Brazilian Environmental Laws and Small-Scale Farmers in Santa Catarina's Atlantic Forest, Southern Brazil

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Abstract

Santa Catarina's Atlantic Forest is a biodiversity hotspot sheltering many endangered species. Nevertheless, this Brazilian state currently suffers the most rapid loss of Atlantic Forest. Small-scale farms account for 87% of all properties, 44% of the land in the state. The Brazilian Forestry Code (BFC) requires Legal Forest Reserves (RL) and Permanent Protection of Ecologically Sensitive Areas (APP) on all rural properties in order to improve the conservation and rehabilitation of natural resources and ecological processes. Despite the importance of RLs and APPs, there is very little enforcement of these protected areas in Brazil, particularly in Santa Catarina. This happens because compliance threatens the livelihood of small farmers. In this context, Payments for Ecosystem Services (PES) for restoration activities might facilitate restoration while keeping small farms viable. We are currently developing a tool for PES planning in order to support decision-making at the municipal level. This method uses forest cover mapping and shape index to estimate local potential for ecosystem services production, and it also estimates beneficiaries' willingness to pay for targeted ecosystem services in order to evaluate actual availability of financial resources for conservation. A pilot survey in the city of Joinville points toward the potential of restored RL and APP for ecosystems services production. We used high resolution aerial photography and achieved the aims of identifying forest remains and land owners. Beneficiaries' willingness to pay for targeted ecosystem services demonstrated a great interest to find external funds to PES, what pointed to a lack of enthusiasm and local engagement in Atlantic Rain Forest conservation by local public institutions.

Key Words. Tropical Rain Forest, Payment for Ecosystem Services, decision-making.

1. Introduction

Santa Catarina's Atlantic Rain Forest is a biodiversity hotspot sheltering many endangered species (Costa et al 2005, Dean 1995, Tabarelli et al 2005). Nevertheless, this Brazilian state currently suffers the most rapid loss of Atlantic Forest (INPE and SOS Mata Atlantica 2012).

The Brazilian Forestry Code (BFC), under the Federal Law 4.771/1965, requires Legal Forest Reserves (RL) and Permanent Protection of Ecologically Sensitive Areas (APP) on all rural properties. The RL must be committed to the conservation and rehabilitation of natural resources and ecological processes. RL corresponds to 20% of rural land that must be set aside. The APP requires the maintenance or restoration of forests in 30 meters margins along small rivers and waterways and in 50 meters margins around springs, on all slopes over 45 degrees and on hilltops. Small-scale farmers are allowed to extract non-timber forest products from these protected areas. The goal of this policy is to preserve hydrological resources, the landscape, geological stability, biodiversity, and genetic flows of flora and fauna; and to protect the soil and to ensure the well-being of human populations (Aronson 2010, Aronson et al 2011, Brancalion et al 2010; Calmon et al 2011, Durigan et al 2010, Metzger 2010, Metzger et al 2010). At this time, Brazilian congress is debating revisions to BFC that would significantly weaken current levels of forest protection at the national level.

Despite the importance of RL and APP, there is very little enforcement of these protected areas in Brazil (Laurance 1999), particularly in Santa

Catarina. This happens because compliance threatens the livelihood of small farmers. Enforcing the law would require many small farmers to reforest well over half their property, which would drive them into poverty (Farley et al 2010). Santa Catarina's landscape presents few plains, many hills, and an extensive hydrological network. Small-scale farms account for 87% of all properties and 44% of the land in the state (Epagri/Cepa, 2010).

Furthermore, RL and APP limit economic activities on private properties without any compensation. Property rights can be important for economic development and wealth generation in developed and developing economies. These rights serve three key social and economic purposes: They prevent aggression, avoid forced dispossession by the state or other parties, and guarantee the individual liberty and security essential to keep peace within a society (Ingram and Hong 2008, Ostrom 1990). However, BFC restricts property rights on rural properties. This statement raises a concern regarding the symmetry between lost property rights and financial compensation. Farmers must decide how much of their land should be allocated towards economic production, and how much land should be conserved or restored to provide ecosystem services.

The BFC provides an additional incentive for conservation, but without enforcement, it remains inadequate, and with enforcement, it threatens the farmers' welfare. The results of this conflict are particularly important in Santa Catarina state where 87% of remaining forest cover is located on small-scale farmers' properties (Schaffer, 2010). In this context, Payments for Ecosystem Services (PES) for restoration activities might facilitate restoration while keeping small farms viable.

Muradian et al (2010) define PES as "a transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources" (p. 1205). PES is receiving global recognition as a serious option for conservation of ecosystems because it potentially improves the livelihoods of those people providing environmental services for the society (Petheram and Campbell 2010). PES is a policy that recognizes the need to bridge the interests of landowners (producers of ecosystems services) and external actors (users of services) through compensations (Wunder 2007).

Most of the existing PES schemes can be classified in four types of environmental services: (1) carbon sequestration and storage, (2) biodiversity protection, (3) watershed protection, and (4) protection of landscape beauty (Wunder 2007). Schemes for PES are used in developed countries but remain restrict in developing countries, with exception to Costa Rica and other pioneer experiences around the world. (Alban and Arguello 2004, Landell-Mills and Porras 2002; Pagiola et al 2002, 2004). Part of the difficulties to establish PES policies in developing countries regards to the low capacity to demonstrate incremental conservation effects in relation to a predefined baseline (additionality), a poor understanding of PES recipients' livelihoods, and a lack of balance between efficiency goals and considerations of fairness (Wunder 2007).

Following these concerns, we are currently developing a tool for PES planning in order to support decision-making at the municipal level. For this, we consider implications of accuracy of different remote sensing derived data sets to define ecosystem services baseline estimation, intending to increase municipal capacity to demonstrate additionality. We also estimate beneficiaries' willingness to pay for targeted ecosystem services as an estimative of actual availability of financial resources for conservation.

2. Materials and Methods

2.1 Study Area

In order to develop a tool for PES planning we started a pilot survey in the municipality of Joinville, located in the Northern end of the state of Santa Catarina, Southern Brazil. Joinville is the largest city of the state of Santa Catarina and it is located over the Atlantic Rain Forest on 260°18'05"S and 40°50'38"W of South America geographic coordinate system. Our study area is located in the Cubatão River basin. The area of study has 742.13ha (7.421.379,56m^2), which corresponds to 1.5% of Cubatão River basin, and it is located on the transition area between urban and rural areas on the UTM projected coordinate system, planialtimetry referential SIRGAS 2000, zone 22S, between 7102400mS and 7099600mS, 707450mE and 709500mE (Figure 1).

The Cubatão River basin is composed of a mixture of secondary forest in various stages of regeneration (IPPUJ 2009). Brazilian environmental laws (Conama 1/1994) refer to three stages of succession in Atlantic Rain Forest: initial, intermediary, and advanced (Table 1). The highest annual precipitation of the state of Santa Catarina (average 2255mm/year) occurs in this place (IPPUJ 2009).

In the 1900s, German immigrants established a settlement in this area based on agricultural activities that are in conflict with Forest cover. Deforestation and local high levels of rain cause annual floods and landslides. Nevertheless, this place still has forest remains and some legal green protected areas, and it produces ecosystems services.

2.2 Forest Cover Assessment

We produced a visual classification through a forest/non-forest map by interpretating the aerial photography with scale 1:1000 meters acquired in 2007 and 2010 using Conama 1/1994 criteria with a minimum mapping unit of 0.1ha for study area. The overall accuracy of the data set was estimated to be 90–92% by the municipal secretary of planning of Joenville. The evaluation of the accuracy of the forest cover data set provides greater confidence in this data, and it can help to increase municipal capacity to demonstrate additionality on ecosystem services production.

We used Shape Index to establish pattern measures to landscape ecology through characterization of fragment's shape deviation in relation to a circumference. This index assumes that values close to 1 represents adequate relation area-edge, *i.e.*, the core of the forest remain is as distant as possible of fragment extremities, keeping from external interferences (Forman and Godron 1986).

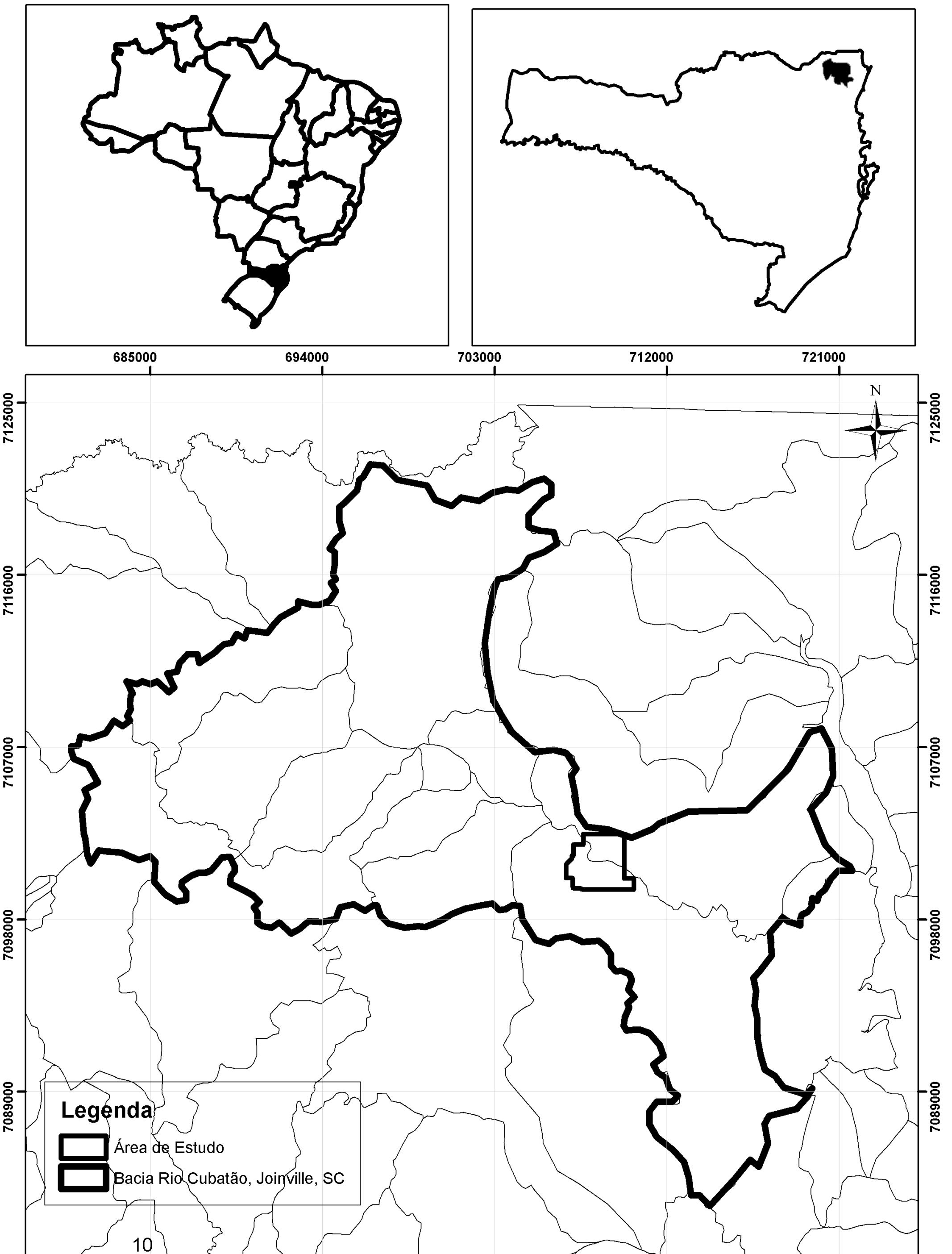


Figure 1. Localization of Research Area

In the upper left frame is the state of Santa Catarina, in the right frame is the municipality of Joinville, and our study area is placed in the central in the Cubatão River Basin

Table 1. Forest structure characteristics for all secondary stages of forest in the Cubatão River Basin

Forest stage	Canopy height	Basal area	Max. diameter at breast Height	Indicative species
Secondary Initial	4m	$8m^2$/ha	8cm	*Pteridium aquilium* (Samambaia- das-Taperas), *Melinis minutiflora* (Capim-gordura), *Andropogon bicornis sp.* (capim-andaime ou capim-rabo-de-burro), *Biden pilosa* (picão-preto), *Solidago microglossa* (vara-de-foguete), *Baccharis elaeagnoides* (vassoura), *Baccharis dracunculifolia* (Vassoura-braba)
Secondary Intermediary	12m	$15m^2$/ha	15cm	*Rapanea ferruginea* (Capororoca), *Dodonea viscosa* (Vassoura-vermelha)
Secondary Advanced	20m	$20m^2$/ha	25cm	*Miconia cinnamomifolia* (Jacatirão -açu), *Cecropia adenopus* (Embaúba), *Schizolobium parahiba* (Guapuruvu), *Piptadenia gonoacantha* (pau-jacaré), *Hieronyma alchorneoides* (licurana), *Hieronyma alchorneoides* (licurana), *Miconia cinnamomifolia* (Jacutirão-açu), *Alchornea triplinervia* (Tanheiro), *Nectandra leucothyrsus* (Canela-branca), *Ocotea catharinensis* (Canela-preta), *Euterpe edulis* (Palmiteiro), *Aspidosperma olivaceum* (peroba-vermelha)

[a] Forest structure data for Atlantic Rain Forest from Conama 1/1994.

2.3 Availability of Financial Resources for Conservation

In this research, we inquired about funds to restore riparian forest on the Cubatão River basin. We interviewed local water utilities and local water users to estimate willingness to pay for improved water quality.

We also estimated local political willingness to pay for an interactive workshop in Joinville with 12 participants from local public institutions such as the Municipal Secretary of Territorial Planning (Seplan), the Municipal Secretary of Tourism (Promotur), the Municipal Secretary for Environment (Fundema), the Municipal Foundation for Rural Development (Fundação 25 de Julho), and the State Facility for Rural Research and Extension (Epagri).

3. Results and Discussion

Forest cover mapping showed 110 fragments in the study area. Total area of forest remains was 192ha, corresponding to 26% of the study area. A rough rule of thumb from island biogeography suggests that when an ecosystem decreases in size by 90%, species diversity decreases by 50% (MacArthur and Wilson 2001). While biodiversity is not an ecosystem service itself, it plays an essential role in sustaining all ecosystem services (MEA 2005), suggesting that without active intervention, the Atlantic Forest may be due for a catastrophic loss of biodiversity and the ecosystem services it sustains.

The overall forest remains are shown in Figure 1. The fragments demarcated as “Secondary Initial Stage” are short, bushy with several permanent steams instead of a single trunk, and the *Melinis minutiflora* is the most predominant presence (Capim-gordura), covering 4.1% of the study area (8ha). The extent of the “Secondary Intermediary Stage” encompasses 39.6% of this area (76ha) and presents shrubs and trees organized in different levels of vegetation. We used *Rapanea Ferruginea* (Capororoca) as an indicative of this forest stage. “Secondary Advanced Stage” showed trees with close canopy, and high biological diversity related to structural complexity. We used species such as *Schizolobium parahiba* (Guapuruvu), *Cecropia adenopus* (Embaúba), Cedrela fisilis (Cedro), *Miconia cinnamomifolia* (Jacutirão-açu), and *Alchornea triplinervia* (Tanheiro) to identify this stage that extends for 55.7% of the study area (107ha).

We measured the perimeter of all fragments in order to calculate the Shape Index. Morphological analysis showed that 84% of forest remains presented smooth forms with index values close to 1, what means a positive relation area-edge (Forman and Godron 1986, Frisom et al 2006, Lang and Blaschke 2009). However, some fragments presented Shape Index values of 4.25. Scientists indicate that irregular edges present negatives relations area-edge pointing to core high vulnerability because it suffers microclimate and population dynamic alterations (Frisom et al 2006, Lang and Blaschke 2009).

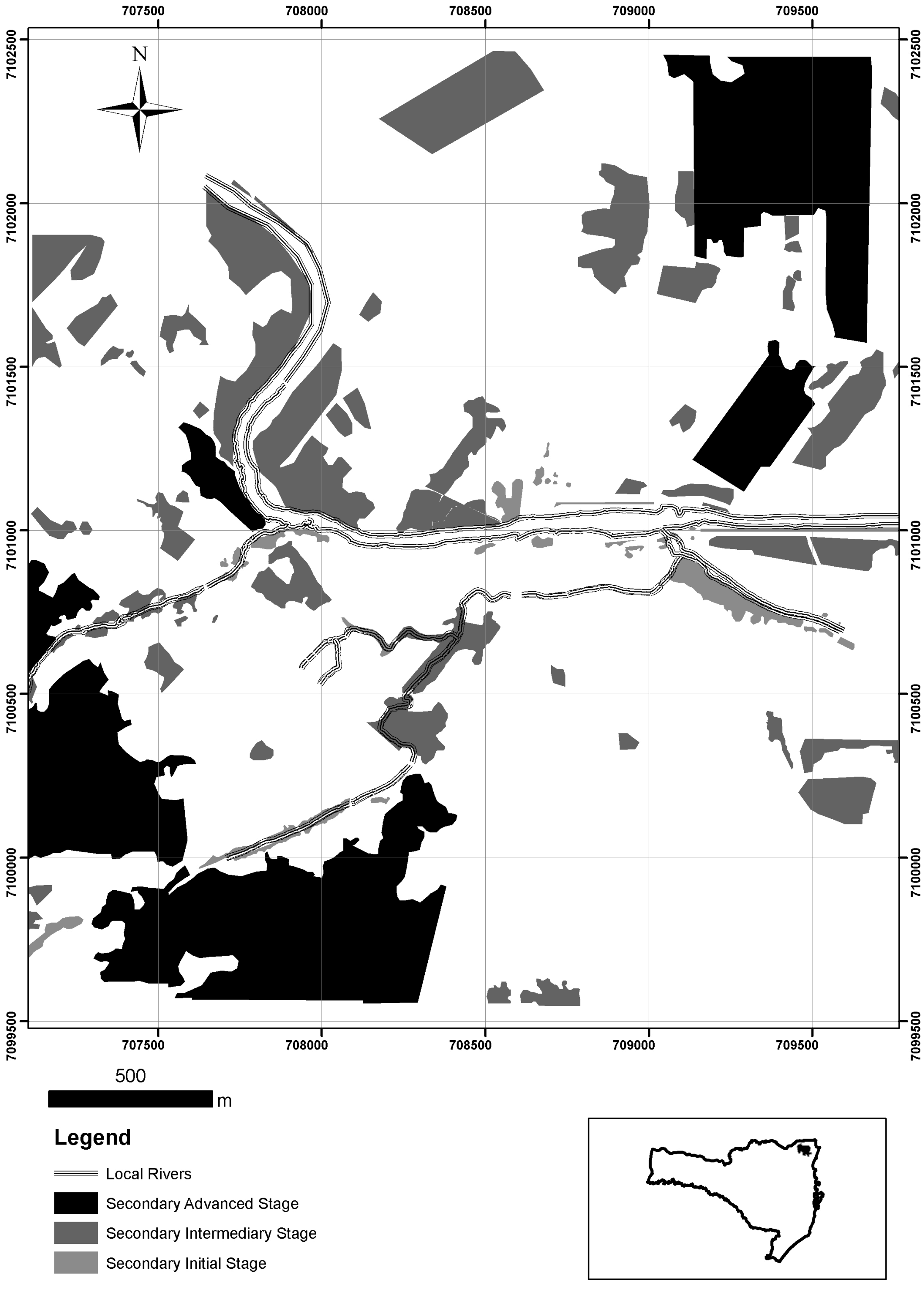


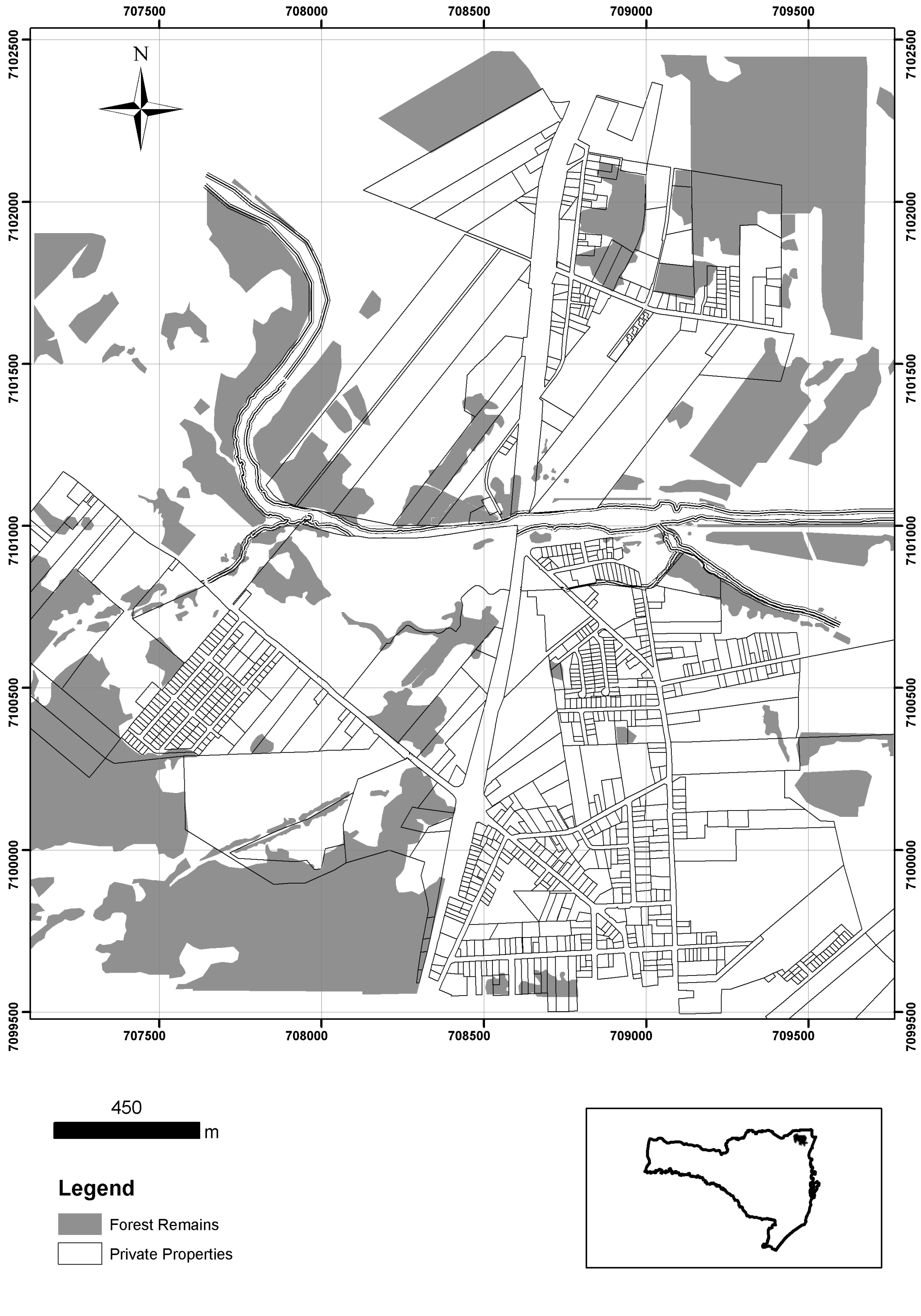
Figure 2. Stages of Forest Remains in Study Area

Fragments individual area ranged between 1ha (10000m^2) and 39ha (397312m^2) with average area of 1,9ha (19643m^2). Most of fragments (78%) presented less than 1ha. Nevertheless, the total amount of small fragments was higher than 100ha. Maciel et al (2011) mapped Atlantic Rain Forest on the entire coast of the state of Rio Grande do Norte and verified that 72% of forest remains presented less than 10ha. Many authors consider that fragment area is relevant to structural complexity and biodiversity conservation (Chiarello 1999, Collinge 1998, Cornelius et al 2000, Santos 2002). Studies on forest fragmentation point out that more than 80% of the forest remains are smaller than 50 hectares (Ribeiro et al, 2009). Nevertheless, official research about Atlantic Rain Forest covering considers only fragments bigger than 100ha. Estimative considering just fragments bigger than 100ha points to 92.5% of deforesting (INPE and SOS Mata Atlântica 2012). If fragments smaller than 100ha are considered too, the estimative can decrease to 86.5% (Ribeiro et al 2009). But, to consider fragments smalled than 100ha, high resolution images are needed.

In the state of Santa Catarina State the dynamic of deforest is different from Amazonian deforest. In the Amazon, there are large areas of deforesting contrary to Santa Catarina where there are many small spots. If official records and monitoring do not consider fragments smaller than 100ha, it can facilitate deforesting in Santa Catarina ways.

Municipal level of research presents many advantages in conservations studies because it permits to identify even small fragments of forest that can be connected. Using high resolution images, it is possible to establish an accurate ecosystem services baseline. Wunder (2007) showed the importance of baseline for the evaluation of the environmental impacts of PES, which can increase PES financial efficiency allowing municipalities to participate on different kinds of payments, *i.e.,* payments with respect to status quo (conservation that would have happened anyway), and payments for forest-cover establishment and the incremental service delivered through PES (additionality).

Municipal level of research also allows identifying specific land owners that can be involved in PES policies. In all Southern Brazil, where small rural properties are predominant, high resolution images can help identifying farmers. In the study area, we could name all land owners that still have forest remains (59), and also identify those who had properties with riparian forest (Figure 3). Studies point out an occupation of 83 millions of ha legally protected (SBPC/ABC 2011). An efficient environmental policy must to be capable to identify the providers of good and bad environment actions.



We tried to estimate beneficiaries' willingness to pay for targeted ecosystem services as an estimate of the actual availability of financial resources for conservation. We met with different public institutions, like Epagri (Public Company for Research and Rural Extension of Santa Catarina), Seplan (Joinville Municipal Secretary of Planning), Promotur (Joinville Municipal Secretary of Tourism), Fundema (Joinville Municipal Secretary of Environment), and Fundação 25 de julho (Joinville Municipal Foundation for Rural Development). We also met with a non-governamental organization of farmers (Associação das Agroindústrias da Bacia do Rio Cubatão). The results of these meetings showed general curiosity about PES but also demonstrated a lack of enthusiasm for seeking municipal funds.

Some of ecosystem services generate global benefits and can be paid by international funds, like carbon sequestration. There are essentially three types of PES schemes for carbon sequestration: payments by collective institutions, private sector payments as a result of regulations, and voluntary private sector payments (Farley et al 2010). Therefore, collective institutions are required to provide it. The Global Environment Facility is currently the leading institution, "a mechanism for international cooperation for the purpose of providing new and additional grant and concessional funding to meet the agreed incremental costs of measures to achieve agreed environmental benefits" (UNDP-GEF 1998). The clean development mechanism (CDM) of the Kyoto Protocol and other carbon emission offset schemes allow supply to adjust prices by issuing certificates for land use changes that increase carbon sequestration (UNFCCC 1998).

Even though biodiversity is not an ecosystem services, payments for biodiversity conservation can be obtained. There are four basic types of PES schemes for biodiversity, reflecting in part the distinct physical characteristics of different aspects of biodiversity: private payments for bioprospecting rights to genetic information, biodiversity offsets, conservation financing by collective institutions (including governments, NGOs and international institutions) that target the general public good benefits of biodiversity, and private payments for biodiversity friendly products (Landell-Mills and Porras 2002). Each of these has different characteristics. Clear laws and policies concerning genetic information facilitate such market-like transactions (Landell-Mills and Porras

2002). We believe that the private sector PES for genetic resources is inappropriate, and payments by collective institutions for open access of genetic information are ideal.

Biodiversity offsets function much like carbon offsets. A collective institution limits the total amount of habitat (e.g. Rain Forest) that can be converted for individual property owners or for society as a whole. Someone can exceed these limits only if they pay for restoration or conservation elsewhere. Brazil currently permits such markets in legal reserves. One major problem with such markets is that providers have an incentive to provide and purchasers to pay for minimal regulator standards. The GEF is the main source of multilateral financing for biodiversity conservation from primarily wealthy nations (UNDP-GEF 1998). Global NGOs also play an important role in collecting voluntary payments from individuals and foundations.

There are numerous types of watershed services, like flood regulation and water provision for households and hydroelectric dams. The spatial distribution of flood regulation and hence the beneficiaries are easily identified, but there is no collective institution that represents solely those beneficiaries. In general, municipal, state and federal governments respond to floods with assistance for flood victims and rebuilding of public infrastructure, and hence the appropriate collective institutions are to pay for the reforestation which can reduce the incidence and severity of both flood events and the associated landslides that cause much of the damage.

In contrast, water for household use is typically controlled by a water utility. This utility is the monopolistic intermediary between services provides and services beneficiaries. In this case, local funds can pay for ecosystems services production. The municipality of Joinville has a policy named Programa SOS Nascentes that pay 13 farmers to maintain forests around springs and main rivers. However, some institutions and all farmers we talked complain about difficulties to receive the payments related to policy problems.

4. Conclusion and Next Steps

A tool for PES planning in order to support decision-making at the municipal level needs to consider implications of accuracy of different remote sensing derived data sets to define ecosystem services baseline estimation.

We used high resolution aerial photography and achieved the aims of identify forest remains and land owners.

Beneficiaries’ willingness to pay for targeted ecosystem services demonstrated a great interest in finding external funds to PES what pointed to a lack of enthusiasm and a lack of local engagement in Atlantic Rain Forest conservation by public institutions.

Our next accomplishment will be to complete a GIS map of the study area that will depict boundaries of all legal APP areas, their degree of compliance with the forestry code, agricultural land uses, remnant forests and managed forests. This will provide a baseline for future land use changes.

We are currently conducting field trips looking for a better comprehension of PES providers’ livelihoods dynamics. The primary researchers are involved with participants in exploring their livelihood dynamics with semi-structured interviews. It is advantageous to use local researchers in this stage of the project because they share the same language and ethnic identity. The participants for the interviews were identified by controlled household selection of properties with rivers inside or in their limits (total 32) on the study area.

In these interviews, we applied Vaccaro and Norman (2008) six steps method that “should allow for a basic understanding of the social fabric of most landscapes, as well as the social backgrounds connections with its concomitant ecosystem”. This method uses a heuristic device of multilayered approach that permits to map the analysis in the geographic information systems (GIS) employed to ecosystem services baseline estimation. The relation of all steps enlightened us about social elements related to the management of natural resources in any landscape. The recognition of the importance of local practices can as well improve local acceptance of PSE policy.

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