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Bringing Biodiversity to Development: Perceptions of Integrating Eucalyptus and Forest-Corridors around the Serra do Brigadeiro, Brazil

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To the Graduate Council:

I am submitting herewith a thesis written by Maggie R Stevens entitled "Bringing Biodiversity to Development: Perceptions of Integrating Eucalyptus and Forest-Corridors around the Serra do Brigadeiro, Brazil." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry.

Dave Ostermeier, Major Professor

We have read this thesis and recommend its acceptance:

Donald Hodges, Ronald Foresta

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Abstract

The Atlantic Forest of south-eastern Brazil is a hot-spot for biodiversity and should be conserved. It is also at the center of the largest municipalities in Brazil and therefore has a severely fragmented landscape. Iracambi, a working farm near the Serra do Brigadeiro state park in Minas Gerais, is working for conservation in an area of intense agricultural production and expanding forestry industry. Most households in this rural area have some amount of eucalyptus on their property and consequently the director of Iracambi is developing the preliminary foundation for a forest corridor program comprised of primarily eucalyptus with the goal of integrating native species whenever possible. In this research, an exploratory case study was conducted with the purpose of determining if an integrated forest corridor should be considered as a viable option for Iracambi in the greater Serra do Brigadeiro region (near the communities of Araponga, Ervália, Fervadouro, Miradouro, Pedra Bonita, and Sericita). The majority of the survey participants revealed interest in the proposed forest corridor program and many expressed further interest if this would help them achieve compliance with the environmental law requiring a Legal Reserve Area (ARL) on private property. There is a need and a desire for programs that would subsidize ARL adherence in this area, since many studies recognize that adherence levels are at approximately ten percent nationally. Barriers to implementation, however, include cultural barriers that would primarily require acceptance with influential community members, knowledge and cost barriers associated with proper stand management, and current economic circumstances which lack a market for sustainably produced, higher quality eucalyptus timber. Additionally, policy barriers, which do not provide sufficient incentives to comply with environmental laws, further impede implementation of an integrated forest corridor program in this area. If these key barriers to implementation could be addressed, an integrated forest corridor program could prove as a viable option for Iracambi and this area and therefore, this thesis offers some recommendations for the successful implementation of this proposed program.

Preface

This research was undertaken in collaboration with the Iracambi Rainforest Conservation and Research Center (henceforth known as Iracambi) and the Federal University of Viçosa (UFV) in Minas Gerais, Brazil. The survey was conducted as a part of a larger research project with Iracambi, and all data was collected under their protocols, and with the guidance of a faculty member at UFV, Professor Marcio, and the director of Iracambi, Robin LeBreton.

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Introduction and General Information

Conservation Biology

The catastrophic loss of biodiversity that has occurred over the past century is astounding as “biodiversity is vitally important for human well-being since it underpins a wide range of ecosystem services on which life depends” (United Nations, 2010 pp 55). According to the United Nation’s Millennium Development Goals (MDG) 2010 report, nearly 17,000 species of plants and animals are threatened with extinction. In spite of the MDG target to stop biodiversity loss, based on current trends the loss of species is projected to continue throughout this century (United Nations, 2010). When identifying thresholds of a safe operating space in which humans can thrive, researchers estimated a biodiversity loss threshold of ten times the long-term background rate. It is now recognized that we are well beyond this biodiversity loss threshold (Rockström 2009). In fact, we are 100 to 1,000 times higher than this estimated maximum threshold for biodiversity loss (Rockström et al., 2009).

One option for addressing biodiversity loss is to save endangered species through conservation activities. However, not all species under threat can be supported with the current level of funding, which Myers (2003) calls a monumental deficit. Therefore, many authors are approaching the problem by identifying priority conservation areas or “hotspots”. These are found around the world and defined as isolated pockets of biodiversity with many endemic plants that often evolved to specific habitats. One leading author, Mittermeier (2000) identifies hotspots that occupy 2 percent of the land surface of the planet, and have 45.9 percent of all endemic plants (124,035 plant species).

Of these identified areas, 9 leading hotspots were noted that contain the sum of 30.1 percent of the world's plant species and 25 percent of the vertebrate species globally. These 9 leading hotspots now occupy 0.7 percent of the earth's land surface. On the majority of hotspot lists generated, the Atlantic Forest in Brazil is listed as a top concern; [#7 on Mittermeier's list (1998), #5 on the list by Myers (2000)]. Mittermeier notes, "what is really needed now is not further unproductive debate on whose method (of hotspot identification) is the best, but agreement on what is most important and collaborative action to ensure that as much as possible is conserved" (Mittermeier 1998, pp.519).

Atlantic Forest

The Atlantic Forest is surrounded by a Cerrado region in the West, North, and South (from 24^{o} to 4^{o} S latitude) (Jepson, 2005). Due to this isolation from other major South-American forests, the Atlantic Forest is home to many endemic fauna and flora (Morellato & Haddad, 2000). Two distinct vegetation types exist in this biome, the Rain Forest (at low to medium elevations $\leq$1000m) and semi-deciduous forest (at usually >600m elevation, on the plateau in the center and southern interior of the country) (Morellato & Haddad, 2000).

Approximately 20,000 species of trees (Conservation International, 2011) and plants (The Nature Conservancy, 2011) [8 percent of the Earth's total of plants (TNC, 2010) and 50 percent of them endemic (Conservation International, 2011)], exist in this biome, and it holds the world record for the greatest diversity of tree species in a single hectare (Bowen, 1996). This forest is home to an estimated 250 species of mammals (55 endemic), 340 amphibians (90 endemic), 1023 birds (188 endemic); more than two-thirds of some higher taxa (for example, primates) are endemic (Conservation International, 2011). Of these endemic species, 55 of the bird species, 21 of the mammals, and 14 amphibians are threatened, and 29 of the vertebrate species are critically endangered (Conservation International, 2011). There has been one documented extinction (Conservation International, 2007), and it is supposed that many species had already gone extinct before documentation began in 1500 A.D. (Morellato & Haddad, 2000).

Threats to Atlantic Forest Biodiversity

The Atlantic Rainforest is currently a sliver of its original size, with patches of secondary forest and very little primary forest remaining (Morellato & Haddad, 2000). This forest once covered 12 percent of Brazil and today has been reduced to cover just 1 percent (Couto & Dube, 2001), less than 100,000 km^2 (Tabarelli, Pinto, SILVA, Hirota, & Bedê, 2005) which can be seen in Figure 1. A long history of land conversion, from forested to agricultural land, in southeastern Brazil has resulted in a landscape with blocks of relatively in-tact forest or forests of varying sizes and spatial patterns (Santos, 2003). These areas, which were either once remote or inhospitable to agriculture, remained forested but now are heavily impacted by some of the deleterious effects of deforestation: fragmentation, island phenomena, and edge effect.

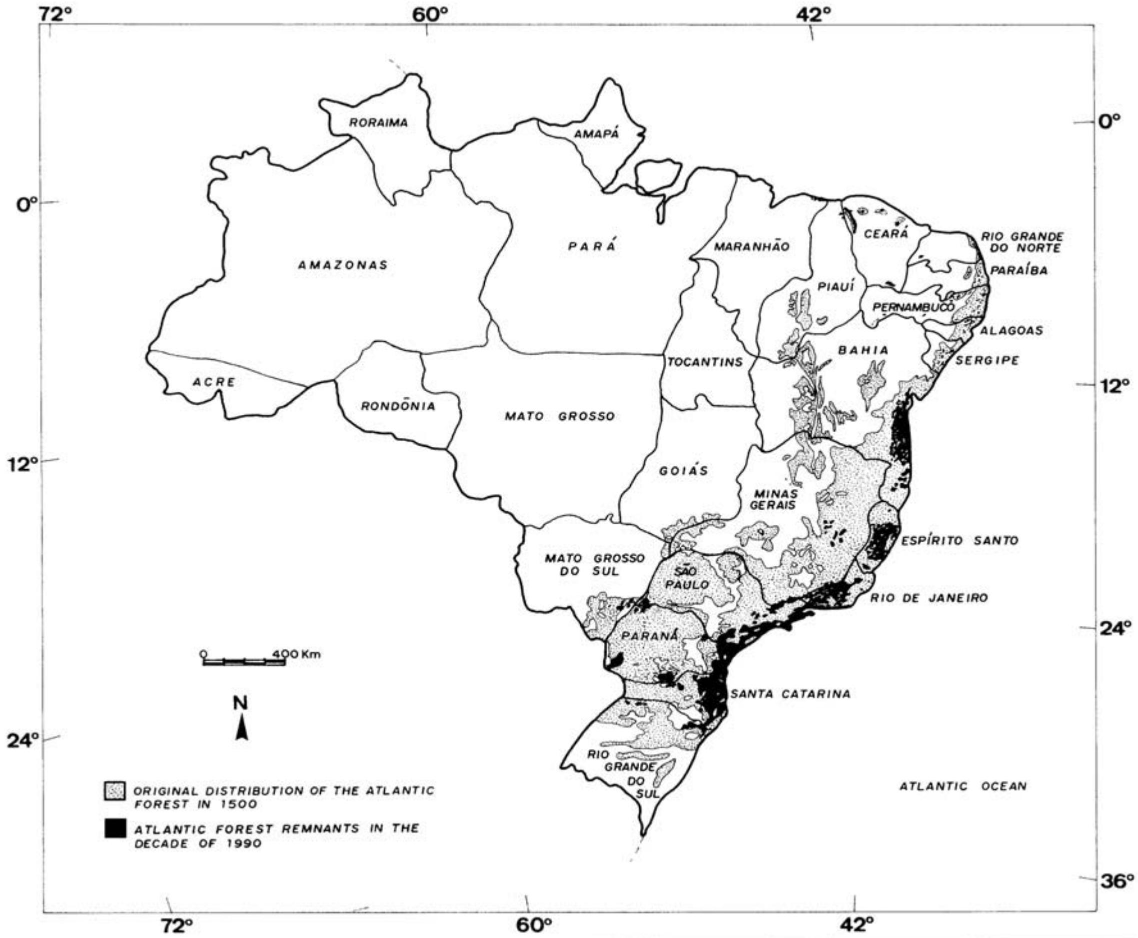

Figure 1: Deforestation in Atlantic Forest (Morellato & Haddad, 2000)

Fragmentation

Severe deforestation results in a fragmented landscape, defined as an area of small, isolated forest blocks in a matrix of dissimilar landscapes with sharp boundaries or edges between fragments (Noss, 1987). Forests isolated as fragments undergo compositional changes; changes occur in biotic and abiotic features. These fragments have more pioneer species and woody vines (lianas), higher tree-mortality, and lower seedling density (Benitez Malvido, 1998). Fragmentation can lead to decreased tree regeneration as a whole (Benitez Malvido, 1998), changes in population dynamics of fauna (Lovejoy & Bierregaard, 1990), and decreased biodiversity (Turner & T Corlett, 1996) as well.

The abiotic changes that occur with deforestation and fragmentation can alter the microclimate within a stand; changing the ability of that area to recover the composition and density of its original forest (Webb, Gaston, Hannah, & Ian Woodward, 2006). It has been shown that more tree cover (in areas ranging from 10^2 to 10^4 km^2) is associated with higher rainfall rates, independent of latitude, longitude, and altitude (Webb, et al., 2006). A regenerating canopy can also have higher interception rates (Parker, Leopold, & Eichenberger, 1985) and reduced soil moisture (Camargo & Kapos, 1995). Additionally, secondary vegetation can lead to increased evapotranspiration at the ground level as well as expose more areas to sunlight (Camargo & Kapos, 1995).

Edge Effect

Forest fragmentation is not a static condition; the edges of the forests continue to recede as natural phenomena and disturbances (such as fire, invasive pests, and opportunistic species) press even harder on the edges of these disturbed ecosystems. This combination of factors pose a serious threat to remnant forest patches as the possibility of an "inward collapse" is realized. Areas where these ecological changes take place are called "edge affected areas". Although the most prominent effects occur within 100m of edges, fragments show effects at distances of greater than 300 ha from the edge, [mortality (>300 ha), damage (>80 ha), and turnover rates (<300 ha)]. The aspect of the edge has no significant impact on these effects; meaning each edge will have an equal chance of affecting the center, yielding an offensive from each side. Effects are increased for small or irregularly shaped fragments with the highest ratios of edges to area. Therefore, the building of roads has had a significant impact on forests, creating frequent and abrupt edges to the forest and islands of fragmented forest. (Laurance et al., 1998)

As shown by Gascon (2000), in the first few years after a disturbance, the new edge of the forest allows sunlight and wind to penetrate. However, soon tree mortality increases dramatically and there is a shift in the vegetation from those of old growth to those of regenerating species. These regenerating species then change the structure of the forest edge significantly. Gascon's estimates are that a fragmented landscape up to 1000 hectares in size will be composed almost entirely of edge-affected habitat. (Gascon, et al., 2000)

Gaps in the forest canopy are natural (occurring in about one percent of mature forest area), but fragmented forests have a higher amount of gaps (Laurance, Ferreira, Rankin-de Merona, & Laurance, 1998). These gaps, which are high-light areas, create additional problems with an abundance of lianas. These woody vines disturb the natural process of germination of pioneer species due to their ability to shade out the forest floor with their mass and rapid recovery after overtaking a tree, causing mortality (and therefore a disturbance in the canopy). Therefore, the natural process of regeneration, led by pioneer species, does not occur as seed germination is stunted. This invasive process will yield fragmented areas becoming dominated by less-developed species and a compositional change in the forest structure (Jacinto Tabanez & Viana, 2000). Management of these species should therefore be considered when protecting fragmented forests as a degenerative process can take place.

Further, Gascon (2000) notes that the Atlantic Forest of southern Brazil has more severe conditions than noted above because the forest fragments are surrounded by large plots of sugar cane and eucalyptus plantations that routinely are burned and sprayed with herbicides. These fragments are at risk as they are unable to regenerate at the edge or to buffer the interior of the stand. The result has been a significant impoverishment (with tree mortality higher than recruitment) of the remaining interior of the primary forest. The edge is therefore dominated by a species-poor transition community or by weedy vegetation. (Gascon, et al., 2000)

Fire is a significant problem in these areas, where the endemic vegetation is easily susceptible to even the lightest fire. This problem is compounded as regeneration species (of edge effects discussed above) fill in forest edges, and where possible strips of forest have been penetrated by fire. Further, these regeneration species are comprised of fire resistant, often non-native, shrubs and grasses. This clearly changes the entire composition of that forest preserve as the species spread and more disturbances occur. Conservation strategies must therefore, include this issue and 1) maximize the area/perimeter relationship, 2) protect the forest edge against damage (fire, structural, and exotics) by leaving a buffer zone, and 3) promote less intensive types of land use in bordering lands in order to minimize the edge. (Gascon, et al., 2000)

Buffer zones of protected areas are now a central component of many reserve management plans and are believed to be a key ingredient of a reserve's success or failure. However, it is important to remember that these long, often skinny, parcels of forest are the most susceptible to outside pressures (both human and ecological) because they have a higher ratio of edge area to preserve area. Therefore, it is important to include enough land to have a successful buffer (Gascon, et al., 2000), although this is an increasing problem as areas around some parks are becoming more and more popular for habitation in Brazil and therefore more expensive to protect.

Island Phenomenon

With severe fragmentation, an area can be left isolated in a "sea" of threatening characteristics (such as completely deforested pasture land, or a monoculture system of exotics), creating an island which saves species that would otherwise fail to survive in that altered landscape. Therefore, isolated pockets of wilderness are now being called "arks" by some conservationists. Species richness is predicted by landscape connectivity alone or a combined catalog of environmental similarities, and is negatively affected by natural disturbances and anthropogenic disturbances (Brown Jr & Freitas, 2000). Fragile ecosystems exist in the Atlantic Forest that are susceptible to even the slightest deforestation, such as the Atlantic Forest caves which support a high level of distinct biodiversity (Trajano, 2000).

However, some taxa are more tolerant of deforestation and have been relatively resilient even as deforestation has encroached (such as the rich butterfly population and the avian populations that have the ability for flight between fragments). Therefore, in spite of the severe fragmentation, the Atlantic Forest is exceptionally rich in avian biodiversity. However, these populations are feeling the effects of the severe deforestation as well. Sixty-eight percent of the Atlantic Forest birds are considered rare because they have either 1) low population sizes, are 2) narrowly distributed, are 3) restricted in their habitat, 4) have displayed a combination of two of these factors, or 5) possess all of these parameters. Sixty-three percent, (419 species, of Atlantic forest species occur only in relatively undisturbed habitat and only 17 species (8.5 percent) of the endemic birds found in that habitat, use disturbed habitats. (Goerck, 1997)

Likewise, many mammals [such as the endemic Miriqui (*Brachytles Arachnoides),* the largest nonhuman American primate] are restricted in their movement and are unable to reach other fragments as the terrain between patches is foreign and often inhospitable (pasture and mono-culture forest crops such as coffee and eucalyptus) (Strier, 2000). Patch type and distance from the patch edge have also been found to be significant predictors of biodiversity (Sachs et al., 2009). However, it has been determined that the number of species present in a patch is largely dependent on the patch size (Sachs, et al., 2009), and therefore, many researchers and conservation groups are now trying to link patches.

Atlantic Forest Corridors in Minas Gerais

As noted by the director of Iracambi, a small but aggressive non-governmental organization (NGO) working for conservation objectives in a rural community in Minas Gerais, "the most promising conservation programs of the future will allow for alternative approaches to biodiversity corridors" (LeBreton, 2010) which will maximize limited funding and community involvement. These alternative approaches, would be best to involve a system of economically viable crops integrated into traditional corridors (integrated forest corridors), which would allow the participants an alternative income should funding for conservation programs wane. These types of forest corridors are then considered productive by community members and thereby maximize community interest in the conservation program. (LeBreton, 2010)

In addition to habitat loss previously discussed, areas of forest are also threatened by harvesting of firewood, illegal logging, hunting, plant collecting (in spite of legislation that prohibits such acts), and invasion by alien species (Tabarelli, et al., 2005) from neighboring rural communities. The corridors that provide an inherent incentive to conserve and protect the resources housed within them, are more viable approaches to traditional corridors that try to keep community members out of these stands. Additionally, productive corridors can allow for a larger-scale program, pulling in stakeholders that may not be willing or able to commit to a traditional corridor program, and minimizing the cost of corridor establishment.

Iracambi Rainforest Conservation and Research Center

Iracambi is a working farm of approximately 500 hectares situated in the southern border area of the Serra do Brigadeiro state park in Minas Gerais, a state with intense agricultural production and also with mineral wealth and heavy extractive activities. Current research of this organization is focused on finding possibilities for conservation and engaging the community to find alternative sources of income[1]. One area that they have been exploring is the use of forest resource products derived from eucalyptus. Many of the farmers in this region have some (although limited) knowledge of eucalyptus cultivation as it was promoted as an economically viable crop and good conservation tool

[1] Alternative to coffee, cattle, and other regionally traditional agricultural practices

(to discourage deforestation for fuel-wood) in the period between 1967 and 1984 (Turnbull, 1999). Now, most households maintain some eucalyptus on their property for personal consumption and often at least a minimal amount for sale as well.

The Iracambi research director, Robin LeBreton, established a four-hectare stand of eucalyptus in 1992 to allow the recovery of native forest in the understory of this stand. Additionally, another area of approximately six hectares was abandoned in 2000 and recently, in 2007, another stand of less than one hectare was established for forest corridor research as well. One recent researcher, Ted Karfakis) studied one of these test-plots of Eucalyptus and native forest, and determined that natives will dominate the canopy of a 15 year old stand (Karfakis, 2008). This research also noted several native species that were well-suited for reforestation efforts in integrated corridors (see Appendix 1 for a specific list). Many native species should not be planted in open areas but thrive in the understory of eucalyptus (Karfakis, 2008) where shade-intolerant grasses are absent.

Other Iracambi research has questioned property owners that would be affected by a proposed productive forest corridor very near to the Iracambi property. The research determined that the farmers grasped the nature of corridor programs easily and that the Legal Reserve Area (ARL) requirement of 20 percent of rural property (as set out in the Forest Code of 1965) could be a key to corridor creation. Further findings noted that the need for external funding for corridors is unavoidable as the costs of fencing materials, seedlings, labor, and other inputs is too high for most farmers to cover. Additionally, these productive corridors should not rely on the integration of fruit trees as the market for fruit is locally week, (as most rural properties have an abundance of fruit trees near their homes). This native crop could be a promising option for streamside corridors. (Evans, 2004)

However, in these rural areas of Brazil, there is much skepticism regarding conservation programs since in the past they have not been able to meet their stated goals, and/or have not materialized at all. The rural Brazilian culture, which is just now recovering from many years of a dictatorship, is additionally skeptical of government-led programs because funding for these have waned with changes in the economy and/or political climate and have had disastrous effects for some participants (LeBreton, 2010). For example, there are reports of land owners never receiving compensation for their involvement (LeBreton 2010; personal observation from survey participants' comments 2010). Specifically, the rural population living around the Serra do Brigadeiro, has a distrust of "bolsas verdes" (green subsidies) as this often means for them a removal of valuable land from their already limited economic portfolio. Although rural farmers caused much of the land degradation, most now recognize the need for conservation of some mechanisms of nature; specifically the tangible ones that contribute to water security. Additionally, some of the laws that require native forest protection on private rural property (ARL and APP), are now beginning to be enforced in this region (LeBreton, 2010).

Due to increased enforcement of APP and ARL requirements, a resurgence of environmental ethics brought on by an increased standard of living for some, and an awakening to the importance of some ecosystem services for others, it is now a good time to initiate conservation programs in this region. However, due to the reasons discussed above, conservation programs must integrate some economic productivity into land management planning, apart from the subsidies property owners would receive from such schemes (LeBreton, 2010). Fragmentation around the Serra do Brigadeiro will likely not be addressed with a large-scale subsidy program in the near future although the director of Iracambi is actively looking for such opportunities (LeBreton 2010). Thus, any implemented corridor program must be as close to self-sufficient as possible, requiring little to no funding outside of the resources available from Iracambi's foundation,.

Iracambi has been developing the preliminary foundation for a forest corridor program comprised of primarily eucalyptus with the goal of integrating native species whenever possible. As noted by LeBreton (2010), the preliminary proposal for this project would be "encouraging farmers to plant a portion of (degraded pasture land that is going to be replaced with eucalyptus) with native forest and rewarding them for it with some kind of payment for environmental service" (LeBreton 2010).

Objectives/Purpose

Given the need for biodiversity protection in the Atlantic Forest and the potential of a forest corridor project as conservation tool, several critical questions remain. First, how feasible is a forest corridor program that integrates native and eucalyptus species? How would rural landowners react to such a program, and what challenges would there be to implementing such a forest corridor program in the area around the Serra do Brigadeiro? The intent of this research was to answer these questions through an exploratory case study. A corridor program or any other type of conservation program, such as a payment for ecosystem service (PES), in this area will be difficult for the reasons discussed above. Therefore, timely studies are needed to investigate the potential for these programs, assess the perception of potential participants, and identify the implementation challenges.

Specific objectives of my study were to determine: 1) the degree to which eucalyptus producers would be willing to integrate native species in future eucalyptus stands, 2) perceptions of barriers or complications to integration, 3) preferences for methods of planting both the species in one stand and perceptions of what would work best for their specific circumstances, 4) farmers' willingness to participate in a program that would restrict the location of their stand, and 5) adherence levels to ARL requirements. This study was focused on farmers in five communities (Araponga, Ervália, Fervadouro, Miradouro, and Pedra Bonita/Sericita) bordering the Serra do Brigadeiro, which are outside of Iracambi's closest zone of influence (in the nearest town to Iracambi, Rosario da Limeira).

Chapter 2

Background & Literature Review

Given the severe and complex ecological conditions discussed in Chapter One, the future of conservation in the Atlantic Forest region depends on integrating new and diverse regulations, public policies, and incentive mechanisms for conservation and restoration into a succinct comprehensive conservation plan for the region. This chapter will discuss current conservation steps and forest policy reform in Brazil, as well as some of the reasons for the motivation to initiate changes in natural resource management. It also will outline some conservation projects underway in the Atlantic Forest and smaller-scale conservation research projects in the Serra do Brigadeiro region. Finally, the chapter will provide more detail on corridor ecology, eucalyptus production, and national forest laws that are directly applicable to the land-use of properties in the study area of this research project, which will also be discussed in detail. The information will supply the reader with sufficient background to understand the factors affecting land-use decisions in Brazil and in the study area.

Conservation Biology Steps in Brazil

Even though the federal universities and the approximately 50,000 Brazilian student researchers are conducting a great deal of research in Brazil, it is a complex process to gather their findings into collective action reports. The various independent projects and programs established by university research projects, NGOs, and local and state governments need to be better integrated in order to avoid further deforestation and massive species loss (Tabarelli, et al., 2005). Therefore, among the main issues in the

Atlantic Forest, the need for more efficient management of protected resources and the need for more comprehensive research into appropriate restoration strategies are the most pressing.

International Pressure

International pressure on the Brazilian government, due to the international attention warranted by Amazonian forest loss, has resulted in increased funding for the Atlantic Forest of Brazil as well. Research in 2007 by the United Nations (UN) Food and Agriculture Organization (FAO) estimates that between 1990 and 2000, 2,681,000 hectares of total forests were lost annually in Brazil; this rate increased to 3,103,000 hectares annually during the period of 2000 to 2005 (FAO, 2007 pp 114). Logging operations and government agencies are still expanding the road network in the Amazon, which is contributing to the rise in deforestation levels and drawing much international attention. As a result, a national debate has arisen in Brazil over this issue, which is in part about the appropriate balance between national and local interests in determining the use and protection of these resources. Many of these debates have directly affected national forest laws directed at the Amazon Basin and the Atlantic Forest.

Government Response

The government has responded with innovative and rapid policy change according to some authors, and recent significant changes could further alter forest policy in Brazil. One of the policies being debated is related to the Areas of Permanent Protection (APP), which requires native forest to be protected in areas of steep slopes and near water sources (discussed in more detail later in this chapter). This is one of the main environmental laws established in 1965 with Brazilian Law 4.771 and is also a law that many rural producers do not follow as it restricts land-use activities such as agriculture and forestry. This law is litigious in areas with an abundance of steep slopes and water sources, and currently is being debated as some influential groups are lobbying for amendments that would open up tracts of land for agriculture and forestry development. Since the forestry sector in Brazil accounts for 3.5 percent of Brazil's gross domestic product (GDP) and generates 2 million jobs (Banerjee, Macpherson, & Alavalapati, 2009), this is a very hot-topic for Brazilian politics. The proponents arguing for these changes include large and small agriculture producers and forestry operations in the Atlantic Forest region and in the Amazon.

Government Response: Forest Policy Reform

Brazil has some of the most complex forest laws in the world, (discussed in more detail later in this chapter), which are enforced by the Brazilian Institute of the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renovaveis, IBAMA). The Brazilian government reformed the federal forest laws in 2006, creating new institutions as well as new regulatory, development, and incentive policies. The main component of the policy[2] change is the division of IBAMA's authorities and responsibilities among three branches of the agency and to the states and municipalities. Additionally, this law provided the creation of the Brazilian Forest Service (Servico Forestal Brasileiro SFB)[3] in March 2007, and the 2007

[2] Law N. 11.284 de 2/03/2006 and Decree N. 6.of 03/20/2007
[3] Decree no. 5.776, 2006

creation of the Institute of Chico Mendes of Conservation and Biodiversity (Instituto Chico Mendes[4] de Conservação da Biodiversidade, ICMbio) which is based on a division of IBAMA (Bauch, et al., 2009).

The SFB is responsible for regulating the management of public forests and for administering the National Forest Development Fund. The organization now manages zones designated for production within federal protected areas and has duties including funding and technical assistance to develop the private concession system. This system was created in order to generate opportunities to earn income from productive forests, which is believed to be a better way to protect them than by command and control alone. The ministry of the Environment (Ministeirio do Meio Ambiente, MMA), also helps with the management of forests and now oversees the day-to-day operations of logging in the National Forest Concession program. (Bauch, et al., 2009)

Additionally, a new law has transferred the approval and enforcement of the management plans required of natural resource extraction activities, Plan of Sustainable Forest Management (Plan de Manejo Florestal Sustentável PMFS), to the state environmental agencies. Some of these state agencies have assumed the responsibility of transportation authorizations required for selling timber, Documents of Forest Origin (Documento de Origem Florestal DOF), which is a difficult task to oversee in the remote areas. Many other functions are retained under the direct control of IBAMA, including

[4] Chico Mendes was a famous leader of the rubber tapper movement, who was assassinated in 1988. The movement campaigned for the creation of extractive reserves, areas that are co-managed with their residents primarily for non-timber forest products such as rubber (Bauch, Sills, Rodriguez, McGinley, & Cubbage, 2009).

final approval of any forest management plans prepared by the SFB for the national forest with which the logging will be undertaken. (Bauch, et al., 2009)

The challenges of implementing the new policy are the lack of authority of the SFB and a deficit in the personnel of the SFB and the state environmental agencies that have taken over DOF and PMFS authorizations. Bauch, et al. (2009) notes that the approximately 50 employees of the SFB are dedicated to creating the new agency and fulfilling promises, as well as strengthening the organization's legal authority. However, the SFB does not have authority to create personnel positions within the agency (i.e. they cannot hire more employees) and is operating with a "modest budget" (Bauch, et al., 2009). Additionally, there are controversial elements of the new policy: 1) the transfer of power from IBAMA to the state agencies for the approval of DOFs and PMFSs and 2) a directive that allows the SFB to offer long-term concessions to private industries for harvesting from national forests. Some critics of the law point out that many agro-industry representatives and developers did not oppose the shift because state and local authorities may be more sympathetic to local business, or at least have less power to stop unlawful actions (Bauch, et al., 2009).

Conservation Projects and the Atlantic Forest

Conservation efforts are at a critical point in the Atlantic Forest region as Brazil is rapidly developing and the aspirations of its population will strongly push to continue economic expansion. Brazil is a country looking towards the future, a country that had for the first time in the country's history elected a Worker's Party (a left-wing, democratic-socialist, party) representative, Luiz Inácio Lula da Silva ("Lula"), and most recently a female president, Dilma Vana Rousseff ("Dilma") from that same party. It is a country that highly values the upward economic progress and increased standard of living for the rural poor. However, further development will only exacerbate biodiversity loss and a need for even more significant conservation initiatives, which is a global phenomenon. Therefore, new innovative policies and institutions are needed to address these clashing imperatives.

The Atlantic Forest houses the top 4 municipalities and approximately 80 percent of Brazil's Gross Domestic Product (GDP) comes from the cities and rural areas in this region (Conservation International, 2010). Therefore, it is important for conservation programs to recognize the established dependency, *mentally*, of the population on economic output. Simultaneously, it has been projected that the degradation of ecosystem services worldwide could drastically increase during the first half of this century (United Nations, 2000) as more development and consumption occurs. Therefore, significant changes in policies, institutions, and practices are needed to reverse the degradation of ecosystems, supporting the growing economy in Brazil in a sustainable way while contributing to global environmental health. As more is discovered about complex international and inter-continental natural resource exchange and dependency, and the need for "protecting our common environment" (United Nations, 2000), even more pressure will be put on Brazil[5], as many call the Amazon the "lungs of the world". The Atlantic Forest region will receive some of the exposure this pressure will bring, and

[5] as well as Canada, China, and Russia, and the countries of the South Asia Pacific and Africa which have the largest in-tact forests in the world

hopefully some of the conservation resources in order to stave off more fragmentation and biodiversity loss.

National Conservation Projects

As governmental institutions were being enhanced in the 1970's, new types of NGOs focused on the environment emerged since environmental criticism was the only type of criticism tolerated by the government during the military regime of this time (Diegues, 1994). A list of some of the most significant NGOs is provided in Table 1.

Regional Conservation Projects

Due to the natural richness of this region, and the concern that the fragments and protected areas are too small and isolated to maintain many species over the long term (IPEMA, 2011), a number of conservation programs have been initiated. Although national funding is high, regional and local funding can be spread thin among the competing projects. Approximately 700 environmental NGOs operate in the Atlantic Forest region (Conservation International, 2007) but nearly 70 percent have annual budgets of $50,000 USD or less (Conservation International, 2011). State and federal environmental agencies lack the capacity to halt deforestation because they are insufficiently funded and lack the resources to properly staff protected areas and ensure enforcement of laws (Conservation International, 2011).

Table 1: Main Brazilian Environmental Organizations

Institution/ Program Name	Objective/Main Focus	Geographic Concentration	Funding Sources and Supporting Agencies
The Pilot Program to Conserve Brazilian Rain Forests	The program is "aimed at developing innovative tools and methodologies for conserving Brazil's rain forests" (World Bank, 2011) with the creation of two large-scale corridor programs (IPEMA, 2011). In the Atlantic Forest, the Central and Serra do Mar Biodiversity Corridors have been created	Atlantic Forest and the Amazon (IPEMA, 2011)	The World Bank with the governments of: Germany, the Netherlands, Italy, France, Japan, Canada, the U.K. and the U.S.; the European Commission and the Brazilian government (World Bank, 2011)
CONABIO The Brazilian National Biodiversity Program	The promotion of communication between programs, projects, and activities related to implementing the principles and guidelines of the National Biodiversity Policy	Atlantic Forest	Global Environment Facility (GEF), the World Bank, and the Brazilian Ministry of the Environment (MMA) (Conservation International, 2011)
IESB The Institute of Social and Environmental Studies	Focus is on "the sustainable use of natural resources and the improvement of living conditions for rural communities located in the Atlantic Forest" (IESB, 2007)	Atlantic Forest	USAID and other sources
The Green Corridors Program	A tri-national initiative with Argentina and Paraguay that has the aim to link important fragments of the Atlantic Forest in each country	Atlantic Forest and the Amazon	World Wildlife Fund & the Atlantic Forest Biosphere Reserve, a Man and the Biosphere (MAB) and United Nations Educational, Scientific and Cultural Organization(UNESCO) program (IPEMA, 2011)
S.O.S. Mata Atlântica	This organization is overseeing the creation and management of the Atlantic Forest Biosphere Reserve (SOSMA, 2011)	Atlantic Forest	The World Bank and other G-7 countries, the Brazilian Ministry of Environment, state environmental agencies, and other NGOs
The Brazilian Natural World Heritage Sites	Supporting seven conservation programs in Brazil of which 3 sites are in the Atlantic Forest (IPEMA, 2011)	Atlantic Forest and the Amazon	The UNESCO World Heritage Forests Program (UNESCO, 2011)
FUNBIO The Brazilian Biodiversity Fund	To enable the implementation of several protected areas within the Atlantic Forest areas of Parana, Sao Paulo, Minas Gerais, Santa Catarina, and Rio Grande do Sul.	Atlantic Forest and the Amazon	German Government's KfW Bank, Climate Initiative International (ICI), Germany's Ministry of Environment, Nature Conservation and Nuclear Safety (TWB, 2011)
CEPF The Critical Ecosystem Partnership Fund	Supports the Species Protection Program, The Program for Supporting Private Natural Heritage Reserves (RPPN), and The Institutional Strengthening Program (IPEMA, 2011)	Atlantic Forest	L'Agence Française de Développement (the French Development Agency), Conservation International, The Global Environment Facility, The Government of Japan, The John D. and Catherine T. MacArthur Foundation, and The World Bank

State Conservation Projects

Minas Gerais has a long history of participation in environmental issues[6] and grass-roots movements, supporting approximately 159 NGOs working in the region (Débora Nacif de Carvalho, 2006). However, a review of three leading organizations in Minas Gerais found many issues with these organizations, including legal systems, management of partnerships, public image management, advocacy, accountability, and financial and human resources management (Débora Nacif de Carvalho, 2006). This review highlights the complexity of organizing conservation programs, as well as managing competing interests and political pressure from all stakeholders, on a limited budget.

Local Conservation Projects

The main organizations[7] conducting research in the geographic area around my study area, the Serra do Brigadeiro, are The Federal University in Viçosa (UFV) and Iracambi Rainforest and Research Center (Iracambi)[8]. Following international conservation trends, recent conservation-based studies by these organizations are often based around payments for ecosystem services (PES). PES is a recent trend that combines natural resource management and economics to allocate financial resources

[6] The Minas Gerais State Council for Environmental Policy (COPAM) was created before the National Council for Environmental Policy (CONAMA)

[7] Additionally, there are three other small NGOs working around the Serra do Brigadeiro, (The Center of Alternative Technology of the Forest Zone (CTA-ZM , http://www.ctazm.org.br/), The Center of Family Integration (CEIFAR, http://www.ceifar.org.br/), and The Center of Research and Cultural Promotion (CEPEC), http://www.cepecmg.org/objetivo.php), but these focus more on community development programs and very little on the environmental protection of the area (LeBreton, 2010).

[8] Previously discussed in Chapter 1

from people benefitting from natural phenomena (an ecosystem service) to people who own areas that house that ecosystem. Ecosystem Services were defined by Daily & America (1997) as conditions and processes through which ecosystems support human life. Traditionally, landowners who receive PES control large tracts of forested land since tree cover contributes to the ecosystem service of producing and protecting water resources. This is completed through hydrologic processes in which debris slows down surface runoff and roots create openings in the soil that allow for increased infiltration. These processes are especially important in the Serra do Brigadeiro region and other areas with intense rainfall and compacted clay soil that allows for rapid overland flow of water.

The forests of this region provide many other services to the people living around them: aesthetic beauty; recreation; wood; habitat for biodiversity; medicinal plants; and habitat for plants, animals, and insects important to human life. In addition to these valuable services, forests also provide essential services such as sequestering carbon, mitigating soil erosion, improving microclimates, and stabilizing hydrological flows that are vital to sustaining and fulfilling human life (Daily & America, 1997; Pattanayak & Butry, 2003). Therefore, there has been much focus on these services in recent research projects and for this reason one of these research projects will be discussed.

Federal University of Viçosa (UFV)

A Master of Science student, Mariana Barbosa Vilar, in UFV's Department of Forest Engineering (DEF) recently analyzed ten farms outside the Serra do Brigadeiro based on a proposed conservation program for the area. If created, the program would be both a competitive program and also a potential partner to any corridor programs. Vilar (2009)valued two different ecosystem services, carbon sequestration and water production, due to conservation efforts around springs on the properties. The landowners maintain their APP areas, thereby protecting their water resources. Water use measurements indicated that the properties had a net-flow of water from the springs (Vilar, 2009). This study then calculated a Reference Value for Environmental Benefits (RVEB), of between $R402.18/ha/yr^{-1} ($227.61 USD/ha/yr[9]) in Scenario 1[10] and $R517.78 ha/yr^{-1} ($293.03 USD ha/yr[11]) in Scenario 2[12]. In the conclusions, the researcher suggests that further investments be made in the Payment for Environmental Services (PES) program, suggesting that funding sources exist within the water and energy provider sectors (VILAR, 2009).

Any corridor project in this region would need to provide comparable prices to the carbon sequestration project in order to secure long-term commitment of participants. Although the carbon sequestration project still lacks funding and will therefore not likely be implemented in the near future, such projects must be developed for integrating into the larger focus of a corridor program. If the PES markets develop, it may be possible to incorporate the funding available through this market into a corridor program. Although the carbon sequestration program discussed in this research cannot be a substitute for a corridor program, as it does not include steps for ensuring that these areas are linked or

[9] At 2010 average exchange rate of 1.76697(IRS)
[10] scenario 1), using monetary values derived from the amounts charged to consumers of water in the South Paraiba River Watershed
[11] At 2010 average exchange rate of 1.76697 (IRS)
[12] scenario 2), where the payment for environmental services were employed in Apucarana-PR

beneficial to native fauna, these types of programs could provide additional subsidies for participants. Further, the assets of a corridor program, which would focus on restoring appropriate species and not just the abandoning a stand to natural regeneration which can contain native or foreign invasive species, could be used to further the benefits of any carbon sequestration program in the area.

Corridor Biology

As noted by Brudvig, et al. (2009), reserves would have more of an impact if their benefits extended beyond their boundaries into surrounding habitats. He also notes that opportunities for creating new reserves are limited, and the greatest conservation gains will likely be realized from increasing the positive impact of existing reserves. In landscape-level conservation strategies, the literature stresses the need for broad corridors of natural habitat with restoration of larger managed areas and multi-use buffer zones (Noss, 1987).

A corridor is generally defined as a linear habitat, embedded in a matrix of dissimilar characteristics, which connects larger blocks of habitat in order to enhance or maintain the population viability of wildlife in those blocks of habitat (Beier & Noss, 1998). It is a concept that is easily grasped (by conservationists and the general public) and has obvious intuitive appeal (Bonner, 1994). Therefore, many believe corridors to be a successful way to increase within-patch species richness [by 20 percent according to (Brudvig, et al., 2009)] and have advocated heavily for corridors to be a component of the plan of action in the next Millennium Development Goal (MDG) period.

A Debate

Some researchers question the effectiveness of forest corridors and argue that the case for corridors is based on theoretical population models, and demonstrate only the service of habitat connectivity (Beier & Noss, 1998), while the viability of populations is benefitted only by ways of the rescue effect (Brown & Kodric-Brown, 1977). The shape, size, orientation, and location of corridors can affect their utility for conservation (Tewksbury, 2002), and many say that there is a lack of concrete figures on the specifics of these attributes for effective corridors (Beier & Noss, 1998; Rosenberg, Noon, & Meslow, 1997; Simberloff, Farr, Cox, & Mehlman, 1992).

Other criticism of corridor programs is a lack of scientific studies that implemented an experimental design to measure re-colonization rates or population viability as the dependent variable (Beier & Noss, 1998). In addition, critics argue that there is insufficient data to show that corridor 1) lower extinction rates, 2) lessen demographic stochasticity, 3) stem inbreeding depression, and 4) fulfill an animal's perceived inherent need for movement (Simberloff, et al., 1992). Further, they argue that most corridor studies have a narrow taxonomic focus and do not study other components of the biological communities, such as the indirect effects on plant populations (due to increased pollination and seed dispersal), and other indirect effects (Tewksbury et al., 2002).

In 1987, (Simberloff & Cox) argued that corridors can promote the spread of diseases and catastrophic disturbances into areas that would otherwise not be affected. Further concern that corridors might lure animals into areas where they can experience higher mortality (Hobbs, 1992). Even when it is demonstrated that a linear patch has led to increased immigration rates, it does not necessarily mean there has been an increase in viability for the population. Some studies just show that the patch acted as a corridor for movement (Rosenberg, et al., 1997). Additionally, some studies ignore the effects of the increase in habitat area and how this increase affects the population to be studied, separate from any effects of increased movement between patches (Tewksbury, et al., 2002). These types of studies add to the inconsistencies and vulnerability of the results of this science (Tewksbury, et al., 2002).

Much of the controversy surrounding corridor science is focused on the difficulty of designing a replicable and randomized experiment to test the effectiveness of the corridors (Inglis & Underwood, 1992; Nicholls & Margules, 1991). Studies that measure demographic parameters require creating and destroying corridors in landscapes and collecting pre- and post-manipulation data, an approach that could lead to localized-extinction of a species (Beier & Noss, 1998). This clearly creates ethical problems and this type of study would not be fully useful since corridors are not designed for abundant species (Beier & Noss, 1998).

However, a large-scale experiment by Tewksbury, et al. (2002) synthesized the results of an experiment replicated eight times in one site and was able to show that the benefits of corridors extended beyond the attribute of added area. Each study was undertaken in a 50-hectare site with mature (40 to 50 years old) forests, with 5 early-successional habitat patches created (through tree removal and burning). Movement rates and pollen dispersal by animals were measured in connected (through a 25 meter wide corridor) and unconnected patches. An area equal to the connected patches plus the area of the corridor was maintained, thereby controlling for added habitat area. Additional measurements were taken on the effect of patch orientation (winged patches vs. rectangular patches) in order to test the hypothesis of "drift fences" and the movements of butterflies, pollen, and seeds dispersed by birds. (Tewksbury, et al., 2002)

The results showed that for all taxa studied, the movement between connected patches was higher than the movement between unconnected patches (even when controlled for size and shape–winged vs. rectangular patches) and correlated to a higher rate of pollination in connected patches. Additionally, the corridors did not act as drift-fences for insects or birds. Therefore, this study claims to have shown that the benefits of corridors extend beyond the effect of increased habitat area and actually facilitate movement. Tewksbury, et al. (2002, P. 12926) predicts that "the effect of corridors will have greater demographic and genetic consequences for populations at larger scales, where movement among isolated patches becomes rare or nonexistent".

These results support an earlier study which measured the sex ratios and survival rates of the mountain pygmy-possum (*Burramys parvus*) in one isolated but in-tact area and another area fragmented by a ski-resort development (Mansergh & Scotts, 1989). This study measured skewed sex ratios and lower survival rates in the fragmented area before a corridor was created. After the corridor was established these variables changed to match those observed in the undisturbed area (Beier & Noss, 1998; Mansergh & Scotts, 1989). Additionally, a recent experiment by Brudvig (2009) found that spillover of biodiversity was increased by connectivity of fragments, for both plant and animal experiments, and that corridors promoted spillover of native but not exotic plant species.

Although the studies cannot be used to generalize about corridors (Beier & Noss, 1998), the demonstrated utility can be combined with other studies to infer to the landscape level. Beier & Noss' (1998) concluded that the evidence supports the utility of corridors as a conservation tool. The research strengthens earlier hypotheses that corridor immigration can assist with the survival of extinction-prone populations (Noss, 1987), and decrease inbreeding depression through gene flow (Schonewald-Cox, 1983). Therefore, many now believe that species immigration to patches can allow an area to better accommodate metapopulations and natural disturbances (Evans, 2004), and the level of investment in corridor projects reflects this stance.

Much controversy around corridor science persists, however. Many conservationists still warn about the lure of corridors that are "roads to nowhere" and are offered by logging, mining, or development groups in place of larger tracts of land that have value to these companies (Bonner, 1994). Additionally, some argue that the presence or lack of corridors a few hundred meters long for many avian populations likely has little effect (Beier & Noss, 1998) and does not justify the investment. These corridor skeptics argue that funds would be better spent by acquiring areas for imperiled species, even if areas are isolated (Simberloff, et al., 1992), rather than investing in a science that is not proven and may not yield favorable results in all areas (Inglis & Underwood, 1992). They also argue that programs based on proven science must be quickly implemented to ensure the protection of intact ecosystem patches, even if they are not part of a corridor system (Simberloff, et al., 1992). Although the question of whether corridors in general provide connectivity is left unanswered, research has demonstrated corridor management provides some conservation value.

Productive Forest Corridors

Productive corridors have been considered as an alternative to a complete conservation of an area for a corridor because of the cost of many conservation projects. Logged forests, as part of an innovative forestry program, have even been considered part of a landscape level management program that would support the entire biotic community (Simberloff, et al., 1992). As worldwide demand for wood fiber increases and carbon sequestration programs come to fruition, forest plantations will likely occupy even more land in the Atlantic Forest region. Sutton (1993) estimated that plantations occupied about 100 million hectares (100×10^6 ha) worldwide in the early 1990s, and estimates projected future global plantation establishment of 5-8 million hectares per year ($5\text{-}8 \times 10^6$ ha/yr. Further, with the United Nations Framework Convention on Climate Change's (UNFCCC) Kyoto Protocol (1997), plantation establishment increased drastically to meet the obligations for carbon sequestration (Newmaster, Bell, Roosenboom, Cole, & Towill, 2006), and future UNFCCC's protocols are expected to require even more carbon sequestration. Additionally, technology is advancing for fuel production from pulp wood, and therefore production of eucalyptus could increase worldwide and in this area of Brazil as well (LeBreton, 2010).

Integrated Forest Corridors

Tree plantations are credited with the ability to restore soil fertility and improve microclimatic conditions, and therefore have the potential to facilitate forest regeneration (Guariguata, Rheingans, & Montagnini, 1995). Therefore, there has been a movement in many countries to restore biological diversity through plantations that can produce positive effects for some areas and species. Corridors that have integrated traditional commercial forestry species with native species have been suggested for restoring biodiversity while still providing economic viability for program participants (LeBreton, 2010). Although there is economic rationale for the creation of such programs, the limited scientific literature on the methods and results for these programs is limited, and several questions remain unanswered as to their contribution to biodiversity restoration (Newmaster, et al., 2006). Many of the supporters of these programs state that criticisms are based on qualitative evidence, and these proponents point out research that has recorded higher native species diversity in plantations than in natural forests during the first few years following the plantations establishment (Newmaster, et al., 2006; Roberts, 2002).

A study, in which 24 environmental variables were measured on 2 eight-hectare study sites of plantations established in 1950, revealed 156 species within the plantations (Newmaster, et al., 2006). It was noted in this study that “native plant diversity can be recovered in the most extreme forest management scenario, that is, agricultural cultivation followed by plantations with little variability in structure” (Newmaster et al., 2006, pp. 1228,). The study author also demonstrated that invasive alien plant species are more abundant in a plantation system than in native forest (10-27 percent vs. 2-3 percent), however, and the abundance of many native species declined, although there was no loss of native herbs (Newmaster, et al., 2006). Therefore, this research shows that plantations may lack diversity in microhabitats needed to support a rich fauna composition. Older plantations were found to contain more plant species used by wildlife, however, suggesting that increasing microhabitat diversity in plantations would be "a positive step towards restoring native plant diversity and the many corresponding elements of biodiversity" (Newmaster et al., 2006, pp. 1232).

Guariguata et al. (1995), found that a species' ability to rapidly close the canopy is an important attribute for restoration purposes. The spatial heterogeneity of light micro-habitats is higher and contains more vertically complex foliage stratification in a mixed-species plantation (*Vochysia*, deep-crowned, and *Jacaranda* and *Stryphnodendron*, open-crowned). However, there was no evidence of increased diversity in the mixed species treatment in this study (Guariguata et al., 1995). In fact, the authors concluded that herbaceous cover plays an important role (more influential than structural or light heterogeneity) in suppressing early woody invasion and the mixed-species plantation contains the highest density of herbaceous cover (Guariguata et al., 1995). Additional conclusions show that shrubs may inhibit tree incursion in the long term through competition for belowground resources (Guariguata, et al., 1995; Putz & Canham, 1992). Also, mixed-species plantations include a high percentage of shrubs (more than 75 percent of all recorded stems at initial sampling and at 1 year) (Guariguata, et al., 1995). Therefore, species-specific effects of forest plantations on the understory differ and "patterns may vary with degree of isolation from forested areas, species richness and abundance of soil-stored seeds, and land-use history" (Guariguata, et al., 1995, pp. 259). However, this research is limited by site-specific characteristics that may not transfer to other geographic areas and types of plantations such as eucalyptus (Guariguata, et al., 1995).

Integrated Forest Corridors around the Serra do Brigadeiro

As Köhler (2003) points out, "it is imperative that restoration programs based on a firm knowledge of the ecology of fragmented forests be developed" (pp.114). Therefore, any corridor establishment must be site-specific, and directed by a restoration ecologist. Each corridor must be established on an individual basis with targeted management (Karfakis, 2008). The species that property owners or conservationists favor may not be best for the area. The species that will naturally establish themselves in this area (Appendix 1) should be avoided and efforts should be concentrated on the rare species which require cultivation. The rare species near the Serra do Brigadeiro are late-successional, anachronistic species[13] (Karfakis, 2008). The forests have been depleted of large-rodent populations, such as the tapir, agouti, and peccary, which disperse seeds of the rare flora. Because these interdependencies have been absent for decades[14], restoration activities must first occur, followed by species re-introduction to promote seed dispersal.

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[13] Species whose seeds are dispersed by animals

[14] Tapirs specifically have been absent from the Serra do Brigadeiro region for several generations and wouldn't be able to survive in an un-restored, fragmented forest (Karfakis, 2008).

An integrated or productive forest corridor in this area could be used as an incubator for native forest regeneration by replacing grasslands with eucalyptus trees to shade out the grasses that compete with native saplings (Karfakis, 2008). The success of such a program would depend on what type of grass exists in each particular stand; Bracchiara grass (spp *Brachiaria serrata*), a cultivated grass from South Africa that was brought into this region and is now somewhat invasive, is not resistant to shading out techniques (LeBreton, 2010). However, some of the more cultivated grasses are highly resistant. After the canopy closes, normally at 3-4 years after stand establishment, some native species will begin to move in naturally (Karfakis, 2011). Within 10-20 years after establishment, eucalyptus would actually promote the growth of the native tree species (Karfakis 2011), and many eucalyptus stands will revert to native species if isolated.

A rehabilitated native stand differs from a plantation with a few native tree species. Therefore, an integrated forest corridor program requires a forest restoration silviculturist to manage these stands, determining what to cut and how much. A rehabilitated stand would contain late-succession tree species, as discussed above, and require a strategy such as "enrichment planting" to reach the desired composition. Prior research suggests that enrichment planting can completely fail (Karfakis, 2011), however, wasting valuable resources that could be used for other conservation projects. The intent of some studies have been to promote regeneration by harvesting commercial tree species, (tropical silvicultural systems), but the majority of the studies conducted in this area were based on theoretical grounds, being trials rather than formal experiments. (T. Karfakis, 2011)

Further, available information is not sufficient from which to base landscape-level conservation programs. Some data are available from Amazonian studies (supported by EMBRPAPA) but nothing exists for neo-tropical forests such as in Atlantic forest. Analysts doubt the validity of the existing data because some research was funded by institutions, such as industry or sectors of the Brazilian government, with a desire to prove that regeneration under commercial forests would be possible (Karfakis, 2011).)

Eucalyptus

Australian eucalypts are among the most widely used trees for plantations globally because of their rapid growth. Mean Annual Increment (MAI) rates of 80 to 90 cubic meters per hectare per year have been reported on fertile sites in Papua New Guinea, reaching 38 meters in height and 39 centimeters in diameter at breast height outside bark (DBHOB) at three years of age (Mead, Ugalde, & Perez, 2001). The species of eucalyptus cultivated in Brazil are *E. camaldulensis, E citriodora, E. cloeziana, E. deglupta, E. paniculata, E. grandis, E. robusta, E. saligna*, and *E. urophylla* (Mead, et al., 2001; Turnbull, 1999).

Eucalyptus grandis is the most widely planted type of eucalyptus for the industrial wood production industry worldwide. It is planted in large plantations in Argentina, Australia, India, Uruguay, Zambia and other countries with the largest areas in South Africa and Brazil (Turnbull, 1999). Stand rotations in Brazil average seven years and a MAI of 55 for an *E. grandis* clonal plantation ("Aracruz Celulose Sustainable Growth Strategy: Challenges and Opportunities," 2008). FAO (2001) estimates indicate that about four million hectares of eucalyptus exist in Brazil, with the majority of these being plantations of *E. grandis* grown on five to ten year coppice rotations (Turnbull, 1999).

Ecology

More than 500 species of Eucalyptus occur, mostly in acidic soil conditions. They exist naturally in Australia and the neighboring islands of Indonesia, Papau New Guinea, and the Philippines. Eucalyptus stretches from hot, humid tropical lowlands to cool, temperate highlands in this region. Some Eucalypt species have allelopathic effects, where the leaf litter can significantly inhibit germination of other plants (May & Ash, 1990). Additionally, the leaf litter can inhibit the emergence of other tree species, separately from the allelopathic effects, due to its slow decomposition rate (Reis & Reis, 1993). Eucalyptus litter can also have low levels of nitrifying bacteria (Couto & Betters, 1995).

Eucalyptus, possesses one of the highest (second to Pine) rates of interception (Poore & Fries, 1985) and has been shown to consume more water per ha than other monoculture crops in the region. Eucalypt roots can grow up to depths of 30 meters (Jacobs, 1955) and can extract water from up to 15 meters in depth (Macpherson & Peck, 1987). However, the most significant effect of eucalyptus plantations on the hydrologic system is the interception effect in which large quantities of water remains in the canopy. Soil water content is an important aspect of the ecological effects of eucalyptus plantations. Changes in total water yield are related to changes in storage capacities of soils. Intensive agriculture will often result in the frequent disturbance of a larger proportion of a watershed which amplifies these effects (Edgar, 1984).

History of Cultivation in Brazil

Eucalypts were first planted in Brazil along railways to provide fuel for wood-burning locomotives and it was therefore hailed as the answer for fuel-wood shortages and deforestation problems. Between 1967 and 1984, 2.9 million hectares of plantations were established with government incentives. These plantations, which in 1989 yielded over 15 million m^3 of medium to low-density, short-fibered pulp, make Brazil the largest producer of eucalypt pulp in the world (Turnbull, 1999). However, the majority of the eucalyptus timber was cultivated in order to provide high-quality industrial charcoal for the iron and steel production industries primarily in the state of Minas Gerais. Legislation was passed that required most charcoal be produced from plantations in order to curb deforestation and to supply this need (Turnbull, 1999).

Many plantations were established in rural areas with low population density and in need of economic development (Turnbull, 1999). The government encouraged charcoal producers to assist rural farmers in establishing (Turnbull, 1999). The charcoal producers were encouraged by the government to assist rural farmers in the establishment of eucalyptus stands on land that was unsuitable for agriculture (Calle et al. 1992). The main barriers to cultivation are a fungus called stem canker (*Cryphonectria cubensis)* (Rosillo-Calle & Hall, 1992), and leaf-cutting ants (*Atta* spp.), which can destroy a stand unless the site is treated before planting (Turnbull, 1999).

History of Controversy

The industrial forestry model in Brazil evolved into intensively managed, single-species plantations with high inputs to provide high productivity and uniformity. The plantations were confined to relatively small areas and offered limited social and environmental benefits beyond economic viability (Turnbull, 1999). Some of the controversy came from some of the displaced species or ecosystems when a new plantation was established. Additionally, some workers complained of hazardous logging activities leading to high accident rates and damage to road systems in communities (Couto & Betters, 1995). Environmental controversy has also arisen regarding short-rotation plantations given the loss of water through evapotranspiration, soil nutrient depletion, and sedimentation of rivers and streams (Couto & Betters, 1995). The principal criticism of eucalyptus plantations is that "they lead to diminished rainfall in their area of influence" (Couto & Dube, 2001, pp. 819).

Forest Industry

As the northern states of Brazil specialize in timber production from native species, the southern states of Brazil specialize in production of wood products from short-rotation eucalyptus plantations (Couto & Betters, 1995), which can be seen in Figure 2.

Figure 2: Brazilian Forestry Industry ("Celulose, Papel e Produtos Florestais (Brasil 2010)," 2010)

Minas Gerais contained the largest area of short-rotation plantations in 1995 (Couto 1995) but now is second to Bahia and São Paulo states ("Celulose, Papel e Produtos Florestais (Brasil 2010)," 2010). In the southeast region of Brazil[15], Minas Gerais produces 97.56 percent[16] of wood produced which accounts for 4.61 percent of total national wood production (IBGE, 2009).

The majority of all eucalyptus planted by the main pulp companies are clones, and an increasing amount of small-scale producers are now utilizing clone technology as well. Clones constitute approximately 85 percent of Aracruz Celulose's[17] stands (Bertolucci, Demuner, Garcia, & Ikemori, 1995; Turnbull, 1999). Forestry researchers and eucalyptus companies are constantly producing new clones and hybrids which are believed to have higher productivity and better technological properties than traditional species. Additionally, after the first rotation of eucalyptus, stand yield declines by 20 to 50 percent (Couto & Betters, 1995). Therefore, increasingly, many eucalyptus plantation owners are choosing to replant rather than coppicing a stand (Couto & Betters, 1995).

Eucalyptus timber is often sold in "steres"[18], which are stacked meters of roundwood in 1m^3 piles (Couto & Betters, 1995). The latest Brazilian government's report (IBGE, 2009) indicates that a total of 109,911,408 tons of roundwood[19] was extracted in the forestry sector in 2009 with 61 percent (65,345,690 tons) going for paper

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[15] As defined by IBGE, Table 1 – Quantity and price of extracted plant products, by regions and states – 2009

[16] Percentages for main regions (as calculated by author from IBGE, Table 1 – Quantity and price of extracted plant products, by regions and states – 2009): North-East 43.49%, North 29.55%, Central-West 12.41%, South 9.81%, South-East 4.73%

[17] One of the top two producers of eucalyptus pulp in Brazil

[18] A measurement similar to "cords" in the U.S. and approximately equivalent to ~0.276 cords

[19] Reported in m^3 (steres) according to IBGE, Table 1 – Quantity and price of extracted plant and forest products, by principal products – 2009

and pulp. A 2010 report by the International Forest Industries noted the majority of demand (48 percent) for eucalyptus timber coming from the fuel-wood industry, which supplies charcoal primarily for steel production, with just 45 percent of annual consumption used by the paper and pulp industry. Sawmills (approximately 4 percent of total demand) and wood pellet producers also consume a small amount of eucalyptus, which may increase if the major wood pellet export markets in Europe improve ("Eucalyptus log prices in Brazil jumped 25%," 2010) Further demand could also come from the emerging potential for the use of eucalyptus generated pulp to be used in a Biomass Integrated Gasification/Gas Turbine (BIG/GT)(Couto & Betters, 1995; LeBreton, 2010). A pilot facility is proposed to be built in the state of Bahia, on the northern border of Minas Gerais, due to its' close proximity to many eucalyptus plantations (LeBreton 2010) and the pig-iron industry.

Demand for Eucalyptus timber has increased primarily from pulp industries and paper manufacturers and also from sawmills who are producing timber for the construction market ("Eucalyptus log prices in Brazil jumped 25%," 2010). However, Brazilian legislation has decreed that eucalyptus plantations can only operate on land that the companies currently own, increasing output only by improving productivity or engaging in tree-farmer programs[20]. In such programs, a company provides seedlings to

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[20] Such programs can promote further noncompliance to environmental laws in rural communities as the producers are weighing economic incentives (increased yield often means increased revenue) against land-use restrictions. As will be discussed further in this chapter, most rural areas of Brazil are lacking sufficient numbers of personnel for enforcement and policing of environmental laws (LeBreton, 2010; Watson & Achinelli, 2008). Therefore, these types of programs can add to the deficit in the overall level of native forest cover in Brazil as rural producers will be more likely to cheat on reserve requirements than large-scale forestry operations which have more attention from policing agents.

local communities for the reserved right of purchase for the resulting timber (Couto & Betters, 1995).

Additionally, forestry companies have adjusted the initial spacing to site-specific parameters and rotation length, with the most common spacings being 3 by 2.5 meters, 3 by 3 meters, 3.5 by 3 meters, 3.5 by 3.5 meters, and 4 by 3 meters (Couto & Betters, 1995). Conversely, with the continued improvement in genetic technology, genetic improvement of cultivated eucalyptus and management of plantation soil to increase supply is emphasized (Couto & Betters, 1995; Turnbull, 1999). However, even with the legislative constraints and shifting focus to genetic improvements, the area of eucalyptus plantations has still increased by more than 7 percent annually between 2005 and 2010, ("Eucalyptus log prices in Brazil jumped 25%," 2010).

Brazilian Forest Law

The laws governing Brazilian forests are very complex and stringent (by international standards), although not always upheld. There have been three specific stages in the development of forest and environmental regulation in Brazil. From around 1500 until the early 1950s, there was an era of no regulation, except for a few unrelated laws that were designed to safeguard human health or to ensure the survival of valuable natural resources. The second stage, which occurred when economic interest began to be jeopardized, imposed controls on exploration and extraction activities. Finally, in the third stage, the National Environmental Policy Law was established in 1981 with law no.

6.938[21]. This law created the National System for the Environment and the National Council on the Environment, which are two institutions responsible for the legal regulation of the environment and the enforcement through administrative, civil, and criminal law recourse. Therefore, these organizations are a significant factor that should shape daily land management decisions for industry and rural agricultural producers in Brazil.

Also during this stage, in 1992, the organization with the most authority over Brazilian forest laws, The Ministry of the Environment, was created. The Public Forests Management Law, which has the main purpose of protection and preserving forests that belong to the federal, state, or local governments, created this organization. The Ministry of the Environment has the authority to create Conservation Units (e.g. National Forests), allocate areas for free community use (e.g. forest settlements), and approve forest-concession contracts. As discussed earlier, in 2006 a decree of this law also created the Brazilian Forest Service as part of the Ministry of the Environment (de Aguiar Patriota, 2009).

The enforcement agency for the Ministry of the Environment is the Institute of the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, IBAMA) which was created in 1989. However, this institute has not been well organized. To date, IBAMA has had more than 13 presidents with a shift in policy during each transition. There also have been widespread reports of corruption in the Institute (as well as in the Ministry of the Environment as a whole), high

[21] available at http://www.planalto.gov.br/ccivil/Leis/L6938org.htm

turnover rates, and inadequate training for inspectors. All of this has led to a lack of enforcement and collection of fines levied for non-compliance (Hirakuri, 2003). A total of 30 percent of all forestry-infraction reports by IBAMA auditors are unsupportable (i.e. they are overturned) (Hirakuri 2003). This has resulted in much non-compliance in rural areas (LeBreton, 2010).

Other government policies have contradicted the values set out by the Ministry of the Environment. The Rural Land Tax system (Imposto Territorial Rural, ITR) until recently classified unused or abandoned land as “unproductive” and therefore disallowed any tax breaks. Additionally, Brazil’s Land Statute of 1964 established that unused land could be confiscated and transferred to a third party and that if any third party cultivates land for one year, thereby keeping it “productive”, they have temporary right to the title of that land. (LeBreton, 2010)

As a result, a culture has emerged that is best explained by the common saying “mata em pe, homem dietado” (“wherever a tree stands, a lazy man lies in its shade”) (Hirakuri, 2003). It is common practice in this area to routinely manage lands through cutting or fire in order to keep them appearing “productive” which is a deterrent to having more forested land than required by law (LeBreton, 2010). However, two specific laws, ARL and APP, should encourage the conservation of native forest on the property of rural farmers in the Atlantic Forest. These laws are a part of Article one of the Brazilian Forest Code (Law no. 4.771[22]) of 1965, which recognizes existing forests and

[22] available at http://www.planalto.gov.br/ccivil_03/Leis/L4771.htm

other types of vegetation as assets and thereby a common interest of all inhabitants of Brazil.

Areas of Permanent Protection (APP)

Brazilian Law 4.771 also mandated conservation of native forest within 30-500 meters (depending on the size of the watercourse) of rivers and streams. This buffer is to be a permanent protection area (APP), as mandated under Articles 2 and 3 of the law. It states that this area must be permanently protected, "whether or not (it is) covered by native vegetation, which has the environmental role of preserving water resources, landscape, geological stability, biodiversity, the gene flow of fauna and flora, protecting the soil and ensuring the well-being of human populations".

Historically, few have complied with APP or ARL. Rural property owners are preserving areas around water sources (e.g. springs, streams/rivers, lakes, and waterfalls) in greater number, however, because these assets are valued for ecotourism and water security (LeBreton, 2010) The aspect of APP that is most often ignored in rural Minas Gerais is the restriction of areas having a natural slope of more than 45 degrees (LeBreton, 2010), which under the APP law cannot be cultivated and must remain in native cover. The law also requires that any hilltop above 1800 meters be permanently preserved as part of the APP. As noted above, this is hotly debated because it restricts development in some areas. Many environmental groups such as the World Wildlife Fund (WWF) oppose these changes while many developers and rural producers are very supportive (Bensusan, de Sá, & Lima).

Legal Reserve Area (ARL) Requirements

An ARL of 20 percent of rural property, which is considered "free area" (e.g., not subject to conservation under the APP requirement) in the Atlantic forest, is required[23] by law. It is defined as "an area located inside a rural property or landholding, except those for permanent conservation (APP), which are necessary for the sustainable use of natural resources, conservation and recovery of ecological processes, conservation of biodiversity and shelter and protection for native fauna and flora" (Law no. 4.771, art. 1 as cited on pp. 614 of Patriota, 2009). This area can be sustainably used but cannot have any land-use change (i.e. it cannot be deforested) and the functionality of the ecosystem must remain intact. The ARL is calculated based on the APP requirements for a specific site but for the sake of this discussion, a generalization can be made that at least 20 percent of the rural properties need to be in native forest cover.

The ARL must be recorded in the title and must remain unaltered even if land is divided and sold (Alston & Mueller, 2007). Any landowner that has violated this regulation, whether it was acquired that way or whether that landowner was responsible for the infraction, is required to recover the forest at the owner's expense. They are given a 30-year period to do so and any land included in the estate must meet this ARL requirement or is subject to the same recovery conditions (Alston & Mueller, 2007) . A legal reserve can be an abandoned, regenerating, native forest with little or no

[23] Other specific legal requirements of the ARL have been omitted in this discussion due to the complexity of these requirements and the length that would be required to fully describe them. Fully describing all of these requirements, would take this thesis away from the original intent and focus.

management for proper native species. Generally, an area of the appropriate size that is no longer managed for agriculture will suffice for an ARL.

Amendments to this law allow for the "sustainable economic use" of this legal reserve area but only after a detailed management plan, which must be drafted by a qualified forester, has been approved by a state or federal environmental agency (Alston & Mueller, 2007). This requires two field inspections and the frequent renewal of the approved plan (Alston & Mueller, 2007). According to an intensive study conducted in the Amazon, this process takes approximately 170 days on average to complete for the initial approval (Hirakuri, 2003). Clearly, this process is a deterrent to any legal use of the ARL area and is infrequently undertaken in the Atlantic Forest region (Alston 2007). Oliveira & Bacha (2003),determined that 10.7 percent of properties in Minas Gerais declare to have the ARL requirement and even these have less than the required area (taken from data held by the federal land reform agency, INCRA, which specifically collects data on ARL compliance). This is in spite of the maximum penalty of one year in prison or a fine equal to 100 times the monthly minimum wage (Oliveira & Bacha, 2003).

These complex Brazilian forest laws are part of the environment within which rural farmers make land management decisions. Obviously, these laws also influence decisions regarding rural corridors. As discussed in chapter one, Iracambi research concluded that the ARL requirement could be a key to the establishment of corridor programs by encouraging farmers that do not meet their legal requirements to be involved in a conservation program that would bring them closer to compliance.

The Study Region

The study region of this project is comprised of five communities around the Serra do Brigadeiro state park in southeast Minas Gerais. These communities border the state park with two of the communities each on the east and west sides, and one community on the northern end of the park. The elevation of the park varies from approximately 1,000 to 1890 meters and the surrounding areas located at a slightly lower elevation, between 500 and 1,000 meters above sea-level. The area is mountainous, with acidic soils and an annual rainfall of between 1,000 to 1,200 mm per year with a dry season extending on average from approximately April to August (LeBreton, 2010).

Creation of the Serra do Brigadeiro (Funding and Controversy)

The Serra do Brigadeiro extends approximately from longitudes 42º40' to 42º20'W and latitudes 20º33' to 21º00'S and was created in September of 1996 with decree n.º 38.319 (LeBreton, 2010; MOREIRA et al., 2009). The decree protects the highest mountain peaks, originally at an elevation above 1,000 meters, and has approximately 14,984 hectares with approximately 65 percent of the park covered by lower montane forest. The highest peaks, Soares (1,985 meters), Campestre (1,908 m), Grama (1,899 m), Boné (1,870 m), are comprised of granite, some with sheer vertical cliff faces having bromeliads (up to 61 species found in this area) and orchids (98 species found) growing on them (LeBreton, 2010). These high peaks may also have semi-deciduous formations, although this is rare since only 4.2 percent of these formations have survived in the Atlantic Forest (SOSMA, 2011)

Current biological state

The majority of this park consists of intact tropical lower montane forest, characterized by a canopy of 12 to 25 meters in height with a dense understory of great biological diversity (Atlântica, Integrados, Conjuntos, & Integradas, 1992). Accessible forest patches have been disturbed, with the most valuable timber harvested, thereby categorizing them as post-extraction secondary forests (Chokkalingam & De Jong, 2001). At approximately 1400 meters above sea-level, the vegetation transitions into higher montane forest conditions (Evans, 2004). These forests have mesotrophic vegetation of grasses, shrubs, mosses, sphagna, bromeliads, and orchids (LeBreton, 2010). Approximately 40 percent of the park has primary forest, containing trees such as native cedars and ipes which are valuable and rare. Other areas of the park have approximately 25 percent in secondary forest, 25 percent in recovering vegetation, and 10 percent in higher montane communities (LeBreton, 2010). Below 1,500 meters there are meadows, which were naturally formed by flash-floods.

Rare cat species have been spotted periodically, including ocelots (*Felid pardalis*) pumas (*Felis concolor*), and possibly even jaguars (*Panthera Onça*) (Evans, 2004). The jaguars are believed to be extinct from this park, however, as they have been hunted by local agricultural producers for generations. These producers fear the predation of livestock by the jaguars and therefore have hunted them to near extinction. The Serra do Brigadeiro also contains the brown-throated three-toed sloth (*Bradypus variegates*), a threatened species, and a great variety of birds[24], reptiles, and arachnids many of which are considered rare or threatened (Iracambi, 2011).

Culture and Trends

The people of Minas Gerais are called "Mineiro/as" and are largely farmers, producing nationally recognized cheese called "Minas cheese", cachaça (a liquor made from sugarcane), and a brand of the sweet "doce de leite". The main agricultural products of the region are coffee, milk, beef cattle and black beans, which are part of the national cuisine and a staple food for most Mineiros. They also rely heavily on rice, although this is not often grown locally as it is more economical to import, as a staple crop for the traditional feijãoda dish that is eaten most days for lunch. Most rural Mineiros also cultivate herbs, vegetables, and fruit trees such as banana, avocado, oranges, and mangoes, which are also a large part of their normal diet and culture.

Most farms do not exceed 30 hectares (Evans, 2004; Le Breton, 2000) and the families are usually large with an extended family composition. The average income is just above the national poverty level, and the literacy rate is less than the national average of 70 percent, with approximately a 50 percent literacy rate for the whole population and around a 30 percent rate for women (Le Breton, 2000). The majority of the roads are unpaved and most of the population utilizes public transportation, motorcycle, or horse and buggy to travel around. Some families are now able to afford cars, although this is still uncommon as even used-cars are expensive in Brazil. Homes are often simple, built

[24] A list can be found at http://birdingsiteguide.com/index.php?option=com_content&task=view&id=22&Itemid=1

by family members and neighbors, and sometimes lack electricity and running water. There are many springs and rivers in this area which are highly valued by the property owners and are now being protected through preservation of native forest nearby. However, native forest is kept to a minimum as the common perception is that trees take up land that could be more productively used in agriculture (Watson & Achinelli, 2008).

Economy and Development

Minas Gerais is a state that highly values agricultural production and production of raw material. The name translates to "General Mines" as it is the center of a long history of mining operations and the only place in the world where imperial topaz is mined. Minas Gerais also has the majority of the country's iron and steel production industries and has therefore had a long history of supplying fuel-wood from area forests. Since 1990, this area has largely been providing charcoal for these industries from cultivated fast-growing species such as eucalyptus and pine; clearing native forest for this purpose has nearly ceased (LeBreton, 2010).

The mountainous terrain, temperate climate, and heavy rainfall with a distinct dry season yields a near-perfect environment for coffee cultivation. By the end of the 19th century, coffee was Brazil's largest agricultural export, supplying three-quarters of the world's coffee (Dean, 1997; Watson & Achinelli, 2008). Today, no other country in the world produces more coffee than Brazil (23 million bags in 2005 (Watson & Achinelli, 2008). Minas Gerais contributes approximately 50 percent of the total production (Watson & Achinelli, 2008) and competitive factors include the state's low land prices and abundance of cheap labor. Additionally, the poor soils and steep topography, which makes much of the state unsuitable for commercial crops requiring mechanization, makes coffee one of the only crops grown on a large scale throughout the state (Le Breton, 2000; Watson & Achinelli, 2008).

In the 1950s, when coffee prices were very high in the world market, the Brazilian government created a program that provided financial credit to farmers for establishing coffee stands. Farmers were encouraged in the 1970s to increase their level of coffee production with even more financial incentives. Now, many of the rural farmers in Minas Gerais are financially dependent solely on coffee, which leaves them incredibly vulnerable to instability in the global coffee market. Further, as Brazil practices a system of sun-grown coffee cultivation, a high-yielding but environmentally exploitive strategy, the land is now highly degraded and suitable for very little once a coffee-stand rotation of 15 years[25] has been reached. At this point, farmers either need to apply an increasing amount of fertilizers, convert the land to another use, or abandon it. (Watson & Achinelli, 2008)

Farmers with other available land have traditionally converted old coffee plantations into pasture land and relocated their coffee stands to more productive areas. Minas Gerais is also a main cultivator of beef cattle, for meat and cheese production, and therefore has a demand for pasture land. A type of grass, brachiaria mutica (*Panicum purpurascens*), has been cultivated in this area as it grows well on these old coffee lands.

[25] The weak rainforest soils on the steep mountainous slopes of Minas Gerais, which receive much rainfall in the wet season, suffer from degenerative soil erosion which reduces the fertility of the soil. This loss of fertility, coupled with the intensive sun-grown coffee varieties and the typical cultivation model of three to 5,000 trees per hectare, decreases the productive life of a coffee stand to 15 years (Watson & Achinelli, 2008; LeBreton, 2010).

It is an African grass, which spreads mostly by runners, and was brought to Brazil so long ago many believed it to be a native grass called *capim Angola* (Parsons, 1972). Minas Gerais also has Molasses grass (*Melinis minutiflora, spp. Gordura melad*) which is another African grass that is important for much of the modern beef cattle industry (Parsons, 1972). In as early at 1922, scientist St. Hilaire recognized the invasive properties of this type of grass in Minas Gerais (Parsons, 1972). These African grasses are now so well established in Minas Gerais that some people attribute the taste of the economic staple, "Minas cheese", to these grasses of Minas Gerais (Parsons, 1972).

Economic Activity on the Edge of the Preserve

Although it is decreed that only "indirect use" of the state park is permitted, which is defined as activities for research and tourism, some resource extraction still occurs in the park. These activities include trapping rare birds for sale in regional markets and poaching rare tree species such as the heart of palm mentioned above. Further, some property owners collect other plant species from within the park boundaries for culinary or medicinal purposes, although they do not normally sell these outside the local market.

Other economic activity can infringe on the border of the park. There are still some instances in which forest clearing for agriculture through burning encroaches upon the park (Watson & Achinelli, 2008). Heavy fines can be charged to farmers that are caught clearing native forest on public land, but with small-scale burning farmers are not usually caught. A limited number of state officials patrol the park and usually these officials are unable to notice gradual changes from year to year (Watson & Achinelli, 2008). Often, however, the penetration is either unintended (such as breaks in fencing left un-mended which allow cattle to enter) or nonintrusive (such as bees raised for honey production utilizing nearby forested stands).

Productive Corridors in the Study Area

The concept of creating forest corridors for ecological benefits has been known in this area for years now. In addition to Iracambi's influence, the Southern-Minas Institute (Instituto Sul Mineiro, ISM), located in the south-west of Minas Gerais, began a corridor program in the 1980s on unused pasture land (Evans, 2004). In this program, ISM bought this land from local farmers in order to transform it into the corridor. This has had some social consequences, which although never being directly measured (Dean, 1997), are of interest to this study and to Iracambi's productive forest corridor program design. In the ISM corridor, neighboring landowners and other people have infringed on the native forest by cutting back one area for access to water for cattle and by poaching the edible heart of the palm tree (*Euterpe edulis)* (Dean, 1997). These, as well as other unintended violations such as the threat of fire from sugarcane fields or invading cattle through broken fences, are concerns for the Serra do Brigadeiro area as well.

Integrated forest corridors will work best in this area because it will help address the unintended and intentional violations. The Institute of Ecological Research (Instituto de Pesquisas Ecológicas, IPÊ), which is working with the Movement of Landless Workers in São Pãulo state is attempting to undertake another integrated corridor program. Their program has educated new settlers of ARL requirements, which restrict them from full property rights until the 20 percent requirement is achieved, and sponsored the establishment of corridors. These corridors allow for a temporary management of trees for commercial use, integrating eucalyptus and other hardwoods that can be sold after several years for additional income. Through this program, conservationists were able to take settlers who had no knowledge of sustainable agriculture or forestry practices and provide a mutually-beneficial environment. The conservationists were able to provide the same benefits for the community members as they were striving to provide for the wildlife: “a chance to survive, even prosper”. (EcoHealth, 2006)

Chapter 3

Methods

This exploratory qualitative study has a stated purpose of investigating the possibility of developing integrated forest corridors for the NGO Iracambi. This includes determining the challenges to implementation of Iracambi's integrated forest corridor program and investigating the overall viability of such a program in five different towns geographically distributed around the Serra do Brigadeiro state park, Minas Gerais, Brazil.

Study Area

Data were collected in the border region of the Serra do Brigadeiro that was accessible through the communities of Araponga, Ervália, Fervadouro, Miradouro, and Pedra Bonita with Sericita[26] as seen in Figure 3. These communities are geographically distributed around the park with two on the western side, two on the eastern side, and Pedra Bonita and Sericita located on to the north of the state park.

[26] The communities of Pedro Bonita and Sericita were counted as one "sample community" because the geographic location of the survey participants in that area of the border of the Serra do Brigadeiro were outside of both communities

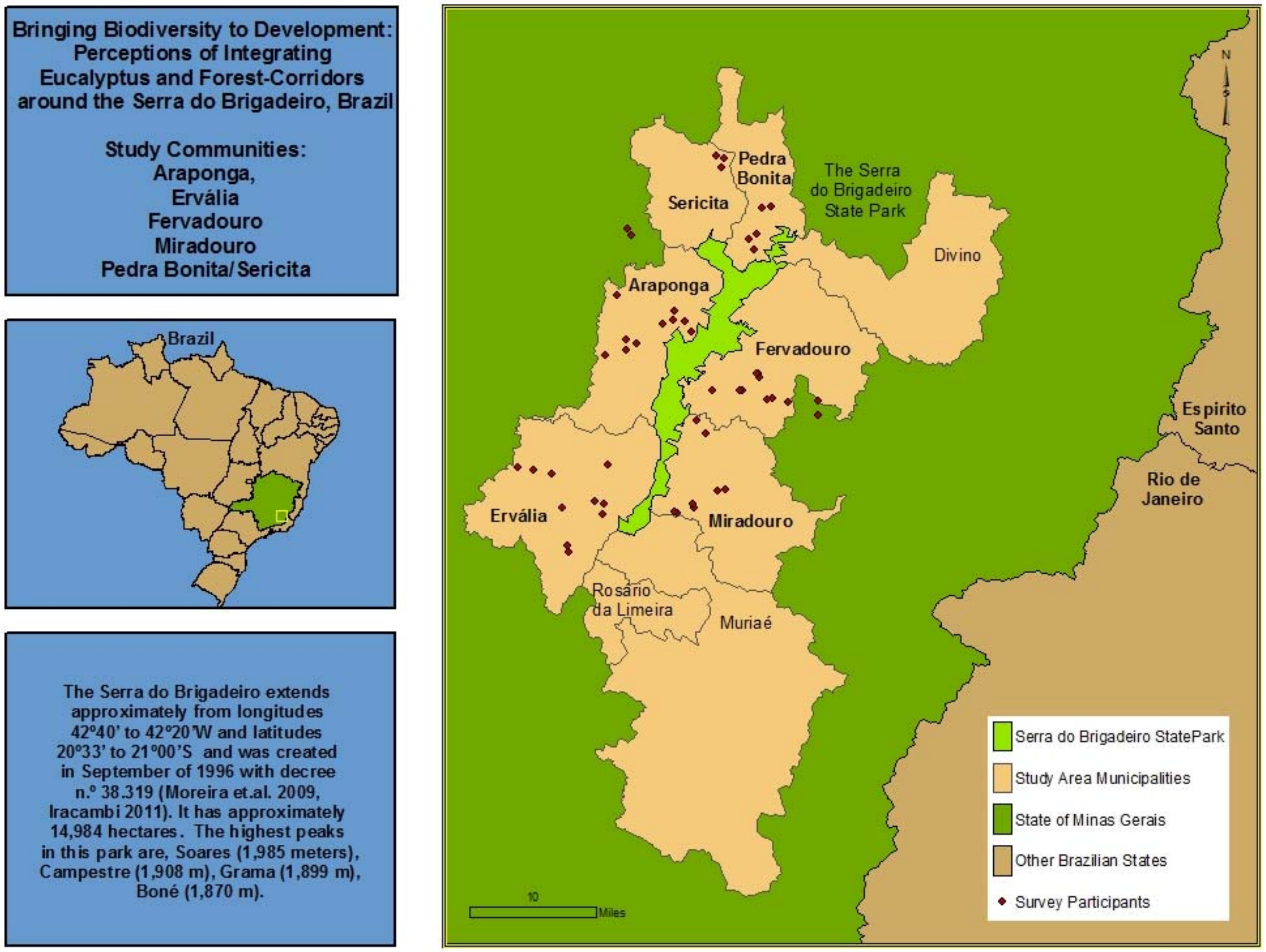

Figure 3: Map of Study Communities (Source Data: I-GIS 2011)

Representativeness of Study

Respondents were selected in each community through on-site observations of eucalyptus stands visible from the network of rural roads outside the community centers. A motorcycle was used for transportation[27] so that all roads could be accessed. The difficult logistics of reaching these farmers required the use of a motorized vehicle because the distance between each eucalyptus stand of an appropriate size was often 5 to 10 kilometers. Additionally, the availability of farmers was limited, and often one farmer was encountered for every four houses visited[28].

The lack of current information about landowners' agricultural and forestry practices was a key factor in choosing this method of participant selection[29]. The sample size of 50 respondents was determined due to these challenging logistics and the availability of survey participants. Due to the limited timeframe available for data collection, the need to collect data for all communities during the coffee-drying season in which farmers are more likely to be at home, ten surveys were conducted in each community[30], one community per week.

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[27] Research in Pedra Bonita/Sericita was undertaken using a car due to the inaccessibility of this region. However, all roads were still able to be accessed using this form of transportation but it was determined that it was less efficient due to gates separating pastures.

[28] Due to deficiencies in APP and ARL compliance, many qualifying participants declined to be included in the sample. Although it was made clear that all data were being collected for scientific purposes only, for use in this research project, and that the survey was being conducted in conjunction with Iracambi and UFV, still several farmers were unwilling to have any land-use practices documented.

[29] A national census is conducted every ten years in Brazil and was being conducted while I was researching in the area. However, due to many landowners lacking full legal rights to their land, some avoid participation in any formal documentation programs such as the census. This leads to the lack of reliable data on small-scale forestry operations in these rural areas.

[30] It was determined that it would be feasible to conduct at least two per day with additional travel time built in each week. Once both researcher and the assistant became more adept at finding appropriately sized eucalyptus stands, however, it was possible to conduct on average more than two surveys per day.

Study Design

In order to fulfill the purpose of this exploratory case study, a structured interview survey (included in Appendix 4) was chosen in order to measure the current practices of eucalyptus farmers in the area and their preferences for the design of Iracambi's proposed integrated forest corridor program. Additionally, this study sought to satisfy the objectives outlined in the objectives/purpose section of Chapter 1. The framework for this study was created in advance, and modified after a pilot test of the questionnaire was completed. The test was conducted in the community on the southern end of the state park in an area closest to Iracambi, with five participating survey respondents, and proved to be very useful in developing the final survey protocol. Some survey questions were dropped or modified and a few questions were added based on the outcome of this pilot test.

To meet the objectives of this study, information was collected on farmer willingness to participate in a proposed conservation program under two separate circumstances: a) integrating native species into future eucalyptus stands on varying ratios of native to eucalyptus, b) integrating native species into future eucalyptus stands in a geographically defined area. Information was also collected on perceptions of barriers to integration of native species into eucalyptus, including estimations of changes in labor and materials expense for planting, cultivating, and harvesting of eucalyptus.

In addition to data needed to meet the objectives of the study, additional information collected included general socio-economic data and general eucalyptus production data (such as typical product yield, sale value, production costs). When possible, additional information on compensation levels needed for participation in the proposed program was collected. Some information, (such as the ARL adherence), was collected using alternative questions rather than a direct line of questioning. This was due to the fact that many of the participants might want to falsify information in order to protect themselves from punishment. An important Brazilian cultural norm is that people often say what they think a guest may want to hear rather than providing true information. This cultural norm further complicated questioning and justified some alternative questioning techniques. To gather information on ARL compliance, for example, respondents were asked both direct questions, such as whether they comply with the ARL law, and indirect questions, by also asking them how much total land and how much native forest they have. The director of Iracambi suggested this format because it is common for respondents to tell a researcher that they are in compliance with environmental laws even when the respondent may fully be aware that he does not comply with the law.

Data Collection

Once appropriate sized stands were identified, inquiries were made in the area to identify the owner. The owner then was contacted to arrange an appropriate time to conduct the survey. Often the survey participant was available only after a certain hour, and in these cases a tentative appointment was scheduled for return visits. Interviews were conducted in a semi-formal structure, with questions about family composition and property structure administered first, and questions related to the conservation program administered second. A native speaker was hired to conduct the more detailed parts of the survey so that a full explanation of the intricacies of the program could be provided in the local dialect[31], thereby diminishing the level of confusion. However, there was still much confusion on the part of the survey respondents.

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[31] The assistant's knowledge of local customs and dialects was also instrumental in securing the full involvement of many participants. Outsiders are viewed suspiciously in many of these rural areas and having a native research assistant proved to be a benefit to this research project.

Methods for Analysis

The research assistant also verified the translation of survey results and the digitization of these results to the format used for analysis. The recursive abstraction technique, which entails summarizing information repeatedly until a compact narrative is reached, was utilized for analysis (Creswell, 2007). This technique was chosen because it is best for producing a well-considered explanation of the farmers' perceptions of the proposed corridor project, including their preferences for program organization and a base assessment of barriers to inception of this project. The author first analyzed responses from each community separately and then combined these into a final analysis of all responses. The separate analyses were conducted so that any outliers could be detected and further investigated. This qualitative dataset was analyzed without coding to facilitate this further analysis.

Chapter 4

Results

Results

Given the sensitivity of the collected information and the confusion that was experienced by many survey respondents, no surveys were answered completely. This confusion was due to questions regarding the following: the cost of native sapling establishment in an integrated stand, the cost of work to plant saplings, and the cost of additional work for eucalyptus when a stand is integrated with native vegetation. In addition there was some confusion relative to the estimation of expected forgone profits and estimation for subsidies needed for the different proposed integration levels. These sections (5.1 and 5.1A) of the questionnaire (Appendix 4), constituted 16 percent of the survey questions and were the most difficult for participants to answer, primarily because many survey participants had difficulty grasping the concept of differing levels of compensation. Although it was explained by a native speaker that more native species (i.e. less eucalyptus) in a stand would mean a higher subsidy due to the forgone profits, the average response rate of these questions was only nine percent. Given the sensitivity and confusion noted above, many questions were not answered by some participants. Accordingly, the analysis of different sections are based on the number of respondents to that question and not the total respondents. The number of respondents are noted for each question.

Therefore, a completed survey was re-defined as “having 75 percent of the questions answered with sufficient enough detail to be analyzed”. Under this definition, the resulting data consisted of 40 completed surveys, or 80 percent of all surveys. The other surveys were determined to be incomplete due to insufficient information for analysis of at least 25 percent of the questions. These surveys still were used for analyzing many of the sections. The resulting section analyses were based on number of respondents to each question and not total respondents.

Basic Demographic and Land Use Information

In order to determine the basic socio-economic information, responses were analyzed for questions related to the number of years the head of the household had attended school, when the household had been formed, how many children each survey respondent had, and the percentage of time that the survey respondent spent working on his farm versus the percentage of time spent in outside employment. Other topics the participants were questioned on included the total amount of land for each farm, the amount of land devoted to each land use type (i.e. number of hectares in agricultural crops, forestry operations, native forest, and other types) and what crop they preferred to cultivate (i.e. eucalyptus, coffee, cattle, etc.).

On average, the sample population of 50 had limited education but not exceeding the eighth grade[32]). Eighty percent of the respondents worked 75 percent or more of their time on the farm and 28 percent of these respondents owned a farm with more than 50 hectares. Out of 47 respondents, the average family was formed[33] 33 years ago with the most recent being 2 years and the oldest being 75 years. The average number of children of the 50 respondents was between 3 and 4 (3.7), with the largest number recorded being 11. 84 percent of the 50 respondents were born in the community of the farm they are managing (i.e. each sample community). Although 72 percent of the 50 respondents owned a farm size of less than 50 hectares (See Figure 4), the average farm size was is 55.52 hectares.

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[32] any response recorded as "0/1" was calculated using a "1"

[33] Respondents answers either indicate 1) how long they have been the head of the household, (if single or taking care of property they do not live on) or 2) how long they have been married (for those having acquired property at marriage which is the most common situation)

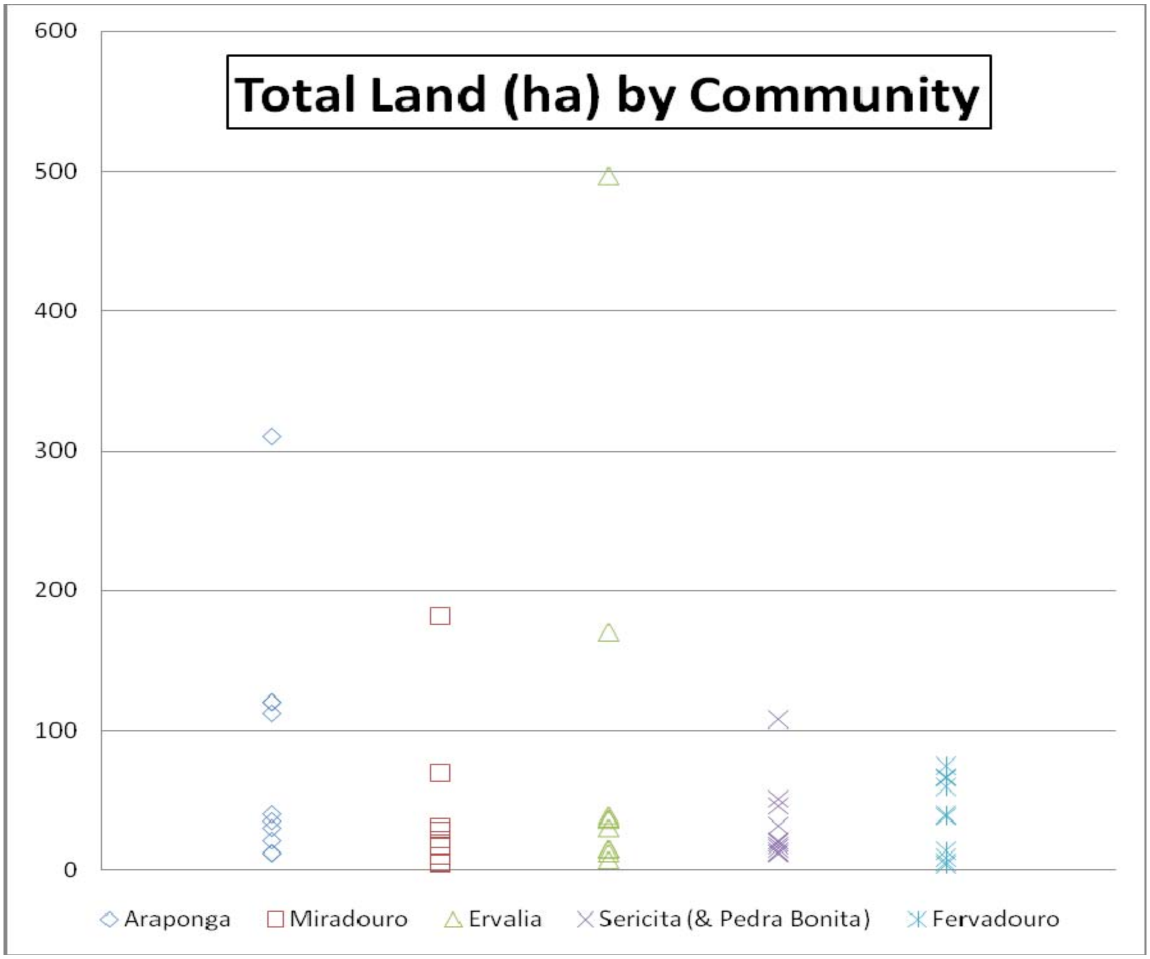

Figure 4: Land Distribution

Figure 4 illustrates the dispersion in land sizes within the sample population; the majority of survey respondents owned less than 100 hectares, with only 8 owning more than 100 hectares. The range was 492 hectares, with the smallest farm size at 4 hectares and the largest at 496 hectares. As shown in Figure 4, this indicates a large disparity in the sample population, (i.e., with a few of the respondents having large farms while the majority of the farmers own less than 50 hectares.

Of the 50 respondents, 85.8 percent have the majority of their land in agricultural crops or pasture. These numbers show the average percentage of land devoted to different uses among the 48 respondents to all of the questions of this section revealed that:

- 23.0 percent of land is in agriculture
- 11.2 percent in plantations
- 42.7 percent in pasture land
- 17.0 percent in native forest[34])

Very few participants (10 percent of the 50 respondents) had a silvi-pasture system and none of these respondents had an agro-forestry system. The majority of the respondents were not familiar with the terms “silvi-pasture” or ‘agro-forestry” systems. An average of 86.2 percent of 41 respondents indicated a preference for growing coffee[35] (1st indicated preference), 9.3 percent a preference for growing eucalyptus, with 2.2 percent for farming cattle and 2.22 percent for farming fish[36]. Although they are currently farming eucalyptus, coffee is still the main crop of this region. There is a very strong economic linkage between the communities’ natural resources and their livelihood.

Native Reserve Information

Forty respondents answered the questions on ARL requirements. Twenty-two of the 50 total participants in the survey population did not meet the small-farm exemption criteria of having 30 hectares or less in total land and are therefore are required to have an ARL. Of the 40 respondents, 69 percent claimed to comply but only 59 percent have calculated compliance (either comply or are exempt under the defined criteria).

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[34] The remaining percentage falls into the "other" category (which includes errors in farmers' calculations). However, the quality of the data doesn’t allow me to make any conclusions about the “other” category due to errors in the respondents total land calculations. This may also have slightly affected some of the other percentages calculated as well.

[35] Although there has been a decrease in revenue from coffee cultivation, this still is the main crop of this region.

[36] Percentages were calculated with the first crop respondents mentioned as being the favored one when more than one was provided

In order to verify the validity of their claims, a "calculated compliance" was derived using their total land reports. Of the total land they reported, a flat 20 percent calculation was determined to be the level at which they would have ARL compliance[37]. The calculated compliance assumes a zero hectare APP requirement for each property owner (i.e., that each farm contains no watercourses or springs, no slopes greater than 45 degrees, and no hilltops above 1800 meters in height). Had any of these farmers had APP requirements (a likely scenario), the amount of native forest that they are required to have would increase and the level of calculated compliance for ARL would decrease[38].

Twenty of the 40 respondents who answered this ARL question indicated that they were required to have native forest for ARL compliance but only 28.7 percent had calculated compliance. These 20 respondents included a surplus of 75.4 hectares and a deficit of 96.8 hectares. Therefore, the total amount of deficient native reserve land, for the 20 respondents required to have ARL, was 21.4 hectares. These numbers include those property owners exceeding their requirements as well since it is possible for property owners who have a deficiency on their property to meet ARL requirements if an arrangement (usually monetary) has

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[37] Calculations for ARL were based on the assumption that they would not have any APP requirements. APP requirements vary by site (due to the variability in shape and size of APP areas) and therefore were not determined with this survey. This variability makes it very difficult for a farmer to estimate the total amount of native forest dedicated specifically to an APP area. To determine APP area compliance, a study would require mapping of each site and was therefore out of the scope of this research project due to time and funding constraints.

[38] ARL requirements are determined after APP requirements have been computed. The calculations allow the landowner to subtract any APP requirements from the "total land" value that that property owner holds. Therefore, if a property owner has 100 hectares and APP requirements dictate that 10 hectares of this should be in APP then the 20 percent calculation for ARL requirements are computed on 90 hectares (100-10) and are therefore less than a flat 20 percent value of the total land amount. However, due to constraints discussed above, the APP for each landowner is determined to be zero hectares. Had any of the property owners been required to have APP, the total amount of native forest required for their property would have increased above the 20 percent value used to calculate "compliance". For example, in the illustration above, the example property owner with 100 hectares was required to have 10 hectares in APP and 18 hectares in ARL {[(total land-APP)*.20] = [(100-10)*.20]}. This totals 28 hectares, well beyond a flat calculation of 20 percent of total land as is used in this data analysis to calculate compliance.

been made for a nearby property with a surplus that counteracts this deficiency. However, some respondents erred in their land calculations (represented by a negative number in the "other" category) which for eight percent of all 50 survey participants, the miscalculations exactly matched the number of hectares that the respondent claimed to have in native forest.

These communities' compliance rates were similar to those reported previously for national ARL compliance rates. This is a sensitive issue in the area, and although a majority of the respondents do not comply, there is little motivation for them to do so since there is little enforcement. Additionally, education on the specific requirements of this law is needed since many are unclear on how to comply or whether they are exempt.

Eucalyptus History and Production

The purpose of the section is to outline some of the main components of eucalyptus cultivation in this area, including: 1) the planting costs associated with eucalyptus establishment, 2) trends in cutting and harvesting eucalyptus, and 3) selling eucalyptus. This section (F.1.-4. on the survey) included questions on the cost of establishing eucalyptus, such as the purchase price of the eucalyptus saplings and the cost of labor to plant and maintain these saplings. Additionally, questions were asked on: a) the amount of eucalyptus harvested within five years of the survey date, b) the number of these respondents that let the stand regenerate, c) how many times it had regenerated, and d) whether they plan to replant after this rotation. Additionally, questions related to the buying and selling of eucalyptus included: a) whether they were currently selling their eucalyptus and b) to whom, c) whether they felt it was easy to find a buyer and d) whether they felt they normally receive a just price. Further, they were asked if they plan to plant more eucalyptus in the future and information on where this new stand would be located was collected when possible.

The average price quoted by farmers to plant each tree of eucalyptus in the first year was $R2.22 per tree ($1.25 USD/tree[39]) as reported by the 34 respondents to this question[40]. Additionally, most of the 44 respondents to the question on the type of eucalyptus grown indicated that they are growing "the pink kind" ("rosa"), "the white kind" ("branco"), or "the red kind" ("vermelho"), (averages of 59 percent, 32 percent, and 23 percent of the 44 respondents) and 39 percent of these respondents are growing two or more of these particular species. Although it is not possible to report the specific tree each respondent was referring to when they indicate these three different types, it is likely that they were referring to different clones of Eucalyptus Grandis that are common in this area and have therefore been given common names related to the coloring of their foliage. Other respondents (25 percent of the 44 question respondents) indicated they were growing "E. Grandis" in general or did not specify a specific type of eucalyptus. An excerpt from this section's results, information from one sample community that was especially detailed and informative, can be found in Appendix 5.

It is common in this region to purchase your eucalyptus from a local dealer or grower and therefore many of the species are the same and often unknown to the farmer. Only 30 percent of the survey respondents (15) made a conscious decision to change the species of eucalyptus that they are growing, which further supports the previous statement that many do not consciously choose their type of eucalyptus and instead just end up with whatever is least expensive and is available. However, the 15 respondents who changed production levels of a certain type of species, often provided specific reasons for doing so. Among the most common species changed to were "branco" (4 of the 18 respondents) and the reasons given were: "grows quicker",

[39] At 2010 average exchange rate of 1.76697(IRS)
[40] There was much variability in the answers provided and many did not provide their answer in the same units (i.e. many indicated for 1,000 trees although some indicated prices for 1 hectare and did not specify spacing)

"develops more rapidly". Additional species changed to by the other 14 of 18 respondents were: the clone E. Uro Grandis ("better for income", "better development of wood"), and Rosa ("Rosa grows more (quickly) and is more resistant", "better adapted"). This shows that there is not much consensus among the farmers as to the superiority of the different types of species.

The survey respondents indicated that they are growing the eucalyptus specifically in order to extract and sell as building material (34 percent of the 50 respondents), charcoal (20 percent of the 50 respondents), logs for the sawmill (4 percent of the 50 respondents), and other logs with unspecified uses (42 percent of the 50 respondents). Most respondents choose the type of timber to harvest once the eucalyptus is mature, taking into consideration the current market prices for each of these goods. Therefore, there is little management of the stand before the extraction phase, (including very little coppicing), except for a little herbicide or pesticide application to combat the leaf-cutter ants or the occasional widespread fungus. Thirty-nine of the survey participants responded to questions on household use of eucalyptus (for cooking fires, timber for fencing, etc.). Of these, 30 percent claim that they do not use eucalyptus wood while 48 percent responded that they used “very little”. This is consistent with personal observations around the area; small branches of eucalyptus are most often used daily for cooking fuel and once every several years or when needed, some logs are used for fencing or the building of small structures. Only one respondent indicated that he uses his eucalyptus crop[41] in his coffee drying device - a system by which a fire is built to heat up a surface in order to dry the coffee faster than by use of natural solar power. These systems are more expensive and are therefore rare[42].

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[41] Although this respondent did not specify an amount of eucalyptus used, judging from the amount of coffee the respondent has and from personal observations of his coffee dryer equipment, speculations can be made that the amount was close to all of his eucalyptus (15 hectares).

[42] The most common way of drying coffee is to spread it on bare ground, plastic sheeting, or concrete slabs and to allow the sun to dry it during the winter months and the dry season.

Thirty percent (15) of all 50 respondents indicated that they were currently selling their eucalyptus and 27 percent of these 15 respondents were selling to a local sawmill[43]. Many of the rest of these 15 respondents indicated that they sold to neighbors (who may then have sold to sawmills), or other community members that then sell the crop on their behalf (middle-men/brokers), often to construction or dairy companies, or for charcoal or firewood. Additional respondents indicated that they were selling to other (non-local) sawmills for the making of furniture, building material-poles or support poles. Many survey participants who had yet to harvest timber declined to answer this question but did indicate informally that they know of places they will be selling it to once they harvest. These informal answers were consistent with the formal answers noted above. Seventy-eight percent of 41 respondents claimed it was easy to find an external buyer and 41 percent of these respondents say that they are planning to plant more eucalyptus in the future. However, only 24 percent of 27 respondents claimed they were receiving a "just price" for the goods that they are selling. These responses show that it is an easy market for them but one which does not provide much financial security.

Seventy-one percent of all 50 respondents let their stand regenerate through the practice of coppicing. The average number of times that stands have been regenerated by coppice has been less than 2 times (1.77), indicating that they are relatively new stands. Only one respondent who has recently cut his stand has converted it to another use (pasture) besides eucalyptus. Two respondents indicated that they will not replant once this rotation goes through. One of these respondents indicated his reasoning was that there was water in that area. There was no indication of what he intends to utilize that area for, although the common (and legal) route is to let it return to native vegetation.

[43] "local" defined as in the closest town or community

In summary, there were just a few types of eucalyptus being widely grown in the area ("the red, yellow, and pink kinds") and the majority of landowners were not practicing much stand-management. Most tended to grow what was available and few of the respondents specifically altered their stand composition based on growth rates or other factors. Although it was easy to find a buyer, most did not feel that they were receiving a just price for the timber although most respondents let their stand regenerate after harvesting the first crop. They were on average selling the timber to local sawmills or neighbors and several (41.72 percent) question respondents indicated that they intended to grow more eucalyptus in the future.

Perception of Native Species, Integrated Corridors, and Eucalyptus Cultivation

First, participants were provided a short explanation of why a corridor might be established[44] and asked if they might participate in a corridor program. This question and explanation were presented first, in order to provide survey participants with a reference with which to answer the other sections of question F.5 (LeBreton 2010). Participants were asked questions related to costs of establishing native species including saplings costs and expenses of cultivating them to maturity). For those respondents that were unable to provide information on these costs, they were asked to compare the costs of native sapling establishment to eucalyptus sapling establishment. In addition, the survey participants were asked questions to determine their perceptions of work involved with integrating native saplings into eucalyptus stands. As with the other questions, when respondents were unable to provide costs of labor or materials they were asked to compare the costs with a stand composed of entirely eucalyptus.

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[44] Explanation read as "In order to promote biodiversity in areas of monoculture and to preserve water resources, if there was a program that someone would compensate you for the expenses incurred to meet a proportion of eucalyptus to native forest in a future plantation,…" See Appendix 4, Question F.5

Of the 49 respondents to the corridor participation question, 94 percent indicated that yes, they would have the disposition to participate if the corridor program ever came to fruition. Although this appears to be a high number, and therefore a significant finding, it should be repeated that it is common for people in this region to say what they think a researcher or guest may want to hear rather than fully expressing their true opinions. Additionally, these respondents were lacking complete understanding on what participation would entail and therefore it is likely that the participation rate would have sharply declined if they had gained full comprehension of the details of the program. However, this data provides useful information for comparison with the results of a latter question (F.6) which again inquires as to their disposition to participate in a corridor program but also provides more details of restrictions of such a proposed program.

The percentage of respondents being able to provide any sort of price for native species saplings was only 8 percent of the 50 sample respondents. The average response of those 9 respondents was $R5.81 per native sapling ($3.29 USD[45]) but the range was between $R1.5 ($0.84 USD[46]) and $R15 ($8.49 USD[47]) per native sapling. This suggests that there is not much knowledge of native species cultivation. The majority of the native species cultivation occurs around the homes of these rural property owners, and these species are primarily fruit trees or occasionally ornamental trees. Only one respondent provided specific prices for two native species, "$R8/tree of cedar (Cedrela spp) ($4.53 USD[48]), $R5/tree of Angica (Anadenanthera colubrina spp) ($2.83 USD[49])". Two respondents did specifically mention that they were aware

[45] At 2010 average exchange rate of 1.76697(IRS)
[46] At 2010 average exchange rate of 1.76697(IRS)
[47] At 2010 average exchange rate of 1.76697(IRS)
[48] At 2010 average exchange rate of 1.76697(IRS)
[49] At 2010 average exchange rate of 1.76697(IRS)

that the Institute of Forest Studies (Instituto Estadual Florestas, IEF) donates native species to farmers of the area.

More often, although still not with much regularity, the respondents were able to provide an assessment of the cost of a native sapling based on a comparison of what they were familiar with, eucalyptus. Eight respondents indicated that the cost of the native saplings were more expensive than the cost of eucalyptus and nine respondents indicated that the amount of work required for cultivation of native species was more than for eucalyptus cultivation. However, twelve respondents indicated that there would be no additional work required in the cultivation of native saplings and gave reasoning such as, "less hand labor (involved)". Although this percentage is higher than the percentage claiming more work for native cultivation, the reasons given for those respondents that believe it would require more work directly conflicts with the one given above of less work. One respondent noted that there is a "higher cost of work than (with) eucalyptus because (native) requires more maintenance", and another that "(native) grows less quickly", which would add to the cultivation labor because there would be a longer period in which the saplings will need maintenance to shelter them from competing grasses if planted in pasture land. One other respondent even indicated that cultivation of natives would require three times as much labor, making it "three times more expensive (than eucalyptus)". These conflicting reasons support the above conclusion of a lack of knowledge of how to cultivate native saplings.

Twenty out of 50 of the respondents indicated that they would have forgone profits when integrating some native into a stand of eucalyptus. Survey participants were asked this question on forgone profits to determine, 1) if they believed the native saplings would be an asset to them and would provide other economic opportunities besides harvestable timber, and 2) if they felt that it would detract from their overall economic gain. When a situation with believed forgone profits was found, the accompanying questioning sought to determine how much they felt they would lose and would therefore need to be compensated for. Due to conservation laws previously discussed, it is very difficult to gain permission to cut native species in this region (and in much of Brazil), although many are either unaware of this or choose to disregard this constraint. Only two of these respondents recognized that they would have “a loss because not (being) able to cut the native (trees)" and would therefore need to be compensated for that loss in harvestable timber.

Further analysis of this section of the survey results showed further inconsistency in the level of understanding of laws regarding native trees and also the integrated forest corridor program. Forty percent of all 50 survey respondents recognized that they would have forgone profits although none could estimate how much compensation they would need for these forgone profits. Ten of the 50 survey respondents indicated that they understood that a subsidy would need to be provided, in order to make up for these lost profits, although none of those respondents were able to provide information on what that subsidy would need to be at any of the different proposed integration levels.

Integration Level and Spacing Preferences

In order to determine the respondents’ preferences for integrating native into eucalyptus stands, a survey section on integration levels and methods was included. Participants were given three choices regarding their preference for eucalyptus planting: a) separated, b) evenly spaced, or c) randomly dispersed or “in blocks” throughout the stand. The levels of integration were defined as: a) integrating 1 native sapling for every 3 eucalyptus trees (1:3 or 25 percent of the stand), b) integrating 1 native sapling for every 2 eucalyptus trees (1:2 or 33 percent of the stand,

and c) integrating 1 native sapling for every 1 eucalyptus tree (1:1 or 50 percent of the stand). It was explained in the introduction and reiterated as needed during this section of questions, that each of these levels would have a different corresponding subsidy levels and that this survey aimed to collect information on what those subsidy levels would need to be. However, as already noted the hypothetical nature of this question proved very difficult for participants to answer. When participants were unable to provide information on what these subsidy levels would need to be, they were asked what their preferences would be for integration levels (i.e. did they prefer 1:1, 1:2, or 1:3). Additional information was collected when possible on their reasoning behind choosing their preferred integration level. The following analysis results depict this information.

Fifty-two percent of 43 respondents indicated that they would prefer an integration level of 1 native species to every 3 eucalyptus trees (1:3), while 22 percent indicated integration level preferences of 1 native species to every 2 eucalyptus trees (1:2). Further, 25 percent of these respondents indicated a preference of 1 native species for every 1 eucalyptus tree (1:1). Only a few indicated a price that they would need for compensation, and some of their prices and reasoning for preferences are listed below.

- For those choosing a ratio of 1:3,
    - 25-30 percent of $R2,000 ($1,131.88 USD[50]) "which is the value of a hectare of (his) eucalyptus"
    - $R510 ($288.63 USD[51]) per month for 9,000 trees with a spacing of two meters by one meter as he already "has a large area of native forest and therefore prefers (a ratio) with more eucalyptus"
    - $R1,000 ($565.94 USD[52]) for one year with the planting of 5,000 trees as he "already has ARL and prefers more eucalyptus"
- choosing a ratio of 1:2,

[50] At 2010 average exchange rate of 1.76697(IRS)
[51] At 2010 average exchange rate of 1.76697(IRS)
[52] At 2010 average exchange rate of 1.76697(IRS)

- a required subsidy of $R3 per tree ($1.70 USD[53]) as the "(program) would help combat the leaf-cutter ants"
- $R1,000 ($565.94 USD[54]) per month because "(he) would have a little less of eucalyptus and would preserve a little more (native)"
- $R510 ($288.63 USD[55]) per hectare per month "to cover the costs" and

- choosing a ratio of 1:1,
  - "on the property (he) doesn't have forest reserve"
  - "(it would be) more simple; native area is cheaper"
  - "because the incentive is higher (with this ratio)"
  - $R1.5 ($0.85 USD[56]) per tree per year because "the two species would have a chance to develop better"
  - "talking (in terms of) preservation, this is best"
  - "(A ratio of 1:1 is) more ecological"
  - "(would) meet the legal reserve requirement and economic needs"

The variability in these responses reinforces the need for a detailed orientation before any integrated forest corridor program could begin. The subsidy for any program would be based on the participants' forgone profits and would likely be a percentage of the revenue from recent eucalyptus harvests and any changes in input costs such as labor, fertilizers, or pesticides. Therefore, although these answers provide useful information, the analysis of the subsidy level responses would not have yielded any reliable data on subsidy costs and therefore was omitted. Further, many of these subsidy level responses were unreliable as respondent answers indicated a lack of full understanding of the question components (i.e. that different ratios would have corresponding subsidy levels associated).

The response rate for the question on planting preferences was much higher, at 46 respondents. Sixty-seven percent of these 46 respondents chose a "separate" planting diagram (see Figure 5), while 29 percent choose an "evenly spaced" diagram, and the other four percent had an "in blocks" preference.

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[53] At 2010 average exchange rate of 1.76697(IRS)
[54] At 2010 average exchange rate of 1.76697(IRS)
[55] At 2010 average exchange rate of 1.76697(IRS)
[56] At 2010 average exchange rate of 1.76697(IRS)

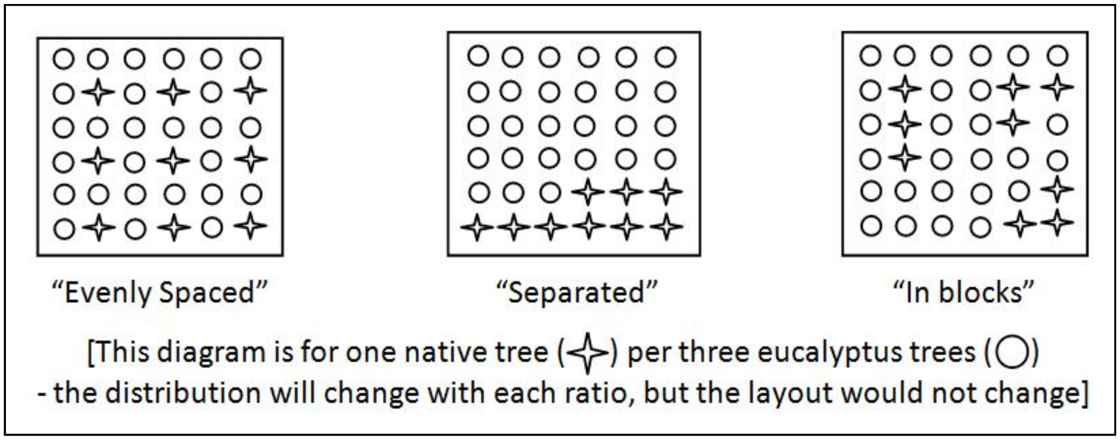

Figure 5: Planting Diagram

The average justification for this was that when harvesting the eucalyptus from a "separated" plantation it 1) "would be easier" and 2) "would not hurt the native". Other responses were related to the development of species when planted together; two indicated that they preferred a separated planting structure as, "planting them together stunts the development (of both)" and "eucalyptus as well doesn't develop well with native". Others indicated that, "natives will need sun" and "eucalyptus would shade out the natives". One respondent who was relatively indecisive, indicated that he preferred separated as it is "best for future management (of the stand)" but that "the others are also good for minimizing pests".

One respondent choosing an evenly spaced preference indicated that, "he would have the eucalyptus at a five meter by five meter spacing with a three to one (3:1) ratio of natives in between the eucalyptus". Another with the same planting structure preference noted that, "(after) the cutting of eucalyptus (he would) let the natives remain; (which would provide) shade and (protect the) fertility of the soil". Another indicated that evenly spaced was "better to (keep it) 'pretty'". One noted that "(evenly spaced is) 'more ecological'", but that "separated is 'more easy'". The variability in these responses shows the differences in the level of understanding of natural processes with native species and exotics, such as eucalyptus, and the need for education before implementing such a program as this proposed forest corridor program.

Corridor Participation

Finally, a survey section was included on a corridor program that would have restrictions on where it could be placed on their property. This section aimed to determine if this would hinder participation. As noted in a previous section, the percentage indicating they would be interested in participating in a corridor program, which was explained without any detail of where the corridor would be located, was 94 percent of 49 question respondents. Therefore, this question was asked to determine if there would be any change in this participation rate. Also, this section sought to determine survey participants' preferences for cultivating native saplings themselves or having these saplings provided as part of the program. It was explained that if the native saplings were not provided, and the program participants needed to cultivate them themselves, that an additional subsidy would be included for this added labor.

Some respondents (30 percent of the 43 respondents to this part of the question) indicated a preference for involvement in a corridor program that would allow them to cultivate the native plants themselves. Some of the reasons for this preference were given as: "because I could take better care of the saplings", "(I) would like to receive the price; and (it would be) under (my) control". However, many (70 percent) of the 43 question respondents that indicated a preference, responded that they would prefer to receive the native saplings instead of cultivating them. Some of these respondents indicated justifications for this preference of: not having experience with the cultivation of native species, "saplings received (from nurseries) are better quality", and "(because they) would only have the responsibility to plant and cultivate".

Of the 38 respondents to the question on corridor participation with restrictions on where the corridor can be placed on their property, 62 percent indicated that they would participate while 38 percent indicated they would not want to participate. Many who gave very definite answers of "no" indicated that they have "cultured land that (they) wouldn't give up", often in areas "that (are) able to produce coffee". This explanation is consistent with the results of the section on preferences for the type of crops cultivated. In that analysis, it was determined that 86.2 percent of the 41 question respondents indicated a preference of growing coffee to all other crops. In this region, coffee has traditionally yielded the highest revenue and has been a part of their rural culture for generations as previously discussed.

Although no survey participants indicated involvement in another subsidized conservation programs (such as the ProMata reserve program or emerging carbon sequestration programs), some do have above average native reserves or progressive ideas related to conservation. One respondent owns a “pousada” (vacation cabins) and campground business and has more than 20 percent of his land in native forest, noting that he has much water on his property which he prefers to protect (and is required to protect it by APP statutes). Another respondent who keeps bees and sells honey locally and regionally, indicated that he had more than the ARL requirement because he uses the native forest (and eucalyptus) as a “corridor” for the bees. This respondent even went as far as to comment that eucalyptus is a “monoculture crop” and is “not good for (the) environment”.

However, other survey respondents revealed some hostility toward conservation programs and the established park. For example, when explaining the program and indicating that the project would establish the feasibility of a forest corridor program in the area, one respondent indicated that “the Serra (do Brigadeiro) already has much land”. Some of the respondents who did not meet their ARL requirement, and were willing to discuss the reasons why, indicated that the Serra do Brigadeiro was nearby and had much native species. This was presented as a justification for why they did not have native species on their property.

Some of the respondents who were lacking their ARL, noted that many of their neighbors do not have native forest on their properties either. However, a few respondents expressed frustrations with neighboring property owners who “do not have any native forest” or who “do not (comply) with the ARL and APP (requirements)”. One respondent noted that, “the whole world cultivates their whole land but (he has his) ARL (requirement)”. Many of the participants were reluctant to record answers to the corridor participation question as a common method of decision making in this rural area is for people to “talk with other producers that have planted”, as one respondent noted. This common practice shows that there is a culture of civic empowerment and community interaction in which neighbors use each other as a resource to gain more understanding of a particular issue. This could be utilized in the establishment of a corridor program such as the one proposed by Iracambi since if it is accepted by some members in the community they would share the information with others in their community and likely influence their acceptance of such a program. Therefore, a more thorough discussion of this issue will be presented in Chapter 5.

Chapter 5

Analysis and Discussion

Analysis

In this chapter, analysis of rural landowner reactions provides some conclusions as to, and the feasibility of, an integrated forest corridor program around the Serra do Brigadeiro. Also discussed is the potential of an integrated forest corridor program as a viable conservation tool for Iracambi in the greater Serra do Brigadeiro region. To answer these questions, the following topics related to the landowner's reactions are discussed: 1) the levels in which eucalyptus producers would be willing to integrate native species into their future eucalyptus stands, 2) perceptions of barriers or complications to integration, 3) preferences for methods of planting both the species in one stand and perceptions of what would work best for their specific circumstances, 4) farmers' willingness to participate in a program that would restrict where their stand would be geographically located, and 5) adherence levels to ARL requirements.

Landowner Reaction: Overview

In addition to survey results, this section also utilizes information gathered from other community members through informal discussions before, during, and after interviews. Additional informal discussions yielded information on other community members' perceptions of the proposed integrated forest corridor program. From these joint results, there is some likelihood that such a program would be accepted by the community, although some additional steps[57] must be taken to ensure an integrated forest corridor program is successfully implemented.

[57] A discussion of these additional steps will be presented in Chapter 5later in this chapter.

As shown in Chapter 4 results of the sections *Perception of Native Species, Integrated Corridors, and Eucalyptus Cultivation*[58], and *Corridor Participation*[59], the majority of the survey participants expressed an interest in the proposed program and many expressed further interest if this would help them achieve ARL compliance. Many other community members who received the basic information about the survey, but who either did not meet the sampling frame requirements of between 1 and 20 hectares or simply declined to participate, indicated that they thought it was an interesting or intriguing idea. However, some participants were very wary of the integration of native species and eucalyptus in one stand. One participant laughed aloud when the idea was first mentioned and said that the idea was "crazy". A few commented that before any agreements were made, it would be necessary to consult other property owners and determine what they would agree to, as is the common practice in this area[60]. Overall, survey respondents were interested in participating in a program of this nature but indicated that they would need more information on both requirements and compensation.

Levels of integration of native into future stands

Fifty-two percent of 43 respondents indicated that their preferred integration level is 1 native to every 3 eucalyptus trees (1:3). However, with additional education steps and a full understanding of variations in the compensation levels associated with each integration level, the willingness of many potential participants to have integration levels higher than this ratio may change[61]. As noted in that same analysis, another 47.8 percent of the question respondents

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[58] Analysis on question section F.5
[59] Analysis on question F.6
[60] As previously noted, civic communication is how they make important land-use decisions and will be discussed more in length in Chapter 5.
[61] The potential for changes in this preferred integration level is based on the lack of full understanding of the program details in which compensation levels would be based on integration levels and therefore would exponentially increase with increased integration ratios.

indicated preferences for integration levels higher than the 1:3 ratio level, (1:2 or 1:1), which suggests some room for upward movement in their willingness. However, just as education of the details of the program may increase integration levels, it may also cause a decrease in the amount of participants in general. Since this survey did not supply detailed, site specific explanations for how participation will affect their economic output, it is probable that farmers would be less inclined to participate in the program if they determine that the integration levels required will take up too much space on their property and/or are not satisfied with compensation offered for this lost economic productivity. This will be discussed more in the knowledge barrier section of the forthcoming discussion.

Perceptions of barriers or complications to integration

The perceptions of barriers or complications to integration are centered on the differing opinions of additional work required for cultivating native saplings, as noted in the analysis of the perceptions of native species[62]. Although there were many respondents who claimed that there would be "less work" with an integrated stand, many others believed that the level of work would be significantly greater. There is a significant need to educate the potential participants as to how to integrate native species into eucalyptus stands, the benefits or costs of doing so, and how to cultivate the native. This will also be discussed in more detail in the discussion section.

Preferences for methods of planting

The preferences for planting both in one stand and what would work best for their specific circumstances were also shown[63] to be oriented towards a separated planting method. This was due to the ease with which eucalyptus timber could be extracted if the native trees were

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[62] Results section: Perception of Native Species, Integrated Corridors, and Eucalyptus Cultivation
[63] Analysis section: Perception of Native Species, Integrated Corridors, and Eucalyptus Cultivation

not intermixed. The majority of the time, the farmers indicated their preference for planting on what is easiest to farm and not what would be best for increasing biodiversity. Also, farmers were concerned over the damage that extracting eucalyptus would cause to the cultivated native species which is a concern shared by restoration silviculturists and therefore an additional discussion section topic below.

Farmers' willingness to participate with geographic restrictions

Further, the farmers' willingness to participate in a program that would restrict where their stand would be geographically located was shown in analysis of questions F.5[64] and F.6[65] to be lower than those willing to participate in a corridor program. The main consideration for most of these farmers, and therefore whether this program should be considered a viable option, was the replacement of productive coffee fields with native forest or eucalyptus stands. Their preferred crop is coffee since it has traditionally been a lucrative crop for the region and is also a part of their culture. Therefore, this program or any other forest corridor program will have difficulty convincing farmers to take fertile land suitable for coffee out of production and into reserves or eucalyptus stands.

Adherence levels to ARL requirements

As noted in the analysis of ARL adherence[66] and in the analysis of question F.5[67] and F.6[68], there is a need and a desire for programs that would subsidize ARL adherence in this area. Of the 40 respondents in the survey, ARL calculated compliance was determined to be 27.6

[64] Analysis section: Perception of Native Species, Integrated Corridors, and Eucalyptus Cultivation
[65] Analysis section: Corridor Participation
[66] Analysis section: Native Reserve Information
[67] Analysis section: Perception of Native Species, Integrated Corridors, and Eucalyptus Cultivation
[68] Analysis section: Corridor Participation

percent, and as noted previously in Chapter 2, national studies have shown that proclaimed adherence levels are approximately 10 percent. Although survey participants expressed an interest in complying with the law, the majority of the respondents indicated their integration preference to be "whichever one had more eucalyptus". Therefore, in order to determine viability of an integrated forest corridor program, further analysis must determine if potential participants are willing or need to comply with these laws and if the integrated stand would suffice for ARL adherence.

Discussion

As noted in the analysis section, landowner behavior is influenced significantly by local norms and knowledge. Facilitating local community forums and processes to introduce potential corridor projects should be undertaken. Factors that should be addressed during such forums or processes are addressed in this discussion section and include: cultural barriers, knowledge and cost barriers, and policy and institutional barriers. Finally, recommendations for the future establishment of this program, and other similar integrated forest corridor programs in Brazil, are discussed.

Cultural Barriers

Gaining acceptance from key local leaders and effectively tapping into local cultural norms have been identified as barriers to introducing an integrated forest corridor project in this area of Brazil. This type of barrier is not unique to this area and is common in rural development projects across the globe. In order to establish a program in these communities, a majority of the influential residents will need to agree that it is a beneficial program for them, their neighbors, and the community as a whole. Therefore, a community process should be undertaken which involves community education, deliberation, and group decision-making. This process should typically begin with several community meetings, led by a local organization that has earned the trust of community members. The initial meetings would need to involve as many community leaders as possible and would need to ensure 1) full understanding of the program details and how these will affect land-use for the community as a whole and 2) acceptance of the program by these community leaders.

Sufficient economic incentives and trusted local leadership are keys to ensuring local participation in an integrated forest corridor project. Local leaders should advise participants of any increasing enforcement of ARL requirements, and nurture any renewal in environmental ethics present in the community. Further roles for program leadership would be to ensure that farmers feel confident that this program will fulfill the terms of the agreement and that it will be stable enough to sustain these terms throughout the agreed upon program period. The program leaders will also need to negotiate the terms of the contract so that the communities' concerns are addressed and it will be mutually beneficial to both conservation efforts and the participants. The community will need to have trust in these leaders as well as confidence in their ability to fulfill the negotiated terms. Once an agreement between program directors and community leaders has been reached, civic empowerment can turn into an asset for this program rather than a barrier. Regular interaction between neighbors can facilitate the dissemination of program information which will be more effective in recruiting participants from the community than if the information was provided by a managing organization. However, in order to ensure that the participation level is sustained throughout the program, when establishing the forest corridor program it is important that correct information form the basis of landowner decisions and that they are fully aware of all responsibilities under the program guidelines.

Knowledge Barriers

As noted in the previous chapter, landowners do not have the knowledge required to effectively participate in a forest corridor program, and it is critical to address this barrier to produce desired results. Establishing a corridor with the right native species, knowing where to plant which native species, and how to manage the species are other barriers to implementing the proposed integrated corridor program. Ideally, qualified specialists would review the proposed corridor areas and recommend the optimal integration levels. Trained specialists would also need to address the misconceptions that some property owners may have with site visits and technical discussions. A restoration specialist may need to be accessible for many years[69] to provide stand management recommendations throughout the process of forest corridor establishment. Preferably, the specialist would provide information on whether to cut some natives that may have become too dominant in the intermediate successional stage, how much eucalyptus to extract from the stand upon maturity, and which eucalyptus tree to extract and by which method: frilling, girdling, or felling.

However, only 1000 specialists are able to provide this type of consultation for the Atlantic Forest environment (Karfakis 2011) and therefore, it may be very difficult and likely expensive to address this barrier [70]. Acquiring a specialist to carry out the tasks described above would also add a significant cost to this program. Additionally, this top-down management approach may be a deterrent for participation in the program since the general perception in the community is that little involvement from authorities, specialists, and governing bodies is best.

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[69] The technical process will have the duration of stand establishment, through the intermediate successional stage (a very long stage lasting 10-20 years in these types of forests), since the stands may require intensive management according to a restoration ecologist who has worked with Iracambi's integrated stands (Karfakis 2011).

[70] Many of specialists on semi-deciduous forest restoration are already working in the Amazon, Central America, or Mexico and would therefore be difficult to obtain for a relatively small-scale and low priority restoration project.

This culture has arisen in part because for many years these rural producers have had heavy legislation and little interaction from supporting agencies except for fines or arduous bureaucratic processes, as will be discussed in more detail in the *Policy and Institutional Barriers* section. Given these constraints, it will be best to omit having a restoration silviculturist involved in the process. However, the lack of technical advisement may produce inferior results and should therefore be noted in the program consideration.

Knowledge Barriers: From Lemons to Lemonade

Just as civic empowerment can be an asset for information dissemination about the program and acceptance of the program, it can also be an asset for implementing a technically rigorous conservation program. The need for regular interaction between trained specialists and property owners may be minimized through neighborhood discussions that distribute the basic information. It is important that program managers be conscious of what information is being distributed, however, in order to maximize results. Therefore, program must be overseen by dedicated personnel and managers.

Cost Barriers

The hurdle of funding and securing a qualified and consistent program manager must be overcome before beginning any forest restoration or corridor program. One benefit of the proposed integrated corridor program over traditional corridor programs, however, is that this type of corridor would require targeted application rather than hired crews planting vast areas of open pasture. Additionally, overall costs are likely reduced by an integrated corridor approach since planted eucalyptus stands are excellent nurseries, which speed up the ecological succession process to established native forest as was discussed in Chapter 2[71]. After approximately 15 years, an integrated corridor should have a composition more like primary forest than an abandoned field[72]. Specifically, these corridors would have more species diversity than a naturally regenerating stand, provided that the program participants plant the eucalypt in such a way that the traditional pasture grasses are suppressed. In 35-50 years after establishment, a producer would be able to have a fully restored forest (Karfakis 2011).

If participants were able to produce an economically viable crop, it would make the lengthy[73] time period more attractive to the landowner. These integrated corridor stands could be managed for economic production but only older trees should be harvested (Karfakis, 2011). The removal should be supervised by an advising restoration specialist so ensure that the correct amount is removed to promote forest regeneration. Program participants would need to leave the established integrated corridor relatively untouched for 10 to 20 years and then they would be able to cut a few trees from most stands[74] (Karfakis, 2011). To achieve this practice, program participants would need economic incentives to not harvest in the corridor.

Policy and Institutional Barriers

It is critical that policy and institutional mechanisms be established to support such incentives and long-term landowner commitment is established. With the right incentives in place, the program will be easily able to retain participants for the duration needed since it would be in their best interest to participate. However, currently these incentives are lacking and additional barriers to this program exist. The specialists, participating NGOs, and sponsoring

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[71] Section: *Integrated Forest Corridors*
[72] As was discussed in Chapter 2, section *Integrated Forest Corridors*
[73] Lengthy when compared to a traditional rotation of eucalyptus of five to seven years

[74] Approximately five trees per hectare (Karfakis 2011)

organizations must be ready to address the political issues, such as the heated debate over ARL and APP regulations previously discussed, which surround native forest management in Brazil. These political issues make it difficult to cut any native trees, even ones that property owners planted and are outside any required APP or ARL areas (Karfakis 2011, LeBreton 2010). This political climate would likely be a deterrent to individuals or organizations involved with the corridor project that may be "caught" cutting native trees as part of a thinning process or worse yet have to wade through the bureaucracy to do so legally.

The Brazilian Forest Law 4.771 of 1965 restricts the removal of native species once they are established. In order to legally cut native trees, a property owner must apply for a permit and doing so will normally take several months given the normal bureaucratic system[75]. The estimated cost for this permit process for the average rural landowner is $R153[76] ($86.58 USD[77]) to get approval to cut one native tree. There is also a similar process for legally cutting eucalyptus, and if a rural producer wants to sell eucalyptus timber, there is a whole other

[75] Currently, this process for the rural communities in Minas Gerias requires: 1) a photocopy of the property title deed and the property owner's identity card and Social Security (CPF) card [if the property owner has not already registered the ARL and APP (which is the norm in rural areas of Minas Gerais), this will need to be done first (which is another lengthy process)], 2) a certificate indicating that the property owner has the title deed from the land registry office, 3) a map developed by a registered professional with the GPS point of the tree or forested area marked on it, 4) a completed Forestry Institute (IEF) form that details, among other general and more applicable questions, the property owner's mother's name and marital status, 5) fee ticket provided by the IEF office to a bank to pay the fee [as is common with many government institutions in Brazil, the IEF cannot take fee payments because of previous financial transgressions], 6) after paying the fee, the property owner must get a copy of the receipt and, 7) take the copy to the IEF, and then 8) go home and wait for the IEF inspector to come to inspect the tree(s) in question (this could take a week or months) and after the property has been assessed, the property owner must 9) return to the IEF office and get the license. If the proper official is not there or has not yet signed the approval form, the property owner must go away and come back another day. (LeBreton 2011)

[76] The estimated cost for this process for the average rural landowner is: a) R$1.00 for photocopies, b) R$10.00 fee for the certificate from the land registry office, c) R$25.00 for a professional to produce the required map, d) R$15 IEF fee (for one tree, other requests have associated fees), e) transportation costs to the IEF office (for the community of Rosario da Limeira, property owners must travel to the city of Muriáe which is approximately a two hour trip by bus and costs R$13 each way or R$26 total per trip), f) foregone wages for each business day spent traveling to the IEF office (in this area, this can be estimated at R$25 per day and approximately two days would be required per request which will total R$50). Estimating that it only took two trips to the IEF office and that no other documentation was out of order and had to be filed, this totals to $R153 ($86.58 USD[76]) to get approval to cut one native tree. (LeBreton 2011)

[77] At 2010 average exchange rate of 1.76697

reporting procedure (LeBreton 2011). Clearly, most rural landowners do not regularly abide by these requirements. Of further interest is that the Brazilian government has tied the ARL and APP laws to this provision, thereby encouraging landowners that are not in accordance with the ARL or APP laws to omit the process to legally cut native trees.

Policy and Institutional Barriers: Time for change

As previously discussed in Chapter 2[78], the national forest policy guidelines have changed recently and now the governing principles of the Minas Gerais' Forestry Institute (IEF) are projected to change with a newly established governing administration. Minas Gerais is planning to abolish the IEF completely, and obviously many landowners are excited about this plan (LeBreton 2011). If this change produces less bureaucracy, and gives more control over land-use to the hands of property owners then this may diminish this barrier to implementation of the proposed integrated forest corridor program.

Ostrom (as quoted in (Korton, 2010)) states "we need institutions that enable people to carry out their (land) management roles". When our laws and rules work against the economic incentives and rules of a free-market economy, these laws need to be changed and new programs should be started to address the specific challenges present in each situation and geographic area (Ostrom 2007). Ostrom also emphasizes that there is no one program that will fix a type of problem in every area (a panacea) and that the public can and should be involved in the management of their natural resources.

[78] Previously discussed in chapter 2, section on *Government Response: Forest Policy Reform*

This concept of panaceas was clearly adapted by the Brazilian government with the 1965 forest decrees requiring APP and ARL reserves on private property. By legally binding landowners to privately held native reserves with no economic compensation, the government has put the task of conservation on the backs of the landowners instead of in the hands of governing bodies. In addition, the government has put the cost burden of biodiversity conservation on the backs of the same landowners. Further, by failing to properly enforce these laws in rural areas until recently, the government has encouraged a culture of delinquency. This delinquency in ARL laws is well known by governing authorities, as previously discussed. Now, government officials are requiring that to comply with other laws, such as the ones governing removal of native species, the ARL or APP offenses must be remedied but this is only adding to further infractions. If the landowner decides to abide by the laws and reverse any previous infractions, the government is not providing any assistance (knowledge based or financial) to do so. Significant changes in policy are needed and a new framework for ensuring some minimum level of biodiversity conservation that is economically, politically, and socially acceptable is needed as well. There is clearly a need for further discussions on these topics, which unfortunately is beyond the scope of this research project.

Recommendations

This research has found that providing needed knowledge and financial incentives to rural landowners deficient in ARL requirements provide a basis from which to build an integrated forest corridor program. Toward that end, the following recommendations are made. The initiation of this program should be delayed until after the IEF is abolished. If this policy change yields sufficiently less bureaucracy then this conservation program should be initiated. However, it should be initiated with the overall goal of to establish a larger-scale forest corridor program. Funding and scientific expertise should be acquired through the Critical Ecosystem Partnership Fund[79] (CEPF) or one of the other main funding organizations listed in Table 1 and would help address the knowledge and cost barriers discussed. Effective processes are needed to empower rural communities and build social capital which could be used to overcome some of the cultural barriers and should therefore be a priority in the initial phases of this program. It is important that the community members feel confident that this program would fulfill the terms that they agree to, and will be stable enough to sustain these terms throughout the program period that they agree to.

An ideal design for this program would involve property owners agreeing to participate in this integrated corridor program for 15 years. The property owner should be advised that they will be able to harvest a few large 15-year old trees per hectare at the end of the program. These producers would then have more product per unit area and a higher price per unit area than if they had engaged in a five to six-year rotation method. This method could still yield less economic output than a stand that could be managed and extracted from every five to seven years, and would therefore need to be subsidized as previously discussed in Chapter 1[80]. Additionally, these producers would need different extraction techniques and equipment for felling large trees, and access to a market for these logs, which would require assistance from program directors. The program should apply for forest products certification[81] extracted from

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[79] This organization is overseeing the creation and management of the Atlantic Forest Biosphere Reserve and has the stated strategic directions and priorities of to "improve management of existing and future public protected areas through targeted civil society efforts" with "support (of) activities led by civil society participants that increase viability, connectivity and forest cover in buffer zones of protected areas (CEPF 2011).

[80] Previously discussed in chapter 1, *Iracambi Rainforest Conservation and Research Center*

[81] Such as from the Forest Stewardship Council (FSC), which is an organization with a record of working with small-communities, and who has previously provided certification to eucalyptus timber. Further, this organization is the leader in the certification industry and has been selected by the major Brazilian bank, Itaú Unibanco, for their new (2010) environmental awareness campaign which orders that all Itaú documents be printed on FSC certified paper.

these integrated stands and further increase the viability of this program through increased marketability.

Further research needs to be undertaken to determine the exact subsidy level needed. This could be achieved with a willingness to accept study (WTA) but would require sizeable funding and a significant amount of time to properly conduct a survey in this rural area. Additionally, the possibility of FSC certification of forest resource products from integrated corridors would need to be explored. All of these recommended efforts should be postponed until the IEF has been abolished in Minas Gerais and the future of environmental and land-use requirements are more stable. Unfortunately, this stability may not be achieved for many years, and may come after the Serra do Brigadeiro and this area of the Atlantic Forest has been further isolated and affected by activities on surrounding land.

List of References

Alston, L. J., & Mueller, B. (2007). Legal Reserve Requirements in Brazilian Forests: Path Dependent Evolution of De Facto Legislation. *Revista EconomiA.*

Aracruz Celulose Sustainable Growth Strategy: Challenges and Opportunities. (2008) (pp. 1-24): Aracruz Celulose.

Atlântica, C. M., Integrados, D. P., Conjuntos, P., & Integradas, A. (1992). *Reserva da Biosfera da Mata Atlântica*: Unicamp.

Banerjee, O., Macpherson, A. J., & Alavalapati, J. (2009). Toward a Policy of Sustainable Forest Management in Brazil. *The Journal of Environment & Development*, *18*(2), 130.

Bank, T. W. (2011). Brazilian Biodiversity Fund - FUNBIO (GEF), 2010, from http://web.worldbank.org/external/projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P044597

Bauch, S., Sills, E., Rodriguez, L. C. E., McGinley, K., & Cubbage, F. (2009). Forest policy reform in Brazil. *Journal of Forestry, 107*(3), 132-138.

Beier, P., & Noss, R. F. (1998). Do habitat corridors provide connectivity? *Conservation Biology, 12*(6), 1241-1252.

Benitez Malvido, J. (1998). Impact of forest fragmentation on seedling abundance in a tropical rain forest. *Conservation Biology, 12*(2), 380-389.

Bensusan, N., de Sá, R. L., & Lima, A. Public Policies, Laws, and Landscape Design in Brazil.

Bertolucci, F., Demuner, B., Garcia, S., & Ikemori, Y. (1995). *Increasing fiber yield and quality at Aracruz*.

Bonner, J. (1994). Wildlife's road to nowhere. *New Scientist, 143*(1939), 30-34.

Bowen, L. S. (1996). New World Record For Tree Diversity, 2010, from http://forests.org/archived_site/today/recent/1996/newrecor.htm

Brown, J. H., & Kodric-Brown, A. (1977). Turnover rates in insular biogeography: effect of immigration on extinction. *Ecology, 58*(2), 445-449.

Brown Jr, K. S., & Freitas, A. V. L. (2000). Atlantic Forest Butterflies: Indicators for Landscape Conservation1. *Biotropica, 32*(4b), 934-956.

Brudvig, L. A., Damschen, E. I., Tewksbury, J. J., Haddad, N. M., & Levey, D. J. (2009). Landscape connectivity promotes plant biodiversity spillover into non-target habitats. *Proceedings of the National Academy of Sciences, 106*(23), 9328.

Camargo, J., & Kapos, V. (1995). Complex edge effects on soil moisture and microclimate in central Amazonian forest. *Journal of Tropical Ecology, 11*(02), 205-221.

Celulose, Papel e Produtos Florestais (Brasil 2010). (2010) (N0. Florestas. ed., pp. 1).

Chokkalingam, U., & De Jong, W. (2001). Secondary forest: a working definition and typology. *International forestry review, 3*(1), 19-26.

Conservancy, T. N. (2011). Brazil: Atlantic Forest, 2010, from http://www.nature.org/ourinitiatives/regions/southamerica/brazil/placesweprotect/atlantic-forest.xml

Couto, L., & Betters, D. R. (1995). Short-rotation eucalypt plantations in Brazil: social and environmental issues: Oak Ridge National Lab., TN (United States).

Couto, L., & Dube, F. (2001). The status and practice of forestry in Brazil at the beginning of the 21 st century: A review. *The Forestry Chronicle, 77*(5), 817-830.

Creswell, J. W. (2007). *Qualitative inquiry & research design: Choosing among five approaches*: Sage Publications, Inc.

Daily, G. C., & America, E. S. o. (1997). *Ecosystem services: benefits supplied to human societies by natural ecosystems*: Ecological Society of America Washington (DC).
de Aguiar Patriota, A. (2009). RAINFORESTS AND REGULATION: NEW DIRECTIONS IN BRAZILIAN ENVIRONMENTAL LAW AND LEGAL INSTITUTIONS: AN INTRODUCTION TO BRAZILIAN ENVIRONMENTAL LAW. *Geo. Wash. Int'l L. Rev., 40*, 611-779.
Dean, W. (1997). *With broadax and firebrand*: University of California Press Berkeley.
Débora Nacif de Carvalho, I. B. C. (2006). Sustainability and Effectiveness of Environmental NGOs - The Influence of the Managerial Process. Retrieved from http://www.istr.org/conferences/bangkok/WPVolume/NacifDeCarvalho.Debora.pdf
Diegues, A. (1994). As áreas naturais protegidas: o mito do paraiso desabitado. *º Encontro Anual da ANPOCS*.
EcoHealth. (2006). Wildlife Corridors Offr Pathways for At Risk Species, 2010, from http://www.ecohealthalliance.org/news/17-wildlife_corridors_offer_pathways_for_at_risk_species[3/10/2011 6:21:05 PM]
Edgar, J. (1984). Social and environmental implications [Eucalyptus forests; wood production; Australia].
Eucalyptus log prices in Brazil jumped 25%. (2010). Retrieved from International forest Industries website:
Evans, C. (2004). Productive forest corridors in the Atlantic Forest, Brazil: Rosário da Limeira, Brazil: Iracambi Atlantic Rainforest Research and Conservation Center.
Gascon, C., Williamson, G. B., & da Fonseca, G. A. B. (2000). Receding forest edges and vanishing reserves. *Science, 288*(5470), 1356.
Goerck, J. M. (1997). Patterns of rarity in the birds of the Atlantic forest of Brazil. *Conservation Biology, 11*(1), 112-118.
Group, T. W. B. (2011, 2009-08-12). Pilot Program to Conserve the Brazilian Rain Forest (PPG7), 2010, from http://go.worldbank.org/G331NVDKL0
Guariguata, M. R., Rheingans, R., & Montagnini, F. (1995). Early woody invasion under tree plantations in Costa Rica: implications for forest restoration. *Restoration Ecology, 3*(4), 252-260.
Hirakuri, S. R. (2003). Can law save the forest?: lessons from Finland and Brazil.
Hobbs, R. J. (1992). The role of corridors in conservation: solution or bandwagon? *Trends in Ecology & Evolution, 7*(11), 389-392.
IBGE. (2009). Produção da Extração Vegetal e Silvicultura (Vol. 24, pp. Table 2).
IESB. (2007). 2010, from http://www.iesb.org.br/english.php
Inglis, G., & Underwood, A. (1992). Comments on some designs proposed for experiments on the biological importance of corridors. *Conservation Biology, 6*(4), 581-586.
International, C. (2007). Atlantic Forest, 2010, from http://www.biodiversityhotspots.org/xp/hotspots/atlantic_forest/Pages/biodiversity.aspx
International, C. (2011). Atlantic Forest Biodiversity Hotspot (Brazil), 2010, from http://www.cepf.net/where_we_work/regions/south_america/atlantic_forest/ecosystem_profile/Pages/biological_importance.aspx
IPEMA. (2011). The Atlantic Forest, 2010, from http://www.ipemabrasil.org.br/ingles/mataatlantica.html

Iracambi. (2011). Serra do Brigadeiro State Park, 2010, from http://iracambi.com/v2/index.php/serra-do-brigadeiro-area/99-serra-do-brigadeiro-state-park

IRS. (February 18, 2011). Yearly Average Currency Exchange Rates, 2011, from http://www.irs.gov/businesses/small/international/article/0,,id=206089,00.html

Jacinto Tabanez, A. A., & Viana, V. M. (2000). Patch Structure within Brazilian Atlantic Forest Fragments and Implications for Conservation 1. *Biotropica, 32*(4), 925-933.

Jacobs, M. R. (1955). Growth habits of the eucalypts. *Growth habits of the Eucalypts.*

Jepson, W. (2005). A disappearing biome? Reconsidering land cover change in the Brazilian savanna. *Geographical Journal, 171*(2), 99-111.

Karfakis. (2008). SecondaryRegeneration in Eucalyptus. Iracambi Reports. Pdf.

Karfakis, T. (2011). [Personal Communication].

Korton, F. (2010). No Panaceas! Elinor Ostrom talks with Fran Korten, from http://shareable.net/blog/no-panaceas-a-qa-with-elinor-ostrom

Laurance, W. F., Ferreira, L. V., Merona, J. M., Laurance, S. G., Hutchings, R. W., & Lovejoy, T. E. (1998). Effects of forest fragmentation on recruitment patterns in Amazonian tree communities. *Conservation Biology, 12*(2), 460-464.

Laurance, W. F., Ferreira, L. V., Rankin-de Merona, J. M., & Laurance, S. G. (1998). Rain forest fragmentation and the dynamics of Amazonian tree communities. *Ecology, 79*(6), 2032-2040.

Le Breton, R. (2000). *Land Management and Sustainable Development in the Atlantic Rainforest of Brazil: The Iracambi Experience*.

LeBreton, R. (2010). [Personal Communication].

Lovejoy, T. E., & Bierregaard, R. (1990). Central Amazonian forests and the minimum critical size of ecosystems project. *Four neotropical rainforests*, 60–71.

Macpherson, D., & Peck, A. (1987). Models of the effect of clearing on salt and water export from a small catchment. *Journal of Hydrology, 94*(1-2), 163-179.

Mansergh, I. M., & Scotts, D. J. (1989). Habitat continuity and social organization of the mountain pygmy-possum restored by tunnel. *The Journal of Wildlife Management, 53*(3), 701-707.

May, F., & Ash, J. (1990). An Assessment of the Allelopathic Potential of< I> Eucalyptus</I>. *Australian Journal of Botany, 38*(3), 245-254.

Mead, D., Ugalde, L., & Perez, O. (2001). Mean annual volume increment of selected industrial forest plantation species. *Forest Plantations Thematic Papers. Working Paper (FAO).*

Mittermeier, R. A., Myers, N., Thomsen, J. B., Da Fonseca, G. A. B., & Olivieri, S. (1998). Biodiversity hotspots and major tropical wilderness areas: approaches to setting conservation priorities. *Conservation Biology, 12*(3), 516-520.

MOREIRA, J. C., MANDUCA, E. G., GONÇALVES, P. R., DE MORAIS JR, M. M., PEREIRA, R. F., LESSA, G., & DERGAM, J. A. (2009). Small mammals from Serra do Brigadeiro State Park, Minas Gerais, southeastern Brazil: species composition and elevational distribution. *Arquivos do Museu Nacional, 67*(1-2), 103-118.

Morellato, L. P. C., & Haddad, C. F. B. (2000). Introduction: The Brazilian Atlantic Forest1. *Biotropica, 32*(4b), 786-792.

Myers, N. (2003). Biodiversity hotspots revisited. *BioScience, 53*(10), 916-917.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature, 403*(6772), 853-858.

The United Nations. (2000). *United Nations Millennium Declaration*.
The United Nations. (2007). *State of the World's Forests: Annex*.
The United Nations. (2010). *The Millennium Development Goals Report*. New York: the United Nations Department of Economic and Social Affairs.
Newmaster, S. G., Bell, F. W., Roosenboom, C. R., Cole, H. A., & Towill, W. D. (2006). Restoration of floral diversity through plantations on abandoned agricultural land. *Canadian Journal of Forest Research, 36*(5), 1218-1235. doi: 10.1139/x06-021
Nicholls, A., & Margules, C. (1991). The design of studies to demonstrate the biological importance of corridors. *Nature conservation, 2*, 49-61.
Noss, R. F. (1987). Corridors in real landscapes: a reply to Simberloff and Cox. *Conservation Biology, 1*(2), 159-164.
Oliveira, S. J. M., & Bacha, C. J. C. (2003). Avaliação do cumprimento da reserva legal no Brasil.
Parker, G., Leopold, D., & Eichenberger, J. (1985). Tree dynamics in an old-growth, deciduous forest. *Forest Ecology and Management, 11*(1-2), 31-57.
Parsons, J. J. (1972). Spread of African pasture grasses to the American tropics. *Journal of Range Management, 25*(1), 12-17.
Pattanayak, S., & Butry, D. T. (2003). Forest ecosystem services as production inputs. *Notes*.
Peter Köhler, J. C., Bernard Riéra, Andreas Huth. (2003). Simulating the Long-term Response of Tropical Wet Forests to Fragmentation. *Ecosystems, 6*(2), 114-128. doi: 10.1007/s10021-002-0121-9
Poore, M., & Fries, C. (1985). The ecological effects of eucalyptus. *FAO Forestry Paper (FAO)*.
Putz, F., & Canham, C. (1992). Mechanisms of arrested succession in shrublands: root and shoot competition between shrubs and tree seedlings. *Forest Ecology and Management, 49*(3-4), 267-275.
Reis, G., & Reis, M. (1993). Competição por luz, água e nutrientes em povoamentos florestais. *Simpósio Brasileiro de Pesquisa Florestal, 1*(1993), 161-172.
Roberts, M. R. (2002). Effects of forest plantation management on herbaceous-layer composition and diversity. *Botany, 80*(4), 378-389.
Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F., Lambin, E., . . . Snellnhumber, H. (2009). Planetary boundaries: exploring the safe operating space for humanity. *Ecology and Society, 14*(2), 1-32.
Rosenberg, D. K., Noon, B. R., & Meslow, E. C. (1997). Biological corridors: form, function, and efficacy. *BioScience, 47*(10), 677-687.
Rosillo-Calle, F., & Hall, D. O. (1992). Biomass energy, forests and global warming. *Energy policy, 20*(2), 124-136.
Sachs, J. D., Baillie, J. E. M., Sutherland, W. J., Armsworth, P. R., Ash, N., Beddington, J., . . . Gaston, K. J. (2009). Biodiversity conservation and the millennium development goals. *Science, 325*(5947), 1502.
Santos, J. S. A. M. (2003). *ANÁLISE DA PAISAGEM DE UM CORREDOR ECOLÓGICO NA SERRA DA MANTIQUEIRA.* Mestrado, INPE, São José dos Campos.
Schonewald-Cox, C. M. (1983). *Genetics and conservation: a reference for managing wild animal and plant populations*: Benjamin-Cummings Publishing Company.
Simberloff, D., & Cox, J. (1987). Consequences and costs of conservation corridors. *Conservation Biology, 1*(1), 63-71.

Simberloff, D., Farr, J. A., Cox, J., & Mehlman, D. W. (1992). Movement corridors: conservation bargains or poor investments? *Conservation Biology, 6*(4), 493-504.

SOSMA. (2011). Retrieved 2010, from http://sosma.org.br/

Strier, K. B. (2000). Population Viabilities and Conservation Implications for Muriquis (Brachyteles arachnoids) in Brazil's Atlantic Forest1. *Biotropica, 32*(4b), 903-913.

Sutton, R. (1993). Mounding site preparation: A review of European and North American experience. *New Forests, 7*(2), 151-192.

Tabarelli, M., Pinto, L. P., SILVA, J. M. C., Hirota, M. M., & Bedê, L. C. (2005). Desafios e oportunidades para a conservação da biodiversidade na Mata Atlântica brasileira. *Megadiversidade, 1*(1), 132-138.

Tewksbury, J. J. (2002). Corridors affect plants, animals, and their interactions in fragmented landscapes. *Proceedings of the National Academy of Sciences, 99*(20), 12923-12926. doi: 10.1073/pnas.202242699

Tewksbury, J. J., Levey, D. J., Haddad, N. M., Sargent, S., Orrock, J. L., Weldon, A., . . . Townsend, P. (2002). Corridors affect plants, animals, and their interactions in fragmented landscapes. [Research Support, U.S. Gov't, Non-P.H.S.]. *Proceedings of the National Academy of Sciences of the United States of America, 99*(20), 12923-12926. doi: 10.1073/pnas.202242699

Trajano, E. (2000). Cave Faunas in the Atlantic Tropical Rain Forest: Composition, Ecology, and Conservation1. *Biotropica, 32*(4b), 882-893.

Turnbull, J. W. (1999). Eucalypt plantations. *New Forests, 17*(1), 37-52.

Turner, I., & T Corlett, R. (1996). The conservation value of small, isolated fragments of lowland tropical rain forest. *Trends in Ecology & Evolution, 11*(8), 330-333.

UNESCO. (2011). World Heritage Center, 2010, from http://whc.unesco.org/

VILAR, M. B. (2009). *VALORAÇÃO ECONÔMICA DE SERVIÇOS AMBIENTAIS EM PROPRIEDADES RURAIS.* Universidade Federal de Viçosa.

Watson, K., & Achinelli, M. (2008). Context and contingency: the coffee crisis for conventional small-scale coffee farmers in Brazil. *Geographical Journal, 174*(3), 223-234.

Webb, T. J., Gaston, K. J., Hannah, L., & Ian Woodward, F. (2006). Coincident scales of forest feedback on climate and conservation in a diversity hot spot. *Proceedings of the Royal Society B: Biological Sciences, 273*(1587), 757-765. doi: 10.1098/rspb.2005.3364

Appendix 1

List of common tree species occurring in naturally regenerating understory of Eucalyptus Grandis, study region of the Atlantic Forest in Minas Gerais, Brazil (pg 72, Karfakis 2008)

Machaerium acuelatum
Machaerium scleroxylon
Peltophorum dubium
Peltophorum reticulata
Caesaria sylvestris
Colubrina glandulosa
Ramhnidius oleocaprus
Savia dictyocarpa
Virolla sebifera
Swetia fruticosa
Schinus molle
Connarus regnelli
Bathysa meridionalis
Cordia superba
Rapanea feruginea
Tapirira guianensis
Vernonia discolor
Aspidoderma ramiflorum
Bochycia glabra
Licania tomentosa

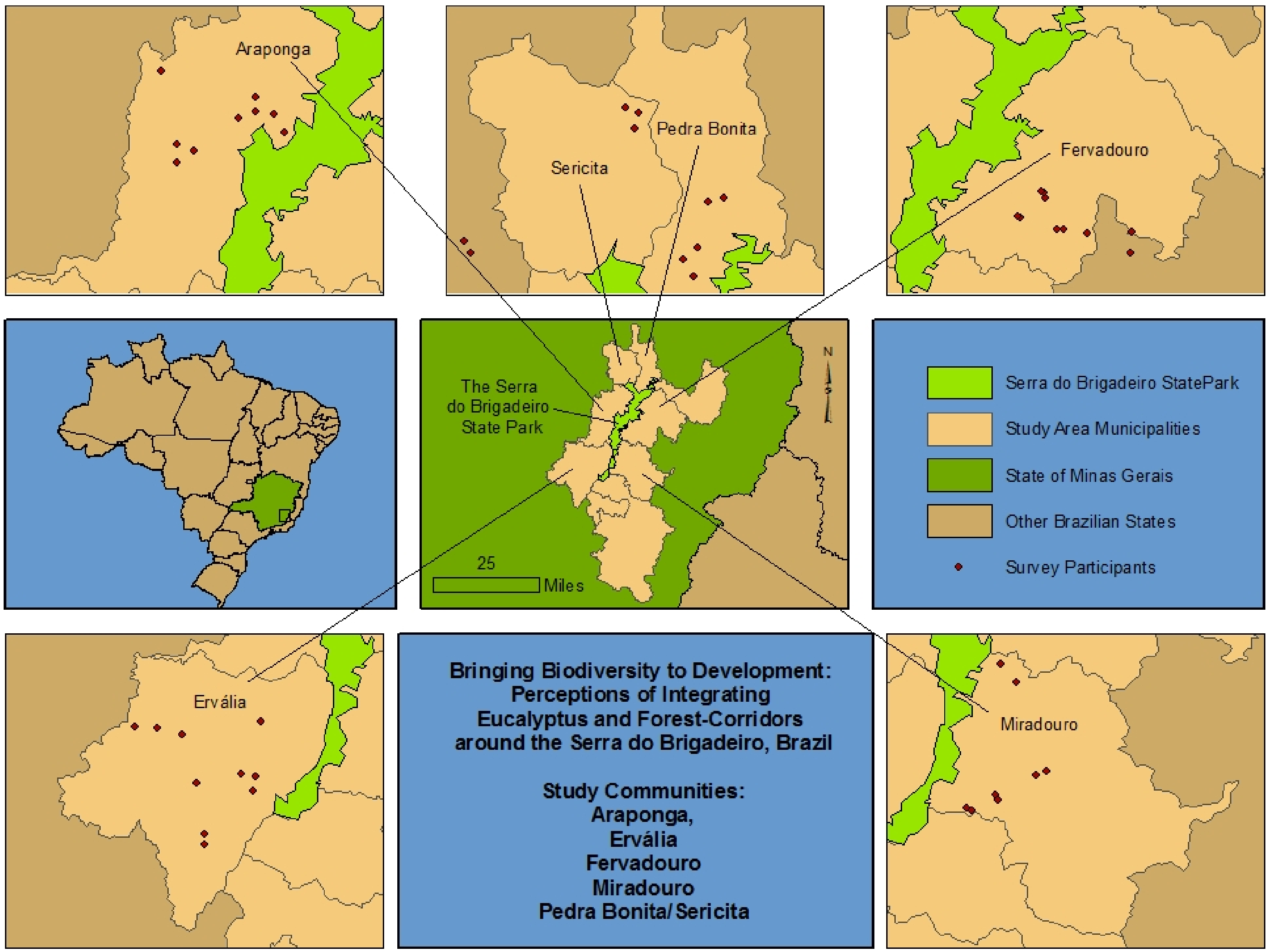
Appendix 2

List of native and medicinal plants, study region of the Atlantic Forest in Minas Gerais, Brazil (LeBreton 2010)

Luehea divaricata
Casearea sylvestris
Tabebuia cassinoides
Senna multijuga
Jacaranda micranthra
Baccharis trimera
Arctium minus
Sparattosprema leucanthum
Echinodorus grandiflorus
Cecropia pachystachya
Phoradendron crassifolium
Maytenus ilicifolia
Senna machranthera
Auchornea triplinérvea
Camponamanesia xanthocarpa
Schizolobium parahyba
Pseudobombax grandiflorum
Inga sessilis
Tabebuia heptaphylla
Piper aduncum
Hymenaea courbaril
Citrus limom
Paciflora alata
Diatenopteryx sorbifolia
Enterolobium cortontisliquum
Carpotroche brasiliensis
Bauhinia forficata
Croton urucurana

Appendix 3

Study Community Map



General data source: USGS, 2010

Appendix 4

1. Household name and code	*(name)	(HID)

Household survey 1

Control information

Task	Date(s)	By who?	Comments
Interview			

A. Identification

1. Identification and location of household.

1. Name of primary respondent	*(name)	(PID)
2. Name of secondary respondent	*(name)	(PID)
3. GPS reference point (RP) of household or property		
4. Closest neighbor to property	*Sur-name*	*GPS RP*

B. Household composition

1. We would like to ask some questions about the head of the household:

1. How long ago was this household formed (see definition of household)	*years*
2. Was the household head born in this community? *If 'yes', go to 5.*	
3. **If 'no':** how long has the household head lived in the community?	*years*
4. If yes, but he lives in the city: When did you move?	*Year*
5. Level of schooling *Codes: 1=illiterate; 2=Primary school (1-4); 3=Secondary school (5-8); 4=High school (8-12); 5=Superior (bachelors); 9=Post-graduate:*	

2. Who are the other members of the household?

1. Personal Identification number (PID)	*** Name of household member**	**2. Relation to household head[1)]**	**3. Less than 21? Y/N**	**4. Sex** *(0=male 1=female)*
1		Household head = code 0		
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

1) Codes: 1=spouse (legally married or cohabiting); 2=son/daughter; 3=son/daughter in law; 4=grandchild; 5=mother/father; 6=mother/father in law; 7=brother or sister; 8=brother/sister in law; 9=uncle/aunt; 10=nephew/niece; 11=step/foster child; 12=other family; 13=not related (e.g., servant). ***If some are less than age 21, see page 5***

1. Household name and code	*(name)	(HID)

C. Employment

1. Please indicate the type of work you do (in % of time devoted to it during the week)?

1. Work on the property	
If 0%: Have any of your children or other family members taken over the management of the property?	
If yes, Do they live close?	
2. Employment off of the property at a steady – non-seasonal occupation	
3. Odd jobs – including seasonal work	
4. Other	

D. Forest clearing

1. Has the household recently (over the last 5 years) harvested any forest resource crop? *If 'no', go to 9.*		*Last 5 years*		
If YES:	2. How much area was cleared?	*ha*		
	3. What was the land used for after the harvest? *Codes:0=regeneration 1=cropping; 2=another tree plantation; 3=pasture; 4=non-agric uses 5=harvest for sale (Rank max 3)*	1.Rank1	2.Rank2	3.Rank3
	1. If used for crops (code '1' in question above), which principal crop was grown? *(code-product) Rank max 3*	1.Rank1	2.Rank2	3.Rank3
2. How much land used by the household has over the last 5 years been abandoned (left to convert to natural vegetation)?		*ha*		

E. Land

1. Please indicate the amount of land (in hectares) that you currently have on your farm.

Category	**1. Area** *(ha ou Alquer)*	*Comments:*
Forest:		
1. Natural forest		
1. Does this meet or exceed your required Legal Reserve Area (ARL)?		
2. If you exceed this requirement, by how many hectares?		
2. Plantations		
Agricultural land:		
3. Cropland		
4. Pasture (natural or planted)		
5. Agroforestry		
6. Silvipasture		
7. Fallow		
8. Other vegetation types/land uses (residential, bush, grassland, wetland, etc.)		
9. Total area (1+2+3+…+8)		

***Map Stand, Note characteristics below – Return for rest of survey**

Characteristics to note	Waypoint?	Comment
1. Natural vegetation		
2 Border of the Serra da Brigadeiro		
3. Other		

1. Household name and code	*(name)	(HID)

F. Willingness to Accept

Control information

Task	Date(s)	By who?	Comments
Interview			
Assistant			
Description of WTA, PPM given:	Yes/no		
Level of understanding by survey participant: *Code: 0=no comprehension, 1=below average, 2=average, 3=full comprehension*			
Entering data			
Checking & approving data entry			

** In order to promote biodiversity in areas of monoculture and to preserve water, we will ask you to calculate the price that would be necessary to compensate you in order to participate in a program of conservation. These scenarios are hypothetical; this is a preliminary data collection survey and that your responses will in no way guarantee compensation or the creation of such a program.*

Program Participation Questions

1. Do you currently grow Eucalyptus? *Code: 0=no, 1=yes; If no, skip to question 3.*				
2. If yes:	Varies/ unknown	**A.**	**B.**	**C.**
1. What three species do you grow the most of? *Ex: Branco, Rosa, Vermelho, Grandis, etc.*				
2. Do you currently sell any of your products to an external buyer? *Code: 0=no, 1=yes; If no, skip to question 2.4*				
3. If so, on average who do you sell most of it to/ who is most reliable to buy it?				
4. On average, how much of your crop is consumed around your household, (i.e. not sold)?				
5. What three types of forest products do you sell the most of? Ex: Charcoal, Wood for making charcoal, building material, saw timber				
6. Have you recently changed production values of any of these types? *Rate changes in + or - % (Ex.+10% on A, -10% on B) Ex.: Have you planted more of one type and less of another?*	Yes → No			
1. Why have you changed practices?				
7. Do you feel that it is easy to find a reliable buyer? If no, why? (specify)				
8. Do you feel that you are getting a fair price for it? If no, why? (specify)				

1. Household name and code	*(name)	(HID)

*4. In order to promote biodiversity in area of monoculture and to preserve water, if there was a program that someone would compensate you for costs that you (currently / would) incur to meet and maintain a certain ratio of Eucalyptus to native forest, would you be willing to participate? *Code: 0=no, 1=yes; *An example of a proportion is, "two of one type of thing (a tree) to one of another type of thing (another type of tree) = 2:1"*			
If no:			
1. What concerns do you have regarding participation in such a program? *See Codes below, max. 3; If none = enter 0 in all 3 columns*			
2. If these concerns could be addressed, would you be willing to participate in such a program? *Code: 0=no, 1=yes If no, go to 5.*			
If yes to 4. or 4.2:			
1. What level of compensation (in $BRL per year) would be needed for you to commit to a level of:			
a) 1 tree of a native species for every 3 trees of Eucalyptus cultivated? So, this signifies that for every 4 trees planted, that only 3 trees of eucalyptus would be harvested			
What are you basing this number on?			
Comments:			
Changes to the estimate 1.a):			
b) 1 tree of native forest for every 2 trees of Eucalyptus cultivated?			
Changes to the estimate 1.b):			
c) 1 tree of native forest for every 1 tree of Eucalyptus cultivated?			
Changes to the estimates:			
Comments on 1a)-1c):			
*5. If there was a program that someone would compensate you for costs that you (currently / would) incur to participate in a ecological corridor program (that had a restriction on where a plantation can be geographically located - to link native forest with other native forest) that integrated native forest with eucalyptus, would you participate if…			
1. it was your responsibility to cultivate the native trees?			
2. if the necessary native trees were supplied to you for free?			
Comments:			

** Re-affirm that this scenario is hypothetical; that this is a preliminary data collection survey and that their responses will in no way guarantee compensation or the creation of such a program*

Appendix 5

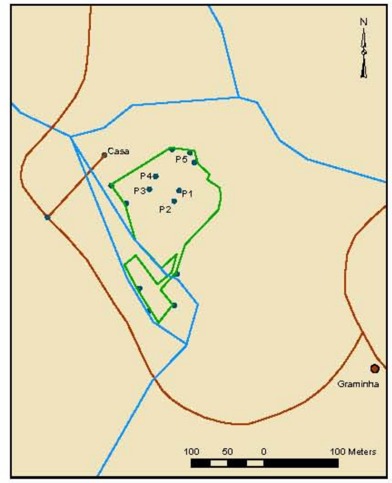
Fervadouro Eucalyptus planting distribution responses

Question Code	Question synopsis	Response 1	Response 2	Response 3	Response 4	Response 5	Response 6	Response 7	Response 8	Response 9	Response 10
F.2.1.	The 3 species you have the most of in your eucalyptus stand:	Grandis	Rosa	Rosa (80%)	Rosa 30%	Rosa 70%	Branco	Branco	Rosa 80%	Branco	Ciitriadora - 300 feet
		-		Branco (20%)	Branco 70%	Branco 30%	-	-	Vermelho 20%	-	Rosa - 2500 feet
		-					-	-	-	-	Urofila - 100 feet

Appendix 6

Example of stand analysis offered to survey participants

Eucalipto de Clovis e Carminha - ~15 Anos & 1 Ano
Graminha - Zona Rural de Rosário da Limeira, Minas Gerais, Brasil



As Florestas de Eucalipto de Clovis e Carminha com ~15 anos Graminha, Rosário da Limeira, Minas Gerais, Brasil				
Área de Floresta (Eucalipto Floresta) (ha)	Altura Média de Arvores (m)	Área Basal para cada ha (m^2/ha)	Volume para cada ha (m^3/ha)	Volume de floresta (m^3)
1.84	12.85	16.20	93.70	172.41

Volume média é entre de 10 (para os solos pobres) e 55 (florestas da Aracruz) m^3/ha/ano
http://www.fao.org/docrep/004/ac121e/ac121e04.htm

Análise de engenharia florestal

Dessa floresta tem grande variabilidade em AB e altura, pois consiste em várias áreas de distúrbios, espesso com sub-bosque e vegetação nativa. Portanto, para atingir a precisão na estimativa de volume, precisa que muitos amostras serão tomadas.

Análise de engenharia florestal e SIG de Maggie Stevens, Bolsista de Pesquisa - Rotary Internacional, Setembro 2010

Origem de dado: Iracambi, Setembro 2010

Vita

Maggie Stevens has a B.A. in Economics and Geography from The University of Tennessee, Knoxville. She has participated in conferences, and has published on topics about the science of sustainability and ecosystem management. Ms. Stevens is also a returning Rotary Ambassadorial Scholar (2009-10) to Brazil where she completed her thesis research. She is now working on a Brazil-U.S. land use change project at the Oak Ridge National Laboratory, Environmental Sciences Division.