Forest biome of Brazil. From interviews with the landowners concerned and the organizations that contributed, we show that local NGOs successfully identified landholders where all these hurdles save one had already been overcome. The remaining barrier was the financial cost to establish and manage a private forest reserve. By meeting this cost, these NGOs helped the landholders over that final hurdle, with significant gains for conservation of this threatened species.

Brazil's Atlantic Forest ecosystem is highly biodiverse (Myers et al., 2000), but largely cleared (Banks-Leite et al., 2014). Its original total area was 1,315,460 km² (SOS Mata Atlântica, 2015a). Of this, only 12.5%, 164,000 km², remains in patches >3 ha in area, and 8.5%, 111,800 km², in patches >100 ha in area (SOS Mata Atlântica, 2015a). The remnant areas are spread between 17 states. There are 960 individual public protected areas containing patches of the Atlantic Forest ecosystem, but only 2% of these operate under strict no-harvesting regulations (SOS Mata Atlântica, 2015a). Areas of Atlantic Forest also occur within 860 individual private reserves, 1760 km² in total area (SOS Mata Atlântica, 2015b).

The golden lion tamarin is one of a number of species dependent on the Atlantic Forest ecosystem (Raghunathan et al., 2015). It was listed as critically endangered in 1982 (Thornback and Jenkins, 1982). Its current status and distribution are detailed by Rambaldi (2002), IUCN (2014), and AMLD (2014), as follows. The remaining global population is estimated at 1000 individuals (IUCN, 2014). The species is now found in only seven of the 24 local-government municipalities in its original range (IUCN, 2014).

There are 46 private reserves protecting 8571 ha of Atlantic Forest within the 24 municipalities of the original range of the

golden lion tamarin, and 29 private reserves covering 2647 ha within the seven municipalities of its current range. A count in 2005 (Holst et al., 2006) found 550 individuals, over half the remaining global population, on 28 private landholdings. This was twice the number counted on private land in 1991 (Kierulff and Oliveira, 1996; Kierulff and Rylands, 2003). There are active reintroduction programmes from breeding centers to private reserves (Ruiz-Miranda et al., 2010). Forest conservation and restoration on private landholdings are thus critical to provide habitat for current and future conservation of this species (INEA, 2013).

Historically, poaching of golden lion tamarin for the live wildlife trade was also a major threat to this species (IUCN, 2014). Individual tamarins fetched prices of over USD 20,000 (RENCTAS, 2001). They were found frequently in the illegal live wildlife markets in Rio de Janeiro, of which there were over 100 (Rocha, 1995; Polido and Oliveira, 1997; Braga et al., 1998). Penalties were increased under Brazil's Laws 5.197/1967 and 9.605/1998. Surveillance by agents of IBAMA, the Brazilian Institute of Natural Resources, also increased. In the past decade, only three golden lion tamarins have been found for sale. Whilst anti-poaching measures continue, therefore, current conservation efforts focus principally on maintaining and expanding areas of suitable forest habitat.

For private reserves to make a successful and significant contribution to conservation of the species, requires parallel but independent decisions by numerous individual landholders. We therefore examined how those individual landholders decide whether to establish private reserves that can contribute to tamarin conservation. To identify factors affecting take-up of private conservation options, we sought information directly from landholders involved, and from key stakeholders in government agencies and NGOs involved in these efforts. Since this is a qualitative study where the primary data are the stated perceptions and experiences of those involved, our focus is on the relatively few landholders who have indeed faced and surmounted all the hurdles and successfully established private conservation reserves. In particular, we examine the strategic role of the NGOs, which in this case operates at the final hurdle.

Methods

We focussed on private reserves in the State of Rio de Janeiro which had been established in conjunction with the state government environment agency, Instituto Estadual do Ambiente (INEA). There are 143 private reserves within this State, with a total area of 12,859 ha. Approximately one third of these, 45 in all, were established with INEA. With INEA's assistance, we obtained personal introductions to the landholders concerned. During 2013/14 we were able to obtain data from 34 individual private landholders, involved in 37 reserves (82%). Golden lion tamarin have been identified on at least 10 of these, though no formal population counts have been conducted.

We used a semi-structured questionnaire format for the interviews, with open-ended questions on: landowners' motivations to establish private reserves; the barriers or difficulties they faced in establishing and maintaining reserves;

and how they had addressed such difficulties. A copy is provided in the Appendix. We obtained responses from 11 individuals through face-to-face interviews, 8 by telephone, and 15 by sending copies of the questions in written form, which they completed and returned. We obtained further information from reserve application and management documents prepared by the landholders, and from published and unpublished documents from INEA (2015), and three NGOs, namely SOS Mata Atlântica (2012), APN Rio de Janeiro (2015), and the Associação Mico-Leão-Dourado, the Golden Lion Tamarin Foundation (AMLD, 2014).

We also interviewed the three senior local staff of INEA who had been most heavily involved in these 37 RPPN's. These interviews covered: background information on INEA and the RPPN Centre; land conservation in the state of Rio de Janeiro; their perspectives on the main threats to biodiversity conservation in the state; threats and conservation efforts for the golden lion tamarin; and partnerships with NGOs and private landowners. They also addressed: the challenges in developing and managing private reserves from government and landowner perspectives; the benefits of private reserves for the environment, government and landowners; the future of the private reserve system in the state and nationally; and the role of ecotourism as an incentive in the establishment of private reserves.

All interviews and most documents were in Portuguese. Interviews were of approximately 90 min duration. Where interviewee consent was granted, interviews were recorded and transcribed using Pamela[®] software. Interviews were carried out by Fernanda de Vasconcellos Pegas, a Brazilian national and native Portuguese speaker, and results translated to English for joint analysis by all authors. Interviews followed appropriate cultural protocols, and were conducted with prior informed consent, in line with research ethics requirements (see Acknowledgments). All interview materials were collected under conditions of individual confidentiality, which has been strictly observed, particularly since some private reserve landholders and their families had been threatened by armed poachers and trespassers.

We analyzed the interview transcripts and documents using an adaptation of standard ethnographic iterative deconstruction/reassembly approaches (Bernard, 2000; Silverman, 2010; Punch, 2014). First, we extracted the smallest-scale concepts from the texts, and assembled them into higher-level constructs. Secondly, we reconceptualized the highest-level constructs as a set of hurdles, which landowners must surmount in order to contribute to conservation of lion tamarins. Thirdly, we identified specific statements within transcripts to test and illustrate this conceptual approach.

Results

Stakeholder Perceptions

Stakeholders identified a wide range of ecological, legal, social, and financial concerns, detailed below. In their interviews and responses, representatives from government agencies and NGOs generally provided more information about larger-scale legal and financial context, and individual landholders generally provided

information about the same issues at much more local scales. Government representatives were well aware of ecological and legal factors, whereas individual landowners focused on local social and financial factors. NGOs were aware of all these factors and their interactions, providing them with information to intervene successfully.

Ecological Hurdles

Private reserves can generally make the most effective contribution to conservation of any particular threatened species if a number of conditions are met, as follows. (1) Individuals of the species concerned actually occur on relevant parcels of private land, or could migrate there, or could be reintroduced successfully. (2) Where possible, and acknowledging that even a few individuals can form important reserve subpopulations, the species occurs in sufficient numbers to make a substantial contribution to the global population. (3) Where possible, the individuals form part of a breeding population, acknowledging that this may also include migratory individuals and adjacent landholdings, and that decisions by one landholder may influence neighboring landholders. (4) Where possible, the individuals add to the overall genetic diversity of the species, e.g., by including genetically distinct subpopulations. (5) Where possible, the geographical distribution of the private conservation areas provides opportunities for individuals to move between different private reserves, or between private and public reserves, either independently or through translocations. (6) Poaching, pathogens, and predation and competition from feral and invasive species are controlled on private landholdings.

Golden lion tamarin do indeed occur currently on at least some these private landholdings, even in quite small patches of remnant forest, in significant numbers and breeding populations. Our site visits showed that most of these forest patches are in good condition, and some are undergoing restoration. Some of these reserves are adjacent to other reserved areas, connected by continuous forest canopy suitable for tamarins. Some are surrounded by forest, but that forest is unprotected. There are opportunities to improve conservation of these remnant forest areas by expanding the private reserve program, so as to ensure that connections between existing reserves are not severed in future. Tamarin breeding and reintroduction programs have proved successful (Ruiz-Miranda et al., 2010).

Poaching is a significant management problem on seven of these 37 reserves, with owners subject to threats of violence, but the poachers are not targeting tamarins. They are after the edible palm *Euterpe edulis*, cut illegally for sale as palm heart. They have machetes and axes, dogs and firearms, however, so they can damage and disturb habitat and wildlife. Despite difficulties associated with control of trespass and poaching, however, private conservation reserves in Rio de Janeiro State can indeed contribute to conservation of golden lion tamarin, by providing additional habitat which can support tamarin successfully.

Legal Hurdles

Land tenure systems and land use requirements can provide major hurdles to private conservation in many countries. Legal requirements to clear and/or drain rural or agricultural land,

and/or to stock livestock at a specified minimum density, applied historically in many countries, including the USA and Australia. In some cases they still do. In Brazil, private conservation remains very difficult because of a “use it or lose it” provision in rural land tenure, part of agrarian reform measures. This provision required landowners to use their land actively for agriculture, or risk forfeiting it to the State, which could redistribute it to landless individuals. Agriculture includes livestock grazing, which need not necessarily involve forest clearance, but in practice generally does. Between 1970 and 2011 a total of 302,380 km² of private land were confiscated under this law (INCRA, 2014), so this is a major threat to landowners.

Landholders interviewed in this study made statements such as “I was afraid the government was going to take my land,” and “The main objective is to protect even the small fragments of Atlantic Forest for the future generations, since this assures the protection of springs within the property.” This blanket use-it-or-lose-it provision still operates, but has been overridden in limited circumstances by specific conservation legislation, outlined below. That is, this hurdle has been overcome, but only if specific measures are adopted.

A second legal hurdle, also widespread in many countries, is the need for a system of covenants or easements on land titles, or enforceable conservation agreements. These are required in order to ensure that private reserves are maintained and managed for conservation indefinitely. That is, they cannot subsequently be (re-)converted to agriculture or other uses, if the current or future landowners change their minds. This is a significant concern, because agricultural practices and agricultural crop, commodity and land values change over time, and so also do the personal circumstances of landholders and their families.

From a landholder’s perspective, the declaration of a permanent conservation reserve represents a financial opportunity cost. This applies even if the land is not currently valuable for agriculture, or is not currently able to repay the cost of clearing, or can currently yield a greater financial return in an undisturbed state, e.g., through ecotourism (Pegas and Castley, 2014). Those circumstances can change. Landowners interviewed for this study commented, for example, that: “I want to save [my land] for my family” and “protect the vegetation and areas with many springs in perpetuity.”

There are currently two legal systems in Brazil that can jointly overcome both these hurdles. The first is a requirement, through the Brazilian Forest Code under Law 12.651 (Brasil, 2012) for land owners to set aside a fixed proportion of their holdings as a reserve, so called *Reservas Legais*. The proportion differs between biomes, and in the Atlantic Forest biome it is 20%. There are also supplementary requirements, under the same law, for legal protection of specific local ecosystem components such as riparian zones. These are known as *Areas of Permanent Protection*, APP. From a conservation perspective, the requirements for *Reservas Legais* are weak. They do not require full conservation, but only that forest cover is maintained. The understorey may still be partially cleared and used for livestock, for example.

Since these *Reservas Legais* are a mandatory legal requirement, however, they remove the need for landowners

to make conservation decisions with opportunity costs. Interviewees commented, for example, that; “We were not using that part of the land because it overlaps the area set aside as *Legal Reserve*.” This makes it a great deal easier for landowners to adopt a higher level of conservation, through a *Reserva Particular do Patrimônio Natural* (RPPN). These are voluntary conservation reserves that may be ratified at federal, state or municipal levels, at the landowner’s choice.

At national level, RPPNs are recognized under Federal Decree 5.746 of 2006, and the enabling agency is ICMBio (2012). At State level, in Rio de Janeiro the relevant agency is INEA. As noted earlier, our focus here is on RPPNs established via INEA. One interviewee commented: “I [set up my reserve] with INEA because the federal government treated me poorly.” Another said that “with INEA there is less bureaucracy,” and another, that “INEA is more accessible and more actively engaged in the RPPN cause.” Several also commented on the role of the local representative of APN Rio de Janeiro (2015) as a champion: “[we overcame] bureaucracy and red tape thanks to Deise.” This NGO has strong ties to INEA via the RPPN program.

RPPNs have much stricter conservation requirements than *Reservas Legais*. In an RPPN, no land uses are permitted except conservation, ecotourism and education, and each reserve must be managed in accordance with a pre-approved management plan. RPPNs are not necessarily required to overlap *Reservas Legais* or APPs, but in practice they generally do, since this minimizes opportunity costs. Landowners commented: “I was able to declare the RPPN as part of the *Legal Reserve*.” Overall, therefore, legal hurdles to private conservation in the Atlantic Forest biome have been overcome through the RL and RPPN systems. Taking advantage of these legal provisions, however, imposes some financial costs on landowners, as considered below. There are also social hurdles to be overcome.

Social Hurdles

Rural landholders do not live in isolation. Typically they live within a small but powerful social context, which is provided by neighboring landholders, other local families and a broader rural community. In some cases, this social context also includes itinerant individuals such as migrant workers, landless squatters, and people who trespass for poaching or other illegal harvesting of natural resources. In some, it also includes very large-scale competitors such as industrial, agricultural or agroforestry corporations, and other industry sectors such as mining, which may compete for water rights. Landholders’ social contexts also include various government agencies. Local municipalities require rate payments. Public and private utilities providers are responsible for roads, powerlines, pipelines, etc. These may improve local economic opportunities, but may also compete for land. Policies, agencies and taxes of national and provincial governments also form part of social contexts for rural landholders.

At local scale, one of the critical social hurdles is the attitude of neighboring landholders, and other local residents, toward conservation. Some rural landholders oppose conservation, either in national parks or in private reserves. In some cases, this opposition is ideological. In others, the key issue is that

local residents who were formerly able to access particular areas informally, e.g., to use or collect natural resources free of charge, find their access much more tightly regulated or entirely excluded.

For the private reserve landowners interviewed in this study, the social hurdles differed between individual sites. In general, the commercial agricultural value of the properties were low, because as landowners commented, “My property is small.” Most of these landholdings were not used for subsistence by the owners, though one did note that “We do earn a living from the property.” Some properties had been purchased for amenity value: as one owner said, “The land was used as a family weekend getaway.” In general, the landowners interviewed had personal interests in conservation. As one said: “I created the reserve to protect the remaining fragments of forest.”

Landowners reported that with very few exceptions, their neighbors had no objections to RPPNs. Indeed, one landowner commented that “My neighbors keep an eye on the reserve when we are not here, in case there are poachers.” There has been an extended educational campaign about conservation of golden lion tamarins, so most landowners have favorable attitudes toward establishing reserves.

The principal social hurdle, for these particular reserves, was from landless and largely lawless local itinerants. These itinerants routinely entered private rural properties, technically as trespassers, so as to harvest the edible palm “*palmito-jussara*” for sale as palm heart. Several landowners reported that when they had confronted such people, they had received threats of violence or death. Since the intruders were carrying firearms and operated as illegal gangs, these threats could not be taken lightly.

Financial Hurdles

Worldwide, there are three main financial hurdles faced by private landowners aiming to establish conservation reserves: opportunity costs, establishment costs and management costs (Buckley, 2008). For Brazil’s Atlantic Forest, opportunity costs to declare the first 20% of any property as an RPPN are very low, because of the requirement for a 20% RL. The only opportunity cost is a small marginal change in land management practices. If a landholder declares a RPPN covering more than 20% of their property, however, there is an opportunity cost in lost agricultural potential for the proportion beyond 20%.

According to the landholders interviewed, operational costs are also low for most of these private reserves. Interviewees listed the key management requirements as control of fire, invasive species and poaching. Of these, poaching is the most serious threat and the most difficult to control, but it is only severe on a few landholdings, and as outlined in the preceding section, is principally a social rather than a financial issue.

Establishment costs, however, represent a significant financial hurdle for most of the landholders interviewed. These involve a number of components. Firstly, it takes time for landowners to assemble all the information needed, and from the perspective of the landowners, this time represents a cost. Secondly, in order to apply for an RPPN, the boundaries of the area concerned must be georeferenced, so there is a survey cost. Thirdly, the application process is conducted through the courts, which are only available

in cities, so there is a travel cost in order to apply. All of these costs are incurred in order to apply for an RPPN, with no guarantee of success.

Once an RPPN is established, landowners must submit a written management plan to the ratifying agency, in this case INEA, within 5 years. These plans must meet predefined criteria and be prepared to professional standards, both costly. RPPN areas must be fenced to define boundaries and exclude livestock, and fencing is relatively expensive both in time and materials. Landowners are responsible for all these costs.

Costs were mentioned by many of the interviewees as a major barrier to establishing private reserves. They said: “It is too expensive to create a RPPN,” and referred to “financial resources that we don’t have.” Different interviewees placed different emphases on the various components: “it is too expensive to get documents certified”; “too expensive to hire someone to do [georeferencing]”; “I have yet to get financial support to develop the management plan.”

In the view of the landowners interviewed, it is these application and establishment costs, more than any other hurdle, which deter private landholders from establishing RPPNs that can contribute to conservation of golden lion tamarin in Brazil’s Atlantic Forest biome. These costs are commonly USD 10,000 or less for a typical small landholding. Whilst this is an order of magnitude less than the equivalent costs in North America (CCALT, 2015), it is about a year’s average income in Brazil (Guia Trabalhista, 2015; IBGE, 2015; World Bank, 2015). For Atlantic Forest landholders who have a well above-average city-based income elsewhere, and use their rural properties principally for recreational amenity, these costs may not form a major barrier. The same may also apply to the relatively few landholders who have established successful small-scale ecotourism businesses on their properties (Pegas and Castley, 2014). For those landholders who survive on small-scale agriculture, however, the financial cost of establishing a RPPN is an insurmountable hurdle.

There are government incentive programmes intended to address this issue, but on their own, these programmes are insufficient. RPPNs are exempt from rural land taxes, but for a typical small reserve, this saves the landholder only about USD 25. Landowners interviewed noted that “the tax breaks are very limited”; and “money from tax breaks is irrelevant.” Payments for Ecological Services, PES, may also be available in some cases. The principal PES is known as E-ICMS, Ecológico Imposto sobre Operações relativas à Circulação de Mercadorias e Prestação de Serviços de Transporte Interestadual e Intermunicipal e de Comunicação. ICMS is the Brazilian state taxation system, “Tax on the Circulation of Goods and Services across interstate lines” PES under the E-ICMS, however, are paid to municipalities (ICMS Ecológico, 2014), and may not be passed on to individual landowners. The landowners interviewed also dismissed E-ICMS, saying: “There is no financial support from the government”; and “I haven’t received any support.”

Competitive grants, known as *editais*, are offered by the NGO SOS Mata Atlântica (2014), in partnership with Conservation International, specifically to offset RPPN establishment and management conservation costs (Conservation International, 2012). Over the decade 2003–2012 inclusive, this program

allocated a total of US\$1,874,140 to 553 RPPNs within the Atlantic Forest biome nationwide (SOS Mata Atlântica, 2012). In the landowner's perceptions, however, these *editais* provide a relatively small and uncertain opportunity to recover application and establishment costs.

Recognizing these complexities and hurdles, a local NGO, the Golden Lion Tamarin Foundation (GLTF), has successfully established a strategic funding programme which essentially covers the residual costs for the landholder, not met from other sources, in establishing RPPNs. The GLTF targets tamarin habitat in four key municipalities, in partnership with SOS Mata Atlântica. Of the 37 private reserves studied here, 21 had received assistance from this NGO. Landowners commented that they had: "received financial support from the NGO," and that "the NGO helped with the costs of mapping" and "the NGO gave me funding to develop the management plan."

For these landholders, all the previous hurdles have already been overcome. By lifting landholders over this final hurdle, the NGO creates private reserves, contributing to conservation of the golden lion tamarin, at a cost far below that of outright land purchase. The cost of establishing RPPNs can be approximated from data provided by SOS Mata Atlântica (2014). Between 2002 and 2012, this NGO sponsored 493 RPPNs throughout Brazil, covering a total area of 57,000 ha, at a total cost of Rs. 6,000,000. This is USD 1,923,000 at current exchange rates (Mar 2015), yielding an average cost of USD33/ha. The current market price of rural land in the municipality of Silva Jardim in the State of Rio de Janeiro, where most of the RPPNs in the current range of the golden lion tamarin are located, is in the range US\$4000–16,500/ha depending on location and local infrastructure.

Even allowing for higher-than-average costs of establishing private reserves in these prime areas, the cost of conservation via RPPNs is still well below 5% of the cost of outright land purchase, and in some cases, only 1% or less (Buckley and Pegas, 2014). Since the Golden Lion Tamarin Foundation commenced operations, 46 RPPNs covering a total of 8571 ha have been established within the original range of the golden lion tamarin (CNRPPN, 2015).

This approach has thus demonstrated success, and could be expanded to include additional areas.

Discussion

The ecological, legal, social-political, and economic-financial contexts for effective conservation of golden lion tamarin on private landholdings in Brazil's Atlantic Forest biome are highly complex and cross-linked. Most stakeholders directly involved may perceive only parts of these processes, especially if those particular parts are their responsibility or expertise. Successful conservation outcomes, however, can be achieved only if all these components are adequately considered and adjusted simultaneously.

The model presented here treats these components as a series of successive hurdles: ecological, legal, social, and financial. Each hurdle contains subsidiary components, which may be thought of as bars which add to the height of the hurdle concerned. We derived this model from a qualitative analysis of materials

from interviews with reserve landowners and other stakeholders, together with relevant documentary materials. That is, from a formal methodological perspective these four hurdles are the higher-tier constructs into which we have assembled the two dozen individual concepts which we extracted from the interview materials, and which we have described here as the bars of each hurdle.

Adopting the hurdle model or analogy provides the opportunity to extend our results from this particular case study, golden lion tamarin in Brazil's Atlantic Forest biome, to the incorporation of private reserves in threatened species conservation much more generally. Methodologically, the hurdle model is a grounded theory derived from a saturated set of interviewees under generally similar circumstances. From those interviews, we conclude that landholders differentiate about two dozen individual factors, forming four higher-tier constructs. Our model takes one further step, linking these four higher-tier constructs by expressing them as hurdles that must all be surmounted for conservation to succeed. Through this additional step, we propose a generalized model applicable to private conservation worldwide, and testable for many other species, countries, and circumstances.

This model is apparently novel. It builds on previous reviews and classifications such as that of Kamal et al. (2015a) by separating the components of successful private conservation into a series of successive stages, seen here as hurdles, which must be surmounted in sequence. As outlined in the Introduction, previous studies have considered ecological (Crespin and García-Villalta, 2014), legal (Rissman, 2013), social (Knight et al., 2010; Raymond and Brown, 2011), and economic (Phalan et al., 2011) aspects, but none has previously assembled these into a combined model which shows how an NGO (Pasquini et al., 2011; Stroman and Kreuter, 2014) can most effectively leverage its limited financial and political resources. We propose that this model is sufficiently general to be applicable across a wide range of biomes and ecosystems, jurisdictions and legal systems, countries and cultures, and socioeconomic situations.

In the particular case of the golden lion tamarin in Brazil's Atlantic Forest, the hurdle model makes it clear just how effective and focused a strategy was adopted by the local NGO, the Golden Lion Tamarin Foundation (GLTF). Amidst a morass of competing and conflicting factors, operating at different scales and through different stakeholders, they were able to identify a critical opportunity and apply limited resources with great effectiveness and efficiency. Through close involvement in golden lion tamarin conservation over an extended period, they achieved a tacit expert knowledge of conservation dynamics on private landholdings. This enabled them to adopt a successful strategy, without ever constructing a formal analytical framework as we have attempted here.

A recent case study from Kenya (Van Wijk et al., 2015) suggests that "conservation NGO's should act as 'opportunity seekers,' focus on incremental rather than radical innovations, [and] note voids and ambiguities in governmental policies that provide opportunities for non-state actors to assume the role of institutional entrepreneur." This is precisely what GLTF has done in Brazil's Atlantic Forest. The four-hurdle model, developed here

to analyse the GLTF approach for golden lion tamarin, could thus be applied for the analysis of other private land conservation initiatives worldwide. The approach suggested by Van Wijk et al. (2015) in Kenya, and taken by GLTF in Brazil, could well be adapted, expanded and copied, for a wide range of threatened species throughout Brazil and other countries.

Within Brazil, this model could be applied to the role of private reserves in conservation of other threatened species in the Atlantic Forest biome (Santos and Costa, 2008; Ferraz et al., 2012; Fink et al., 2012). It could also be applied for conservation of threatened species occurring on private lands in other biomes, such as white-browed guan *Penelope jacucaca*, gray-breasted parakeet *Pyrrhura anaca*, and rufous-breasted leaf-tosser *Sclerurus scansor cearensis* in the caatinga (Farias et al., 2005); and bare-faced curassow *Crax fasciolata*, king vulture *Sarcoramphus papa*, and black-chested buzzard-eagle *Geranoaetus melanoleucus* in the cerrado (Lazara, 2011; Posso et al., 2013). To date, partnerships between conservation organizations and private landowners to promote the establishment and management of RPPNs are relatively uncommon within Brazil. One notable exception is for leopard in the Pantanal (REPAMS, 2013).

There are well-established analogs to RPPNs in other countries, with some structural similarities. Conservation easements in the USA, for example, have been studied extensively from both social perspectives (Cross et al., 2011; Farmer et al., 2011, 2015; Sorice et al., 2013; Ghimire et al., 2014; Meyer et al., 2014; Reed et al., 2014); and also from legal perspectives (Colinvaux, 2012; Deal, 2012; Jay, 2012; Lindstrom, 2012; McLaughlin and Pidot, 2013; Sundberg, 2013). There are comparable systems in Australia, known as voluntary conservation agreements. These are more variable and experimental than in the USA, less well-developed, and less heavily studied to date (Woodroffe et al., 2010; Ollenburg and Buckley, 2011; Adams and Moon, 2013). The four-hurdle model could be applied to analyse all of these approaches.

The GLTF approach may have ecological as well as economic limitations. Private reserves can contribute most effectively to conservation of golden lion tamarin if they are incorporated into a broader integrated strategy. Such a strategy protects remnant Atlantic Forest in on private landholdings firstly in order to maintain landscape scale links and connectivity between

public protected areas, and secondly to maintain as large a total habitat area as possible. However, our study did not determine whether other landholders, currently without RPPNs, possess equally valuable forested areas, and would be equally amenable to establishing RPPNs. In addition, golden lion tamarin are a charismatic and iconic threatened species which can attract funding for conservation NGOs, and gain public and landholder support for NGO conservation initiatives. They can thus act as a flagship species to promote the establishment of private reserves, and these reserves can then also contribute to conservation of other less well-known species in the Atlantic Forest biome. However, as with many conservation efforts (Bennett et al., 2015), it may well-prove more difficult to achieve private conservation reserves in area lacking such charismatic flagship species.

By framing conservation of threatened species on private land as a series of successive hurdles, conservation advocates and analysts can examine a checklist of constraints, identify which are most critical and where they are most readily overcome, and plot a path to maximize the effect of conservation outcomes. This approach recognizes that whilst geographic patterns in biological diversity are indeed one key constraint, this ecological hurdle is only the first of four. The ecological, legal, social, political, and economic contexts for conservation are continually changing. We suggest that a multi-factor hurdle model that considers all these complexities, but simplifies them into an operational process, can make a more effective contribution than analyses which consider only one group of factors at a time.

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Appendix

Issues Addressed in Semi-Structured Interviews with Landholders

Background about the private property and landowner

- Do you live on your property?
- How many years have you lived on your property?
- What year did you or your family purchase this property?
- How many hectares is your property?

Demographics

- What is your gender?
- How old are you?
- What is your education level?
- What is your profession?

Conservation importance

- Does the RPPN overlap with any other protected area, or is it located near one?
- Does the RPPN overlap with the Legal Reserve?
- Is there an Area of Permanent Protection (APP) within your property?
- Does the RPPN overlap or coincide with the APP?
- Is the RPPN located within a watershed? If yes, what is the watershed name?
- Are there any endangered fauna and flora within the RPPN? If so, what species?
- Are there tamarins on your property?

Background information on the RPPN

- What year was the RPPN created?
- What is the area of the RPPN?
- Why did you establish your RPPN?
- How did you first learn about RPPNs?
- What challenges did you encounter during the establishment phase of the RPPN?
- What challenges did you encounter during the process of establishing the RPPN?
- What actions could ameliorate these challenges?
- What are the benefits of creating a RPPN?

Support from and perceptions about NGOs, INEA, Government

- Have you received and support from NGOs or government agencies?
- If so, what types of support, and from which entity, organization and/or agency?
- Have you partnered with any NGO's to achieve conservation goals? If so, which NGO's?

Financial contributions and challenges

- Do you promote tourism within your RPPN?
- Do you receive tax benefits from the establishment of your RPPN?
- If so, what benefits, and how much are they worth?
- Did tax benefits influence your decision to create your RPPN?
- Do you make a living off your property? From the RPPN?
- Do you generate any income from your property? From the RPPN?