Lund University Master's Programme in Environmental Science
Thesis: 2001-02-05

Deforestation, Coffee Cultivation, and Land Degradation: The Challenge of Developing a Sustainable Land Management Strategy in Brazil's Mata Atlântica Rainforest

by

Kelly Watson

In cooperation with
Iracambi Recursos Naturais

Nyängen, Ullersäter
71892 Frövi Sweden
040-431468
kwatson@journalist.com

Supervisor:
Sandra Fernandez
Ph.D. Candidate
Institute for Cultural Geography
046-222 84 03
sandra.fernandez@kulekgeo.lu.se

Abstract

The Atlantic Rainforest of Brazil, known as the Mata Atlântica in Portuguese, is an area of exceptional biodiversity, but is severely threatened, and has been reduced to only five percent of its original extent. The principle causes of its destruction have been its exploration for development and agriculture, especially coffee cultivation. Although the Brazilian environmental protection law gives special recognition to the Mata Atlântica, it has been unable to prevent its continued deforestation.

This study shows how these factors are related to land degradation in Rosário da Limeira, a small municipality in the southeast of the state of Minas Gerais, typical of many others throughout the Mata Atlântica. Enforced legal protection of the forest has not been the solution—instead measures are needed that address the problem of land degradation, not just the symptoms of deforestation. This requires a systemic approach involving the ecological, economic, and social parameters for understanding the causes behind the problems, and the development of appropriate measures to combat these problems.

Presented in the study is an analysis of the relationships at work behind the existing problem cycle of deforestation, coffee cultivation, and land degradation in the region. This analysis reveals that the Mata Atlântica is threatened with further destruction from the demands for productive agricultural land, as small-scale coffee farmers are forced to maximize the use of their resources without the economic liberty to consider the limitations of the land. Continued land degradation, in addition to instability on the world coffee market, is also a serious threat to the livelihood of the farmers.

Based upon the problem analysis, a land management strategy is presented that strives to protect the rainforest by addressing the economic and social needs of the small-scale farmer, in combination with ongoing forest conservation efforts and community education. Such a strategy involves land management techniques that prolong and improve the life of coffee plantations, while seeking alternative markets for diversified production in the region.

The results of the study focus on a case study of Iracambi, a small natural resource organization in Rosário da Limeira, which has taken the initiative to address the problems of deforestation, coffee cultivation, and land degradation. The organization is presented as an example of a sustainable approach to forest conservation, rural development, and community education. Their approach embraces the systematic participation of all levels of the community to make the conservation of the Mata Atlântica more attractive than its destruction.

Keywords: sustainable land management, deforestation, coffee cultivation, biodiversity conservation, Mata Atlântica, Iracambi

1. Introduction

1.1 Problem Definition

Over the past five centuries, deforestation has reduced Brazil's Atlantic Rainforest to less than 50,000 square kilometers—a mere five percent of the more than 100 million square kilometers of its original coverage (Consórcio 1992). Although it is often the Amazon that comes to mind at the mention of deforestation in Brazil, the lesser known Atlantic Rainforest, the *Mata Atlântica* in Portuguese, holds the country's highest amount of biodiversity. Over the last 500 years the Mata Atlântica has disappeared at *5 times the rate of the Amazon* (Dean 1995), and is considered to be one of the world's most threatened biomes. What was once a vast rainforest holding a rich diversity of plant and animal life is now a collection of broken pockets of mostly secondary forest.

As in the Amazon, deforestation in the Mata Atlântica is a result of the seemingly insatiable search for productive agricultural land. Native Indians practiced slash and burn forest clearing as early as 3,000 years ago, but the process of deforestation really began with the arrival of the first Portuguese settlers to Brazil during the early 1500's. Today deforestation in the Mata Atlântica continues at an alarming rate, primarily to provide land for coffee plantations and cattle grazing (ibid.).

Once the rainforest has been cleared the soil remains fertile for only a short period, after which time the land begins to degrade, leading to the felling of even more forest in the continuous pursuit for productive soil. This destructive cycle is driving the Mata Atlântica to its limits, and with it the extinction of hundreds of plant and animal species. Of the 202 species on Brazil's threatened or endangered list, 171 of these are found in the Mata Atlântica, and 85 percent of these are endemic (Ferreira 1999).

Not only is the forest threatened, but also are the rural farmers who are dependent upon its rich soils for their livelihoods. Despite the downward trend in world coffee prices, farmers are unable to receive government assistance for anything but the cultivation of coffee. Yet, an average coffee plantation remains productive for a mere 20 years, after which time the land may be planted with grass and made into pasture for livestock, but eventually must be abandoned. This process is costly, coffee markets are unstable, and the forest continues to be cleared.

This cycle of deforestation, coffee cultivation and land degradation cannot be solved unless a land management plan is found that addresses the causes behind such problems, not merely the symptoms. Such a management plan, once implemented, should provide for the protection of natural resources, while allowing rural farmers economically feasible alternatives for improvement. Encompassing all aspects of a sustainable land management strategy—ecological, economic, and social—is the focus of this study.

1.2 Objectives and Scope

The objectives of this study are to address the causes and development behind the current problems of land management in Brazil's Mata Atlântica rainforest by examining the struggle between forest conservation and agricultural productivity. This struggle is complex and has three dimensions—ecological, economic, and social—involving many factors.

- **Ecological**: the Mata Atlântica rainforest is threatened by the expansion of agricultural land, primarily coffee plantations, which results from land degradation and poor land management. Land degradation and poor land management are largely due to farmers' lack of resources and sometimes knowledge.
- **Economic**: Coffee is a cash crop that offers farmers more than a mere subsistence-based livelihood. However, prices on the world coffee market are volatile and substantial price fluctuations threaten the security of this livelihood. Further, while the long-term trends for global coffee production are predicted to rise, the trends for coffee prices are expected to fall.
- **Social**: With little means for change, farmers continue to grow coffee. Presently, small-scale farmers are living just barely above a subsistence-based existence and poverty is the norm. Improved standards of living, rural development, education, and better access to resources and markets are desirable.

In response to this complex problem of deforestation, coffee cultivation, and land degradation a land management approach is suggested. This approach integrates the use of ecologically sustainable land management techniques, while encouraging the diversification of production and the development of alternative markets to enhance the economic and social prospects for small-scale rural farmers. The result being that the farmers' resources, namely the land and forest, will not be exploited. The process of achieving such a land management approach is one that involves and educates rural farmers, while facilitating community development.

The scope of the paper will focus on coffee production in Rosário da Limeira, a small but typical municipality in the Brazilian State of Minas Gerais. Here the problems of deforestation and land degradation are representative of much of the Mata Atlântica's lower montane forests—where coffee plantations threaten not only the continued existence of the rainforest, but also the long-term security of small-scale rural farmers.

1.3 Study Limitations

In a description of the limitations of this study it is significant to address the complexity involved when attempting to look at such a detailed problem from so many different angles. The dynamic relationships between the ecological, economic, and social components of sustainability are part of a highly integrated and complicated system. The problems in this report are examined through a wide-angle lens, so to speak, which is necessary when looking at each of these components as functioning pieces of a greater system. Of course, another researcher might have chosen to look at only one of the aspects presented in this study; however, this was not the author's intention, as narrowing the scope does not allow for a greater appreciation of the situation, in reference to a systems analysis based look at sustainability. Therefore, the primary limitation of this report is the complexity of the subject matter in which it attempts to examine.

The largest practical limitation of this study is the absence of comprehensive formal interviews with the local small-scale farmers in the region of Rosário da Limeira as a result of a language barrier. Before undertaking this study, it was the intention of the author to complete a series of interviews with local farmers to determine their personal views towards conservation in the Mata Atlântica and the challenge of halting land degradation on their coffee fields. However, the author is not fluent in Portuguese, and the resources of Iracambi unfortunately did not allow for a translator. Therefore, although informal interactions with local farmers were a regular occurrence during the author's stay in Brazil, no formal

interviews have been included in this report. In the future, these interviews would be a relevant and desirable addition to this study.

1.4 Methodology

This study was written in cooperation with three months of work with the non-governmental organization Iracambi Recursos Naturais (Iracambi), located in Rosário da Limeira, Brazil. The time spent in this region enabled the author to gain firsthand appreciation of the relationships existing between deforestation, coffee cultivation, and land degradation. Additionally, the author was able to experience direct interaction with the many actors involved in the work to conserve the Mata Atlântica and improve the economic and social conditions of small-scale coffee farmers. This interaction consisted of observation, research, data collection, and hands-on work in the forest and on the farms. In addition the author attended meetings of the Rural Farmers Union and participated in meetings between EMATER (the region's agricultural extension agency), Iracambi and Partners of the Americas for the development of the Small Farmers Loan Fund. Research also consisted of informal interviews and work with local farmers; one interview with representatives from EMATER; one interview with the mayor of Rosário da Limeira; one interview with Dr. Dale Beckman, Partners of the Americas representative for Brazil, and the everyday interaction within Iracambi.

Below is a more detailed description of the methods involved specific to each section of the report:

- Theoretical framework: the material presented in this section of the report is based on the knowledge gained from the author's educational experience while at Lund University's Masters in Environmental Science (LUMES) program, in addition to a literary review.
- Background: Research and literary review of the development of the events and situations that have led to the existing problems presented in this report; and a description of the study area of Rosário da Limeira and the coffee farmers as observed by the author.
- Problem Analysis: Developed through a systems analysis approach and with the use of a conceptual model. Based upon the information obtained during the author's three-month stay in Rosário da Limeira, collection of data, and literature review.
- Discussion and Results: The author cooperated with Iracambi to research various forms of land management strategies that have the most potential in the region. These strategies are presented in this section. This research was a combination of primary data collection through interviews with the region's agricultural agency, EMATER and work on the farms in the region that take part in semi-experimental land management activities. Secondary data collection consisted of a comprehensive review of relevant literature.

2. Theoretical Framework

This section provides the theoretical setting for the problems discussed throughout this report. Beginning with a broad look at the goals for achieving sustainability and then discussing the importance of such goals on a global scale—then zeroing in on the key points from Agenda 21 with which this paper focuses.

2.1 Achieving Sustainability

The concept of "sustainable development" was introduced to the world in 1987 in a report published by the United Nations World Commission on Environment and Development

entitled “Our Common Future.” This report linked the progress of global economic development with the depletion of the world’s natural resources and the degradation of the environment. For the first time, it was declared to the world that it is “impossible to separate economic development from environmental issues” (Nelissen 1997 p. 277).

In the past the world was concerned about the impacts of economic growth on the environment. But today as our finite natural resource base degrades and environmental quality is diminished, the tables have turned and the focus has shifted to include a perhaps more troublesome concern: What are the effects of environmental degradation on the world’s economic and social development? To deal with these concerns the UN Commission’s report, often referred to simply as the Brundtland Report, suggested that humanity must look at our global problems in a systemic manner, recognizing the inter-relationships between ecological/environmental, economic, and social problems around the globe. Offered in the report is the most widely accepted definition of sustainable development: “development which ensures that humanity meets the needs of the present without compromising the ability of the future generations to meet their own needs” (ibid. p.282).

The idea of a pathway to sustainable development was a global trendsetter and forever changed the way we view the world. As a consequence of the ideas set forth in the Brundtland Report, an Earth Summit was convened in June 1992 in Rio de Janeiro, Brazil to confront the global task of reaching for an internationally cooperative sustainable development. As a testament to the significance of this issue, the Summit was attended by 100 world leaders from countries around the world, representing more than 96 percent of the world’s total population. The Earth Summit was the largest face-to-face meeting in the history of international diplomacy (Sitarz 1994).

In the Brundtland Report it was recognized that poverty is both a major cause and effect of global environmental problems. Thus, the agreement reached at the Earth Summit was that sustainable development must strive to meet the needs of necessary economic development, while managing natural resources and curbing environmental destruction. Such development should proved a reasonable and fair standard of living for the global population, which means bringing a balance to the over-consumption and mass production activities of the industrialized world and the poverty or near-poverty conditions of the developing world (ibid.).

A major result of the Rio Earth Summit was the formulation of Agenda 21, which is a specific action plan designed as a tool for achieving global sustainable development in the 21st century. Agenda 21 addresses the changes needed to charter the course for development now and in the future, in a manner that makes efficient use of natural resources and alters the consumptive and productive patterns of the world (ibid.). In the years following the Summit of 1992, Agenda 21 has become synonymous with sustainable development and with the concept of “think globally, act locally.” As a result, the majority of countries that participated in the Summit have submitted a nation-specific action plan based upon the guidelines of Agenda 21 and have committed to taking steps necessary to achieve sustainability goals. Further, in many countries, Agenda 21 has been translated into state/province and county/municipality action plans.

Many of the concerns for sustainable development as targeted the Earth Summit and identified in Agenda 21 are addressed in this study. As discussed in the objectives, the goal of this study is to look at the relationships between efficient use of the Earth’s natural

resources—the Mata Atlântica rainforest—while providing for economic and social stability in the agricultural sector.

2.3 The Value of Forests and Biodiversity

As discussed in Agenda 21, the conservation of forests and their biodiversity is of utmost concern in the road towards sustainable development. Rainforests in particular are under intense pressure from the demands of man, and deforestation of these fragile and complex ecosystems is occurring at an alarming rate. The main cause for deforestation is human development, and more specifically the pressure to expand agricultural lands (Sitarz 1994).

Much literature has been devoted to the discussion of the economic value of forests (McNeely 1990). The value of economic losses from deforestation has been estimated at between 500-1000 million US dollars (Brown 1991). It can be shown that the health and existence of forests stretches into many aspects of economic development. As discussed in Agenda 21: "Forests are not only a source of timber and firewood, but also play a very important role in many vital areas. Soil conservation, the regulation of water cycles, the exchanges of gases and nutrients, including carbon dioxide, and the maintenance of reservoirs of rich biodiversity are but some of their roles" (Sitarz 1994 p. 94).

Rainforests are home to an astounding amount and diversity of plant and animal life. Agenda 21 asserts that the benefits to be gained from biodiversity go even beyond the intrinsic and humanitarian desire to preserve the organisms that share this Earth. Biodiversity presents a virtually untapped source of genetic material that has many uses including pharmaceutical benefits (25 percent of all medicines are derived from plants [Wilson 1986]), new sources of food, and other products. Further, the threat of biodiversity loss has not yet been determined, but it is well recognized that the survival of humankind is linked to the presence of the organisms that help maintain the same ecosystems we inhabit (Sitarz 1994.)

2.4 Agricultural and Rural Development

In developing countries such as Brazil, agriculture represents a very important share of the national economy as well as a significant livelihood for the country's citizens. Agenda 21 addresses the need for sustainable agricultural and rural development, identifying the need for "policies pertaining to land tenure, population trends, appropriate farm technologies and a more open trading system that would enhance rural households' access to food" (Sitarz 1994 p. 84).

Additionally, Agenda 21 looks at the consequences of uncontrolled land use and the mismanagement of land resources in an agricultural context. Soil erosion and land degradation are decreasing the value of land while the need for agricultural production is increasing. This dilemma is forcing farmers to stretch their resources to the maximum. Agenda 21 explicitly states the need to understand the physical, economic, and social causes behind land degradation in order to develop land use plans and better land management strategies (ibid.).

3. Background

This section provides the background materials necessary to understand the development and significance of the problems presented in this study. Deforestation in Brazil is more often associated with the Amazon than with the lesser-known Mata Atlântica rainforest. Therefore a description of the Mata Atlântica is presented in order to explain to the reader the

importance of protecting one of the world's most ecologically important and severely threatened biomes. A description of the ongoing conservation efforts within the rainforest offers optimism, but also highlights the limitations and inefficiencies of this struggle. The agricultural history of Brazil in relation to the development of the mono-cultured coffee plantations of today is described. Brazil's role as an export nation is linked to the problems of economic and social insecurity amongst coffee farmers. Finally, the reader is introduced to the study area of Rosário da Limeira and the coffee farmers who make their livelihoods there.

3.1 The Mata Atlântica: A Globally Outstanding Biome

Seventeen countries hold 70 percent of the world's plant and animal species, and of these seventeen "megadiversity" countries, Brazil ranks first for species richness, and is second only to Indonesia for species endemism. Brazil tops the list for holding the world's greatest number of mammal, higher plant, and freshwater fish species, while ranking second in world amphibian species, third in bird species, and fifth in reptilian species (see Table 1) (Ferreira 1999).

Table 1: Number of vertebrate and higher plant species of Brazil, with corresponding world rankings in species richness and endemism, and number of endangered species for each category.

Number of species	Vertebrates (not fish)	Freshwater fish	Mammals	Birds	Higher plants	Amphibians	Reptiles	Total
Total	3131	>3,000	524	1622	>50,000	517	468	
Rank	2nd	1st	1st	3rd	1st	2nd	5th	1st
Endemic	788	----	131	>191	>17,500	294	172	
Rank	4th	----	1st	3rd	1st	2nd	5th	2nd
Endangered	----		70	103	100			

---- = data not available

(Adapted from Ferreira 1999)

These attributes make Brazil a world leader in species richness, and as such the country holds an important responsibility to protect its biodiversity—a responsibility that has been incorporated in the Brazilian constitution under Article 225. The Article states: "All have the right to an ecologically balanced environment, which is an asset of common use and essential to a healthy quality of life, and both the Government and the community shall have the duty to defend and preserve it for present and future generations" (ibid. p.9).

However, preserving biodiversity continues to prove a challenge, as a growing population and high demands for land inevitably lead to the destruction of much of the country's ecologically rich biomes. These biomes can be roughly divided into the Amazon rainforest in the north, the Caatinga plains of the northeast, the Cerrado and Pantanal savannas of central and western Brazil, and the Atlantic forests in the south east. Of these regions, no other is as ecologically rich, or as severely threatened, as the Atlantic rainforest—the Mata Atlântica (Rizzini 1988).

The Mata Atlântica stretches along the Atlantic coast from the state of Amapá in the northeast, to the state of Rio Grande do Sul in the south—a distance greater than from northern Sweden to the southern tip of Italy. The area of forest encompasses 50,000 square kilometers. Although the Mata Atlântica remains a substantial forest biome, its size today is dwarfed in comparison with the more than 100 million square kilometers of its original coverage—12 percent of the entire land area of Brazil. The Mata Atlântica of 500 years ago easily surpassed the Amazon, but today the remaining forest is highly fragmented with some

pockets of forest covering more than 100,000 hectares, while other areas covering only 100 hectares or less (Consórcio 1992).

Figure 2: Map showing the remaining forested areas of the Mata Atlântica.

Source: Iracambi Recursos Naturais

Stretching along the Atlantic coast, the Mata Atlântica's location has in fact been detrimental to its existence, as it was the area first penetrated and settled by the Portuguese. Trading cities were established along the Atlantic coast to expedite the allocation of forest resources such as timber. Land was cleared for agriculture to support the growing colony, and animals were hunted for food and sport. The Mata Atlântica has suffered greatly in the last half century, and the activities of man all but doomed the forest. Sprung up from the days of Portuguese trading cities, the region of the Mata Atlântica is now home to 80 million people—nearly half of the total population of Brazil. As a result of relentless pressures from man for land and forest resources, the Mata Atlântica is one of the world's most threatened ecosystems (Rees 1990, Le Breton 2000).

The Mata Atlântica is in fact not one ecosystem, but several. The region can be divided into several different forest typologies including montane rainforest, conifer forest, mangroves, and even grasslands. The focus of this study, however, is on the lower-montane rainforest found between 800 and 1800 meters, primarily along two coastal mountain ranges of Eastern Brazil, the Serra do Mar and Serra da Mantiqueira. This area is located in the states of Sao Paulo, Minas Gerais, Rio de Janeiro, and Espirito Santo. The other typologies of the Mata Atlântica include grasslands in a few areas of the forest's northernmost range and on elevations higher than 1800 meters (upper-montane rainforest), semi-deciduous and conifer forests in the south, and mangroves at the coast (Rizzini 1988). However these areas are less interesting in the context of biological diversity, as it is the tropical rainforest that is the Earth's most structurally diverse and ecologically complex biome. In fact, Whitmore (1990 p.9) concludes that rainforests "are the apex of creation."

In Brazil, the Mata Atlântica is rivaled only by the Amazon in terms of ecological richness. However within these two rainforests exist unique ecosystems, as the Mata Atlântica differs from its famous cousin in many ways. While the Amazon is found on lowland plains, the Mata Atlântica exists at higher altitudes, which is one of the factors affecting the temperature differences between the two areas. Temperatures in the Amazon rarely fluctuate from annual averages of between 26 and 27 degrees Celsius. These temperatures are higher than in the Mata Atlântica, which has annual averages between 14 and 21 degrees. Both have maximum temperatures reaching well into the 30's; however the absolute minimum temperature in the Amazon is 22 degrees, while temperatures in the Mata Atlântica may drop to 1 degree. This extreme contrast in minimum temperatures is a significant differentiation between the two forests (Rizzini 1988).

The precipitation levels of the Amazon and the Mata Atlântica are nearly identical, both receiving between 2000 and 3100mm of rainfall yearly, varying at different locations of the forest. However, the Mata Atlântica is characterized by distinctive wet and dry seasons, and thus receives most of its precipitation during the rainy season, which lasts between October and March (ibid.). Due to this seasonal variation in rainfall the Mata Atlântica can be classified as a tropical moist forest, whereas the Amazon is an ever-wet tropical lowland evergreen forest (Whitmore 1990).

Perhaps the most unique aspect of the Mata Atlântica is that it holds more biodiversity than any other Brazilian biome, and is also the most threatened. The Mata Atlântica is home to 80 percent of the country's endangered species and contains an extraordinarily large portion of endemic species. Of these unique creatures, eighty-five percent are endangered (Ferreira 1999). If these species disappear, they disappear from the planet.

The Mata Atlântica is home to 6 genera of primate species and subspecies. Of the 21 primate species found in the Mata Atlântica, 80 percent are endemic and 14 are endangered. The woolly spider monkey, largest of the Latin American primates, is both endemic and endangered. It is estimated that 400,000 of these creatures inhabited the forest at the time of the first Portuguese arrival, but fewer than 400 survive today (Rees 1990). Other endemites include three species of lion tamarind, all extremely threatened with extinction, including the golden lion tamarind renowned for its bright orange fur. Several species of howler monkey are found no where else but the Mata Atlântica, however scientists predict at least one of these species will likely become extinct within the next few decades (Rizzini 1988).

Several species of the feline family inhabit the Mata Atlântica, such as the jaguar, puma, ocelot, and margay—all of which are threatened. Other animals include peccaries, anteaters, opossums, sloths, coatis, agoutis, porcupines, and raccoons. Birds of the Mata Atlântica include many species of cuckoos, owls, hummingbirds, toucans, woodpeckers, tanagers, and parrots such as the blue-winged macaw and Amazon parrot. Butterflies are abundant in the forest, which contains 2,124 known species, and of these species 913 are endemic. These numbers comprise two-thirds of Brazil's butterfly species, and one-eighth of the world's butterfly species. Exact insect and amphibian numbers are unknown, as most of these creatures have yet to be identified (ibid.).

Because of its extraordinary levels of biodiversity, and its high level of species endemism, the World Bank and the World Wildlife Fund have designated the Mata Atlântica as a Latin American forest of globally outstanding importance. Its conservation status is listed as critical, with a level I highest priority for conservation on a regional scale. In comparison, the

conservation status of the Amazon is listed as stable (Dinerstein 1995). The Mata Atlântica has been declared a national heritage site by the Brazilian constitution, and clearing has been illegal since 1988. However, the Brazilian government chooses not to allocate adequate resources for the forest's conservation, and does not effectively enforce the regulations it has set. As a result, an estimated 50,000 hectares were cleared between 1985 and 1990. The majority of this forest was felled to provide agricultural land (Consórcio 1992).

3.2 Conservation in the Mata Atlântica

The Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA), has established a national protected areas system for the preservation and management of the country's ecologically significant biomes. Within this system the Mata Atlântica receives the highest proportion of protection in comparison with all other Brazilian biomes, as this protection has been deemed an absolute necessity if the forest is to be salvaged from further destruction. The system establishes nationally protected areas of forest, and categorizes these areas under two divisions, Strictly Protected Areas and Protected Areas of Direct Use. Under the Strictly Protected Areas, of which 6.8 percent of the Mata Atlântica's total land area is protected, exploitation and extractivism are forbidden; however indirect use, for activities such as research and ecotourism, are permitted. More than 21 percent of the Mata Atlântica is less stringently protected under Protected Areas of Direct Use, which are considered to be areas of "sustainable use" where planned and regulated exploitation activities are permitted (Ferreira 1999).

Along with the IBAMA national protected areas system, state and municipal reserves also provide sufficient protection for the Mata Atlântica. Within the study area are two significant publicly protected parks: the Serra do Brigadeiro State Park of 13,000 hectares, and the smaller Pico de Itajuru Municipal Park of 200 hectares. Additionally, universities, research institutes, and private non-governmental organizations may create private forest reserves. The Reserva Particular de Patrimônio Natural is a 70-hectare private reserve legally registered by the Iracambi organization within the Rosário da Limeira municipality. Companies may also hold land under protection—generally to counter balance areas exploited by their activities, or as with the paper and pulp industries, to manage their resources (ibid., Le Breton 2000).

Many difficulties exist with the conservation and reserve system of the Mata Atlântica. Firstly, protected areas at all levels—national, state, municipal, and private—may be numerous, but they are often too small in terms of area to be effective. For instance, many of the Strictly Protected Areas are less than 100,000 hectares in size, little more than "forest islands" in a sea of unprotected and exploited areas. Genetically viable populations of many plant and animal species cannot be maintained in heavily fragmented forest and predatory species with large territorial ranges such as puma and jaguar are virtually non-existent in smaller areas (Ferreira 1999).

Another predominant problem with the protection system of the Mata Atlântica is that IBAMA and other forest protection agencies lack adequate resources to enforce their regulations. IBAMA acknowledges this challenge and have determined that on average there is only one IBAMA employee for every 27,560 hectares of protected area. These employees are further limited by the difficulty of accessing and monitoring many of the protected areas—often isolated and inaccessible, lacking sufficient roads and far from large centers of urban activity (ibid.). The nearest IBAMA representative for Rosário da Limeira is 200 kilometers away from the municipality. Much of the responsibility for protecting the forest

and enforcing infractions of the law falls to the State Forestry Institute (IEF) and the Forest Police department of the state military police (Le Breton 2000).

The IEF have set high standards and, when able, strictly enforce violations of the federal laws designed to protect the Mata Atlântica. However, until 1998 the Forest Police, situated in a town 35 kilometers from Limeira, had neither car nor telephone. Although some of the forest and environmental protection responsibilities lie with the local government and the state agricultural extension institute, budget restrictions have kept enforcement of this protection to a minimum (ibid.). Some areas have enlisted the help of the military, police, private organizations, volunteers, and community leaders in an effort to enforce protection measures in the Mata Atlântica (Ferreira 1999).

Another serious difficulty with conservation efforts, especially in the areas around Rosário da Limeira, is that virtually all of the forest is in private hands. Under Brazilian law, government does not manage privately owned forest. Although the law states that at least 20 percent of already forested land under private ownership must remain forested, this does not ensure that the forested area will be protected, quite an obstacle for maintaining conservation efforts. Even fines are often not enough to dissuade the potential profits to be made from exploitation. Furthermore, the privately owned forests are usually not contiguous, resulting in many small forest fragments. These fragments, as mentioned previously, do little to maintain viable populations of many plant and animal species (ibid.).

Coffee plantations in Rosário da Limeira are often adjacent to forested areas. The need for increased land and increased production in the face of declining land productivity and declining incomes puts pressure on small-scale farmers to clear more land. Although further clearing of the Mata Atlântica is prohibited, it is quite common for farmers to slightly increase the size of their fields each year by burning only a few meters into the forested areas bordering their plantations. Heavy fines may be charged to farmers for clearing, but in this manner they are usually not caught. The state's limited enforcement staff is unlikely to notice such "small" changes from year to year. Large-scale farmers, in comparison, will pay fines or bribe officials and burn enormous areas of forested areas. Recently, one of the biggest farmers in Rosário da Limeira has done exactly this. By removing the forested areas on his land, he removed a very important forest corridor that linked the State Park and several private reserves, rendering the smaller private reserves virtually useless.

In response to some of these difficulties, IBAMA established the system of Private Natural Heritage Reserves (RPPN's), which offer promise as a potentially effective tool for future conservation efforts. This category allows government regulation of privately owned forest, and tax incentives for private landowners. Brazil's tax laws were originally designed to promote the agricultural sector of the economy, which inevitably led to deforestation. Forested portions of land were considered "unused" and taxed at the rate of 3.5 percent of their unimproved property value. Thus it was in the farmers' best interests to clear their forests—even if they did not intend to use them—if for nothing else than to avoid the tax. Under the new system, formally established in 1990, landowners pay no property tax for RPPN classified areas, and are eligible to receive resources from the National Environmental Fund for protection and improvements to the area. IBAMA, in turn, is jointly responsible for managing the areas in cooperation with landowners. RPPN's are Strictly Protected Areas where deforestation and exploitation are prohibited, receiving complete and irrevocable protection (Ferreira 1999).

3.3 Agricultural History of Brazil

Brazil gained its independence from Portuguese colonial rule in September 1822, marking a time of great change for the country including significant agricultural and economic transitions. The colonial economy had been dominated by sugarcane and the slave labor used for its production. For the first 10 years following independence, sugarcane continued to be Brazil's leading commercial crop, constituting 30 percent of all exports (Burns 1980). However, foreign competition soon deprived Brazil of its once prosperous sugarcane market. Europe began producing sugar beets, virtually eliminating the need for imports, and the more efficient production of sugarcane in the Caribbean and elsewhere ousted Brazil from the race for foreign capital. During this time the prices for sugarcane fell by 11 percent, and could not continue to support the Brazilian export market (Burns 1980, Dean 1995).

A large share of government revenues were made from the tariffs and import duties of international trade, thus the newly independent government of Brazil was eager to find an export crop suitable to replace sugarcane. Great Britain was Brazil's largest trading partner, and not surprisingly the first attempts to find a replacement for sugarcane were made through the cultivation of tea. Chinese laborers were even brought over from Asia to teach Brazilian farmers the secrets of tea production. However, the crop failed to gain the interest of the British market, as it was presumed to be of low quality and more expensive than Chinese tea. Without the British, tea had little hope of succeeding the prosperous sugarcane market (Dean 1995).

Coffee had originally entered Brazil in 1727 from French Guiana (It may have reached Brazil as early as the 1600's but was of no importance commercially at this time.), and by 1770 had spread through northern Brazil to the Southeastern states of Rio de Janeiro and Minas Gerais. It was discovered that coffee thrived in these mountainous areas, as the temperature, heavy rainfall, and a distinctive dry season, provided nearly optimum conditions for its growth (Burns 1980, Dean 1995). In addition to favorable climate conditions, the slave trade allowed Brazilian coffee plantations to flourish. In the early 1700's slave rebellions in coffee-producing nations of the Caribbean increased world coffee prices, providing a boost to the newly established coffee industry in Brazil. With the Portuguese traders providing adequate slave labor from Africa to man the labor-intensive plantations, coffee became Brazil's largest agricultural export (Wolf 1982).

By the middle of the nineteenth century coffee production was booming in Brazil, and the problem of replacing sugarcane appeared to be solved. However, at the same time coffee spread through Brazil, it had also penetrated many countries of Latin America and the Caribbean. Brazil was spared from a competition crisis due to the fact that it far out produced all other coffee growing countries, supplying three-quarters of the world's coffee by the end of the nineteenth century (ibid.). In addition to out-producing other nations, Brazil was able to corner the United States coffee market. While the rest of Latin America and the Caribbean concentrated on selling high quality coffees to European consumers, Brazil was able to provide for the less discriminating tastes of the growing U.S. market (Burns 1980, Dean 1995). Brazil remains tied to the U.S. market to the present day.

Coffee was the catalyst for the rapid growth of the Brazilian economy, and exports of the crop continued to rise annually. By 1860 Brazil was exporting more than it imported, and by 1890 coffee exports represented nearly 65 percent of Brazil's total export market. At the same time, the United States replaced Great Britain as Brazil's major trading partner. As the

U.S. economy saw continued growth, coffee exports steadily increased and Brazil's economy shared in this progress with its own prosperity (Burns 1980).

Yet economic progress in Brazil did not come without devastating effects for the Mata Atlântica. It is estimated that within the first century of coffee production at least some 7,200 square kilometers of primary forest were cleared to make way for coffee plantations—amounting to 300 million tons of forest biomass. Forest was not only cleared to make way for the plantations, but economic growth from the coffee industry induced population growth, city expansion, and all of the manufacturing and transportation infrastructures needed to support such growth. Primary forest was considered ideal, even necessary, for the success of coffee plantations, as the most fertile soils were to be found under virgin forest. Furthermore, early cultivators relied on 16 indicator species—particular trees that had growth needs similar to those of coffee—to determine the best areas of forest to be felled for plantations. Incidentally, these 16 species were to be found nearly always in primary forest (Dean 1995).

Further contributing to the clearing of the Mata Atlântica's primary forest were the farming methods practiced in the early years of cultivation. Farmers learned to grow coffee from trial and error, leading to many failed yields and the rapid depletion of land quality that resulted in further clearing. Coffee was originally planted in vertical rows along the steep slopes of Rio de Janeiro and Minas Gerais states, a practice long since abandoned in Ethiopia (where coffee originated) and other African countries due to the knowledge that this practice exacerbated the negative effects of runoff and soil erosion. Additionally, early coffee plantations were planted with 800 to 900 trees per hectare, a number much less dense than modern practices of 3,000 to 5,000 trees in the same area. The trees were spaced far apart and grew tall, making harvests difficult and thus less productive. The areas between the trees were left bare and open to the eroding effects of rain, until eventually weeds overtook the fields (ibid.).

These practices, in essence, caused more primary forest to be cleared to compensate for the yields lost on land wasted by poor cultivation methods. Less forest would have been felled had land been able to produce more, and waste less. A poignant quote from Dean makes this point clear: "Had the planting of coffee been done with care, it might still be growing where first it was introduced, and much of the Atlantic Forest might have been spared for some other purpose, or in peace, for none" (1995, p.189).

3.3.1 An Export Economy

In relationship with Brazil's agricultural history, it is important to realize that the country has traditionally held an economic development strategy dependent upon its exports and the continued extraction of resources from the land. This approach is one that is common throughout the developing world, and particularly in Latin America. In a historical context, such a strategy is the result of colonialism and the extraction of resources in response to demands of the international market. This extractive system relied on the system of peasantry (and later slavery), which provided the labor necessary for the functioning of the export economy (Painter 1998). Export pressure exerted on the nation beginning with the Portuguese conquest 500 years ago led to government sponsored monoculture of cash crops in the agricultural sector of the economy (Blaikie 1994, Dean 1995).

Today, the Brazilian government favors a free market approach, with the United States being by far the country's most important trade partner. The self-sufficiency of Brazil as a nation suffers from the "deteriorating terms of trade," which commonly exist between the developed and the developing world (Redclift 1992). Downward spiraling cycles of economic

underdevelopment in Brazil and the gradual destruction of existing arable land through soil erosion and land degradation have been perpetuated by the export economy (Painter 1998). Considering Brazil's massive foreign debt crisis, growing over the last century, exports of cash crops are needed to maintain or increase the country's income. Within Brazil's borders it is not as profitable to produce food crops and other goods for the domestic market, and as a result both large and small farmers turn to export crops. "International trade in agricultural products is orientated towards meeting the needs of rich consumers and undermining those of poor farmers" (Redclift 1992).

Due in part to the country's free market philosophy, the Agricultural Ministry of the Brazilian government offers little or no agricultural subsidies or incentives for farmers. The agricultural sector of the economy is highly taxed, and continuous national inflation makes investments risky. Loans and credits from the Ministry are made available through the *Banco do Brasil*—the nation's largest bank, which has a history of being conservative and concerned with stability more than agricultural progress. They have traditionally supported the production of coffee as a mono-cultured export crop, and this continues to be their dominant interest. As the *Banco do Brasil* is the dominant source for agricultural credit, farmers choose to grow coffee more often than not. Smaller banks and private organizations have in the past offered assistance for non-coffee agriculture, but the majority has gone bankrupt (Le Breton 2000).

3.4 The Study Area: Rosário da Limeira

Rosário da Limeira is a small but typical municipality in the Brazilian State of Minas Gerais. Here the relationships between deforestation, coffee cultivation, and land degradation are representative of many areas of the Mata Atlântica. The research for this study focuses largely on the situation in Rosário da Limeira, with the intention of presenting a typical case study of land management opportunities and constraints in the Mata Atlântica.

The municipality has a population of about 10,000 people and covers an area of 117 square kilometers, in what is considered one of the poorest areas of Minas Gerais. The municipal seat is the village of Rosário da Limeira (referred to simply as Limeira by most of its residents) with a population 2000 people living in a semi-urban environment. Only one paved road exists in the municipality, cutting through the center of the village and then branching off into dirt paths that lead to rural farms and hamlets.

Rosário da Limeira is situated in a mountainous area with elevations ranging between 300 and 1500 meters, and covered by patches of secondary forest and some remaining primary forest in mostly inaccessible areas. No "virgin" forest exists in the area, not surprising when considered that less than 10 percent of the entire Mata Atlântica is virgin forest.

3.4.1 Small-scale Coffee Farmers in Rosário da Limeira

Ninety percent of the residents of Rosário da Limeira rely on agriculture and agricultural services for their livelihood. The percentage of agricultural land used for coffee dominates all other crops, and is rivaled only by cattle grazing, which is often the alternative use for lands no longer fertile enough for coffee. Many Brazilian coffee farmers are small-scale cultivators, farming as little as 5 hectares of land. Coffee is a cash crop that provides income for the purchase of food, household goods, clothes, basic medical care, and other commodities. Most farmers also cultivate a small portion of their land with food crops—primarily beans, rice, corn, and vegetables.

The small-scale farmers often live in simple homes that they build themselves and have very few possessions. Many rural areas lack electricity and paved roads; children attend school in one-room classes with mixed age groups; and most families have no more than a horse and cart to satisfy their transport needs. Both women and men work long hours. Men are responsible for the farm—preparing the soil, planting and tending the coffee trees, harvesting, and sometimes basic processing. Some farms may also have livestock, which the men take care of as well. Women cook the meals, tend to household chores, take care of the children, and also help out with farm duties when necessary.

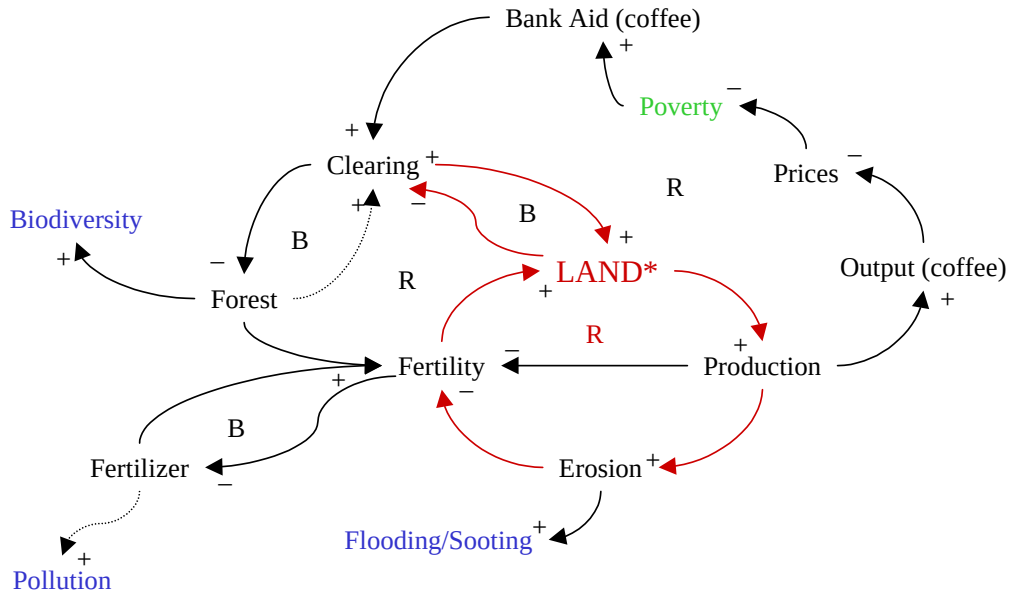
Many small-scale coffee farmers supplement their meager incomes by working on large coffee plantations in addition to managing their own land. In some cases this "extra" work may bring in more income than the farmers' plantations, but the right to "be their own boss" and take care of their land is important.

Depending on the size of the farm, farmers may need to employ seasonal laborers to help with busy periods. However, additional laborers outside of the family deduct from the total amount of income that can be earned from the sale of the coffee harvest. Thus immediate family, friends, and neighbors are relied upon during the busy periods, namely harvest and planting.

4. Problem Analysis: The Cycle of Deforestation, Coffee Cultivation, and Land Degradation

4.1 Conceptual Model

Figure 3: Conceptual Model showing the relationships between deforestation, coffee cultivation, and land degradation.



*Refers to Land Suitable for Agricultural Uses (Amount of land, land quality)

Designates long term change

CLD designed by the author for the purpose of this study.

This conceptual model presents the causal loops between deforestation, land degradation, and coffee cultivation. The central loop, shown in red, begins with **Clearing** of the forest. More clearing provides more **Land** (which represents "land suitable for agricultural uses") for the farmers, and this allows for more **Production**. Continuing on the central loop, more production causes more **Erosion**, and this leads to decreased soil **Fertility**. Also affecting soil fertility is the production itself, as crops deplete the soil's nutrient base. Decreased fertility leads to less land, and this in turn leads to more clearing. This is a reinforcing loop, and is the central problem of the study.

Clearing leads to less **Forest**, and this in the long-term will lead to less clearing since eventually the forest will reach its maximum felling potential. This is shown by a dotted arrow, representing change over the long-term. This is a balancing loop.
Continuing from the decrease in forest, a reduction in **Biodiversity** is shown. The loss of biodiversity, in blue, represents one of the key ecological problems of deforestation. Also a direct result of forest loss is a decrease in soil fertility, since the soil is dependent upon the trees for the regeneration of nutrients and moisture.
Another ecological problem area is the **Flooding and Sooting** of waterways, which increases with greater erosion.

When soil fertility is low, one solution used by many farmers is the increased usage of **Fertilizer** to remedy degenerating soils. More fertilizer can be a solution, as it results in a balancing loop of increased fertility, but the side effect is the eventual increase in **Pollution**. This is shown in blue, since it is an ecological problem.

Returning to the central loop, the increase in coffee production leads to an increased **Output**. While increased output may initially appear as a positive result of greater production of the land, the causal loop shows that more output leads to a reduction in global coffee **Prices**. Lower prices mean less money for the farmers, thus a resultant increase in **Poverty,** shown in green as an economic and social problem. Without the means for self-sufficiency, or the personal capital, farmers turn to **Bank Assistance** and receive loans and credits in order to plant coffee. More coffee planting leads to more clearing, and the cycle begins again. This is a reinforcing loop.

Finally, a small but very important balancing loop in the diagram is found between clearing and land. Clearing provides more land, and assuming that adequate land results in a decrease of clearing, the value of land becomes a key factor in the resolution of the problem relationship between land and clearing. Farmers may always choose to turn to clearing as a solution to degraded land, however if this degradation were alleviated, less clearing would be necessary.

4.2 Deforestation

The process of deforestation, cultivation, and degradation is a cycle. The cycle begins when farmers clear an area of forest through a controlled burn, which transfers the nutrients (with the exception of nitrogen and sulfur, which are largely lost through smoke) from the forest biomass to the soil. This method, known as slash and burn agriculture, provides the soil with a nutrient base rich enough to support crops for a temporary period of time. However, due to the unique nature of rainforest ecosystems, the soil's productivity is largely dependent upon the trees and plants that thrive in it, such that without sufficient vegetation, an area of rainforest is unable to naturally sustain its soil nutrient base (Whitmore 1990).

Unlike the soils of most temperate regions of the earth, rainforest soils of Brazil are often naturally shallow and nutrient deficient. Much of the plant mineral nutrients are contained within the aboveground biomass rather than in the soil itself, particularly the soluble cations K^{+}, C^{2+}, and Mg^{2+}. Trees and plants are dependent upon the continuous cycling of nutrients between the canopy and decaying matter on the forest floor. This decaying matter is organic litter, which is made up of fallen leaves, branches, tree trunks, and other plant materials. This litter is rapidly decomposed by invertebrates such as termites and earthworms, and the nutrients released from this process are directly taken up again by the trees and plants (ibid.).

Once the land is cleared of forest, the nutrient cycling process is disrupted, thus leaving the soil with a low nutrient content and little organic material. The soil requires continuous nutrient inputs from the forest biomass and decaying organic litter, such that when these elements are removed, the nutrient content of the soil cannot be sustained. Agriculture further pressures the soil, as more nutrients are removed than can be returned, thus resulting in eventual degradation (ibid.).

4.3 Soil Erosion

Due to the poor soil nutrient base found in cleared land, the average productive life of a coffee plantation in Minas Gerais is less than 20 years without the intensive use of fertilizers. A coffee plantation loses its productive value when the soil lacks the life-supporting nutrients necessary to sustain its trees. This process of decreasing soil productivity is known as land degradation, and is a result of two main factors. First, agricultural production itself depletes the soil as crops absorb the nutrients from the earth. Second is soil erosion, accelerating the rate at which the land degrades (Dean 1995, Millington 1993).

Soil erosion is a process that occurs naturally as a result of weathering from wind and water, occurring at a faster rate where vegetative covering is sparse. This natural process is known as geological erosion; however, the two primary anthropogenic accelerators of this potentially destructive process are deforestation and agriculture. Anthropogenic soil erosion usually occurs at faster rates than geological erosion, and in areas that might otherwise be protected from wind and water erosion. The results of which are largely responsible for land degradation in many tropical areas (Millington 1993).

Wind and water are the two agents of soil erosion. As in many tropical areas, the primary agent of erosion in the Mata Atlântica is water. The degree of soil erosion by water is determined by several erosivity factors: vegetative cover, rainfall and water runoff, slope parameters, and soil characteristics (ibid.). Additionally the cultivation practices and management of land in the area also positively or negatively influence the rate of soil erosion, both of which are discussed in more detail later in the study.

The risk for soil erosion exists as soon as the land is stripped of its protective vegetative cover. In the Mata Atlântica, the forest's vegetative cover works to counter soil erosion in several ways, namely it provides both above ground and below ground protection. Above ground the leaves and stems shelter the soil by mitigating the erosive effects of falling rain, while below ground the root system works to strengthen the aggregate ability of the soil (ibid.). Such protection is insufficient with row crops, such as on coffee plantations, where the trees are planted several feet apart, while the area between the rows of trees is left bare. The exposed soil between the rows of coffee trees is unprotected from heavy rains and lacks a sufficient root structure to hold the soil together, both of which are likely to increase erosion (Morgan 1995).

Vegetative cover also works to ensure that the trees and plants absorb moisture from rain, whereas on an agricultural field the soil becomes saturated with water, encouraging runoff (Millington 1992). As soil erosion continues, the physical structure of the soil is degraded, reducing its porosity and permeability. As a result, soil absorption capabilities worsen and the amount of water lost in run off increases. This becomes problematic due to its adverse influence on erosion, and because less moisture is available in the soil, causing water deficiencies in crops (Stocking 1995).

Along with the amount of vegetative cover, rainfall and runoff affect the erosivity of the soil. Rainfall intensity is the primary designator of rainfall and runoff erosivity. The Mata Atlântica, with a 6 month long wet season, receives between 1200–1500 millimeters of rainfall annually (Le Breton 2000). Once the land is cleared of the forest's dense vegetative cover, the soil is exposed to these heavy and frequent rains, eroding the soil and carrying it away in the runoff. In these areas, soil may be lost at an annual rate of 100–200 tonnes per hectare (Stocking 1995.).

At particular risk from soil loss is the topsoil, the uppermost layer of earth that contains nearly all of the soil's organic matter and the nutrients necessary for plant growth and productivity. This layer is quite thin in comparison with the entire soil depth, usually only a few centimeters, and when it erodes the organic matter and nutrients are lost in runoff and sediment. Nitrogen, phosphorous, and potassium (N, P, K) are eroded with the topsoil and must be replaced with fertilizers to maintain soil productivity (ibid.).

Aggravating the abject effects of rainfall and runoff erosivity is the influence of slope parameters. Research has shown that a positive quantitative relationship exists between slope angle and length and the amount of soil lost to erosion (Millington 1992). In the Mata Atlântica, and nearly all of Rosário da Limeira, agriculture can be found in hillside regions, increasing the rate of soil erosion. Topsoil from the upper portion of hills is lost first, and the effects of this can be seen in the underdeveloped coffee trees on the upper slopes. On the lower slopes and in gullies where eroded topsoil has collected, the trees benefit and are more productive, until even the soil here is eventually eroded away.

Another factor of soil erosivity is the particular characteristic of the soil, which renders it more or less susceptible to erosion. Most humid tropical soils are highly erodible due to their chemical characteristics, poor structure, and lack of organic matter. In general, the more organic material contained within the soil, the more resistant it is to erosion. One reason for this being that as organic matter decays it releases soil-bonding agents that improves the aggregative properties of the soil. Soils under agricultural use contain less organic materials than forested areas, and soil erosion itself compounds this problem, as organic materials are lost in runoff and sediment (Millington 1992).

4.4 Land Degradation

The results of land degradation through agricultural production and soil erosion are lower yields, often accompanied by higher costs to produce a given yield. Eventually soils may become so degraded that their value as productive agricultural land is lost, and must be abandoned completely—as is the case in many areas of the Mata Atlântica. Until now, many of the solutions to land degradation in the region have focuses on quick fixes. An example being the use of fertilizers to enhance and lengthen the fertility of soils on coffee plantations; however fertilizers have limited success on the steep slopes, which may lose more than 100

tons of topsoil per hectare every year (Stocking 1995). Furthermore, fertilizers provide diminutive results on already eroded soils, as the chemicals may be washed away by runoff, and cannot be effectively absorbed by soil with poor aggregate ability. Fertilizers would provide better results in cooperation with soil protection measures, which is the case in most areas of the world (Pagiola 1995). However, fertilizers may also contribute to pollution, the effects of which have not been thoroughly examined.

Some progress has been made through agricultural technologies, but these are often expensive and not easily accessible to the average rural farmer. Additionally, such technology may be the product of inadequate agricultural transfers. Although soil conservation measures generally follow the same principles from place to place, technologies developed in one area may not be suitable for other areas (Morgan 1995). An example of such being the terracing technique aimed at stopping erosion, which was developed by the United States Soil Conservation Service. This technique, unlike others practiced in Africa and Latin America, was developed in the American Midwest during the dustbowl. However, despite millions of dollars worth of investments, the technique is, for the most part, inappropriate for the steep slopes, fragile soils, and small unmechanized land holdings (Le Breton 2000).

Few effective measures are in place in Rosário da Limeira to control soil erosion and land degradation. Currently, fertilizers are relied upon by the agricultural extension agencies to alleviate erosion and slightly prolong the life of coffee plantations. However, the most widely used fertilizers are sulfate of ammonium based, and can actually lead to further erosion (ibid.)

Land degradation, through agricultural production and erosion, drains the soil of its life-sustaining nutrients. Once the land has been exhausted it is abandoned and the cycle then continues as more forest is cleared to provide more productive agricultural land. This is the basic problem cycle between ecological sustainability and economic and social prosperity.

4.5 The Future of Coffee

According to the International Coffee Organization (ICO), the international market for coffee is reaching a saturation point and the future outlook for coffee prices on the world market shows a declining trend (see Appendix 1). Even now coffee farmers in Brazil receive a mere fraction of the money earned by the sale of coffee exports. The farmers are poor and dependent upon coffee to feed their families. If prices continue to fall the future economic and social security of farmers is questionable. Yet the means to change the situation is out of the grasp of most farmers who lack the capital and sometimes the knowledge to change their security.

Coffee is a cash crop and provides farmers with a way of life above the subsistence-based existence common all over the developing world. However the instability of the world coffee market leaves Brazilian farmers in a precarious situation. Farmers are faced with a multitude of problems, namely major price fluctuations and instability within the world coffee market and a difficulty or impossibility of adequate access to markets, land, credit, and knowledge. A concern is that farmers are too dependent on coffee, dedicating their land and resources to its production while leaving little resources for growing subsistence crops such as beans, rice, and maize. If a farmer does not earn enough money with a coffee harvest, will he be able to feed his family? A bad year for coffee on the world market, or a poor harvest due to an unpredictable weather phenomenon such as frost, may leave a farmer with little money for food or other necessities. Poverty ensues.

4.5.1 Coffee on the World Market

Coffee is the world's second most valuable commodity after oil, and the world's largest agricultural commodity with a total world trade value of 8 million US dollars per year. The bulk of coffee production takes place in the developing world, with these countries exporting the majority of the harvest to the United States and Europe. Brazil is by far the world's largest producer of coffee, contributing more than 30 percent of the world's market total (Fairtrade 1997, ICO 2000). In 1999 Brazil's total production was 27,170,000 bags, of which 23,135,000 bags were exported. Arabica beans make up 85 percent of Brazil's coffee production, Robusta beans the remaining 15 percent—Robusta, which is more commonly produced in other countries around the world (Commodity 2000).

Since the late 1980's coffee prices have been subject to serious fluctuations on the world market (see Appendix 2). Changes in the structuring of the world coffee market were largely responsible. In 1989 severe price drops occurred when the ICO's International Coffee Agreement price control clause was suspended. Without mandates for price controls, coffee prices dropped severely. Major coffee-producing nations including Brazil were unable to agree on export quotas, which through the withholding of coffee reserve stocks, had in the past helped to sustain artificially high prices on the world market. Country after country flooded the market with coffee reserves, pushing prices lower and lower. As a result of this market flooding and a lack of increased demand in the United States and Europe, the price of coffee plummeted (Ahlfeld 2001, ICO 2000).

Coffee prices failed to recover until the mid-1990s. Brazil, a nation with many resources to fall back on, fared far better than other major coffee producing countries in Asia and Africa, which suffered heavy national income losses. However, Brazilian coffee farmers suffered the effects of price plummets, particularly in the state of Minas Gerais where most of the country's coffee is produced (Fairtrade 1997).

The biggest problem facing the world coffee market is oversupply. World production of coffee is increasing, while demand in the consumer nations is changing very little, and in the case of the United States may be decreasing. Brazil's coffee production has increased significantly (see Appendix 3 due largely to a bout of high coffee prices in the mid-1990s. The subsequent harvests from the trees planted during this prosperous time are referred to on the world market as the "Brazilian monster crop." Between 1999/2000 and 2000/2001 Brazil's Robusta production increased by 22 percent. Being that Brazil dominates the world's coffee market, production increases have driven the ICO's indicator prices down to all-time lows. In the year 2000 the ICO indicator price for coffee fell from 98.6 cents per pound of coffee at the beginning of the year to 47.5 by December (see Appendix 4) (Ahlfeld 2001, ICO 2000).

Further affecting the future security of the world coffee market are changes in global consumption patterns. Brazil exports the majority of its coffee to the United States and Germany. These countries are special in that they have traditionally had less discriminating tastes and import the Brazilian Arabica bean coffees. Countries in South and Central America, as well as in Africa and Asia, export the Robusta bean to other European nations. It was in this way that Brazil was historically able to corner the US market, and later the German market, and out-compete other coffee-producing nations (Burns 1980, Commodity 2000).

Coffee consumption in Europe and Japan is, in general, increasing. In the United Kingdom, coffee has almost overtaken tea as the nation's most widely consumed beverage. In Japan sales of coffee overtook tea for the first time in 1998. However, in the United States coffee consumption has not increased and the National Coffee Association of the US predicts a future decrease in coffee consumption due to lifestyle changes. The growth in popularity of premium-branded and a gourmet coffee has been attributed to US economic growth; and habits of the younger generation, which frequent cafes and espresso bars. These higher-quality coffees are not imported from Brazil (Ahlfeld 2001, NCA2001).

Table 4: Downward trends in coffee consumption based on cups of coffee per person per day in the United States.

Year	Cups per person per day
1950	2.38
1962	3.12
1998	1.41

Source: National Coffee Association of the United States

In Germany trends appear even worse. The volume of imports from Brazil began a downward spiral in 1993. In 1997, 2,299,424 bags were imported, a decreased of 1.9 percent from the year before. In 1998 this number dropped to 2,154,458, a further 0.6 percent decrease. According to German importers, these trends are the result of the younger generation's "negative associations with coffee and a preference for soft drinks" (Commodity 2001).

In order to counter these trends, which could negatively affect the Brazilian coffee industry and severely affect small-scale farmers, a campaign has been launched to increase coffee consumption domestically by 20 to 30 percent. In cooperation with the ICO's International Coffee Agreement, which was reinstated in October 2000, Brazil has also targeted Russia and China to promote coffee consumption in these traditionally tea-drinking nations (Ahlfeld 2001, ICO 2000).

The International Coffee Report produced by F.O. Lichts declares "As things are at the present, the entire coffee industry is heading for disaster" (Ahlfeld 2001, p. 217). The Report suggests that the only way to improve the problem with the "virtual non-stop erosion of coffee prices" on the world market is to prevent coffee surpluses. Although this is perhaps an unrealistic goal in and of itself, it identifies the crisis at hand. While small-scale farmers in Brazil receive loans from the *Banco do Brasil* to perpetuate their coffee investments, it is unlikely that they will profit nor will their debts be repaid. In effect, the more coffee they are able to produce, perhaps the less they will be paid. According to the Association of Coffee Producing Countries, farmers in Brazil must have a yield of 30 bags of coffee per hectare or more in order to make a profit at current prices. Considering the national average is 12 bags of coffee per hectare, it is easy to see that small farmers are highly unlikely to prosper (Fairtrade 1997, Ahlfeld 2001).

4.5.2 Obstacles for Farmers

Price instabilities on the world market offer a significant obstacle to small-scale coffee farmers, but even when prices are high farmers are paid only a fraction of what their crop eventually sells for in a Western supermarket. When prices on the world market are low, farmers are paid a price that is often below the cost of production. The biggest contributor to

this situation is that many farmers lack access to markets and must go through middlemen to sell their crop (Fairtrade 1997).

Geographically isolated in the rural, mountainous areas of the state and lacking adequate transportation many farmers in Rosário da Limeira sell their harvests to local dealers. The local dealers, primarily wealthy landowners and investors, exploit small farmers by buying at very low prices and then waiting to sell the accumulated stock when international prices are acceptable. Small-scale farmers, not surprisingly, are rarely aware of world prices and are more concerned with feeding their families and making a basic living. Some farmers in Rosário da Limeira are able to bypass local traders by selling their harvests to coffee farming cooperatives in the south of Minas Gerais. These cooperatives also help farmers by sharing coffee-processing equipment amongst many farms, as processed coffee receives a higher price than raw (green) coffee.

One of the biggest obstacles facing farmers is a lack of credit. While *Banco do Brasil* provides loans for coffee production, farmers are rarely able to remove their debt. Without the financial flexibility to manage their land properly, many coffee plantations are subject to increased land degradation. The cycle keeps farmers in poverty and does nothing to alleviate the environmental stress exerted on the Mata Atlântica. As coffee prices continue to fall, exports will need to increase in order to maintain national income levels. This leads to further flooding of the world market and an exacerbation of the problem. As a negative consequence farmers are paid less and further pressure is placed on the land, forest, and water resources.

5. Discussion and Results: Developing a Land Management Strategy

This section presents options for a sustainable land management strategy in the Mata Atlântica. It identifies the motivation behind the land management strategy presented—targeting the causes of the problems rather than the symptoms—and addresses the alternatives that offer the most promise. The sustainable land management strategy encompasses soil conservation measures to diminish land degradation; the need for development of alternative markets and diversified production; and continued forest conservation efforts.

To illustrate such a land management strategy, a case study of the approach being used at Iracambi, a non-governmental organization based in Rosário da Limeira is presented. Their approach demonstrates a practical and promising method for achieving a sustainable land management strategy in this region. The work of Iracambi presents an example of the “think globally, act locally” concept presented in Agenda 21. The problems facing the Mata Atlântica and small-scale coffee farmers take place on a large-scale. Iracambi’s local action plan in Rosário da Limeira, by working to involve the community in its own development, offers an example that may be adopted in many areas of the Mata Atlântica where the problems of deforestation, coffee cultivation, and land degradation persist.

5.1 Options for Sustainable Land Management

Based upon the analysis of the relationships between deforestation, land degradation, and coffee cultivation, a land management strategy has been formulated that aims at social and economic prosperity for the farmer, while striving to provide ecological protection for the forest. The current situation demands a land management strategy that addresses the causes behind the problems, not merely a quick fix for the symptoms.

Two primary options exist for improving rural farming development and for the preservation of the remaining Mata Atlântica. First, land management techniques should seek to improve the land value of coffee plantations through improved agricultural techniques, thus extending the productive life of the coffee fields and slowing deforestation. Second, alternatives to coffee must be made available, economically feasible, and socially acceptable for the rural farmer. These alternatives, a diversification of production, should seek to provide incentive for forest conservation while generating income for the farmers. The latter option is a difficult one, and what progress is possible in this direction will likely be slow. Neither of these options are meant to be easy answers for such a complex and dynamic problem, but the idea is that progress should move in a practical direction, with efforts focused on local improvements. Additionally, ongoing efforts for forest conservation should be maintained, and rural community education and development is essential.

Farmers need the technical assistance that will allow for improvement and maintenance of existing land under coffee cultivation, and the credit and income flexibility to experiment with diversified markets. Farmers are not unwilling to expand into diversified markets, however they often lack the knowledge and income/credit to do so. The participatory involvement of farmers is essential for expand this development. Further, the roads and infrastructure for market development are lacking in Rosário da Limeira, making change in this direction a slow process.

5.1.1 Improving Land Management Techniques

Increasing soil fertility and thus the productive life and value of the land are the goals for improving land management techniques in the Mata Atlântica. This approach is practical, intended to support the continued livelihood of the farmer by providing a stable or increased amount of production from their lands, and thereby decreasing the need to abandon their fields and clear more forest. The main constraints for such an option are that research for improved land management techniques is ongoing and new technology must be tried and tested before it can be beneficial on a large scale. Additionally, technology can be expensive to implement, may be area specific, and a farmer must weigh and balance his investments in the land with the output. If a farmer cannot be shown monetarily, for example, how slope erosion decreases land value and increases costs, then he is unlikely to be concerned with doing anything about it. Finally, the alternatives must be socially acceptable, meaning that a farmer can not be asked to grow crops that he is completely unfamiliar with, or would probably not even consume himself.

The target of combating land degradation is conserving the resource farmers are dependent upon for their livelihood—land. The process of extending the life and productive potential of coffee plantations by maximizing soil fertility and land value is achieved by improving or maintaining the soil quality through conservation and management. Preservation of the soil nutrient base requires the reduction of erosion via three main methods, agronomic improvements, soil management, and mechanical measures. The goals of these methods are to protect exposed areas of soil from rainfall; improve the infiltration capabilities and aggregate structure of the soil; and increase the surface roughness of the land in order to reduce runoff (Morgan 1995).

Agronomic improvements to the land involve the use of vegetation to protect the soil from erosion and improve the quality of the soil. Vegetation can be used to cover the soil and protect it from raindrop impact, reduce runoff, and improve the aggregate ability of the soil, thereby increasing the soil's water absorption. Agronomic improvements tend to be the best

alternative in developing countries, as these measures are the simplest, most effective, and least expensive to implement (ibid.).

The general rule with agronomic improvements is that a vegetative cover of between 40-50 percent is ideal to obtain the most benefit. This rule should apply during planting and continue until harvest, which makes a vegetative cover of quick growing crops the best option. Less crops on the land means higher amounts of bare ground, encouraging soil erosion. The coffee fields are especially susceptible just after the trees are seeded and during early tree growth (ibid.). The heavy rains of the Mata Atlântica's wet season are highly erosive, so planting should correspond to the changing of the seasons.

The following examples of agronomic measures could potentially be adapted for soil conservation measures in Rosário da Limeira and other areas of the region:

- Intercropping: Multiple cropping between two or more plants per year or in a sequence on the same land; or growing two or more crops on the same land at the same time. Intercropping mimics a natural ecosystem.
- Crop Rotation: Alternating between row crops (of which coffee is a good example) and legumes or grasses. Provides a good vegetative cover and leguminous plants with their nitrogen fixing properties actually enhance soil fertility. A very traditional and effective method of soil conservation, however legumes and grasses often offer no monetary benefit to farmers and are thus not attractive options to many farmers.
- Vegetative barriers: Usually grasses such as *Vetiver zizanoides* (Vetiver grass), which should be resistant to floods and draught, and quick growing. The deep root structures of grasses provide a root structure to hold soil in place, and the vegetative cover reduces soil loss through runoff.
- Soil management improvements: One method being to develop a farm scheme that makes the most use out of each piece of land while avoiding steep slopes. Some farmers may leave the steepest portions of a hill covered with forest, while planting less steep areas and level fields with coffee trees. A second method is to avoid the clean weeding practices that are the norm for farmers in the region. Farmers expend a great deal of time and energy to remove the weeds that grow between the rows of coffee trees in the belief that the plants compete with the crop for nutrients. However, it is more likely that the soil erosion that results from leaving the soil bare has a greater negative effects on the amount of nutrients available to the trees.

Other examples of land management techniques may not be as promising as the agronomic measures suggested above. These include:

- Mechanical Improvements: including terracing and tillage techniques. The minimal results from such improvements on the steep slopes and shallow soils of the unmechanized land holdings in the region are not worth the investment costs for small-scale farmers.
- Mulching: Covering the soil with crop residues to protect from raindrop impact and diminish the velocity of runoff. The primary difficulty with mulching in the region is that mulch can not be distributed effectively on the steep slopes without a significant increase in labor and costs to the farmer. Mulching may also compete with plants for nitrogen as it decomposes, and during the warm and humid wet seasons anaerobic conditions may develop in the soil. Both conditions may result in lower crop yields, thus rendering the potential benefits of mulching insignificant.

5.1.2 Diversification of Production

The need for discovering alternative markets is necessary. Research in this direction is the target of many Brazilian and international organizations, such as the World Bank. The major drawbacks for the option of encouraging farmers to invest in the cultivation of alternative products are that the capital and knowledge for such work is difficult for farmers to access; farmers are unlikely to invest in alternatives that might appear risky or strange; and even if an alternative crop or product can be grown, it is not guaranteed that a market for such a product will be available or secure. Coffee will persist as the dominant crop so long as the market appears stable and farmers are paid for their harvests, and credits for coffee are the most easily accessible.

5.1.3 Forest Conservation

While addressing the need for sustainable land management, it should be reemphasized that ongoing conservation measures, as discussed in the Background section of this report, should continue and be improved upon. The RPPN system could be a potentially promising resource for conservation efforts in the Mata Atlântica. Lands with marginal productivity, and thus profitability, could be turned over to reforestation (either naturally or through reforestation efforts). This applies to eroded land that is too small to be productive, etc. However, incentive for the creation of RPPNs is necessary, perhaps through government or organizational policies favorable to forest conservation. Failing coffee plantations and eroded pastureland, otherwise useless, could be turned into private forested reserves offering tax incentives and opportunities for agroforestry.

5.2 Participatory Rural Appraisal

It is very important to consider the plight of the rural farmer when addressing the need for soil conservation measures. The essential question for farmers is whether the long-term benefits justify the costs involved to implement soil conservation measures. The initial costs of such measures are high, and the benefits are often not seen until the long-term. While the evidence of land degradation and declining soil fertility is abundant in Rosário da Limeira and much of the Mata Atlântica region, the need exists for hard data to show the quantitative relationships between soil erosion and land degradation. Further, farmers need to understand how these relationships translate into the consequent productivity values for their farms. General schemes for soil conservation exist and are used to some extent in the area, however a “place-based” study would do more to develop appropriate programs for land management and soil conservation. Ideally, a team of agronomists, soil scientists and economists would be needed for a land use analysis aimed at understanding and quantifying the effects of agricultural activities on soil and the resultant effect of the degradation on yields (Pagiola 1995, Millington 1993).

The majority of literature implies that while quantitative data for soil erosion analyses are important for the implementation of effective soil conservation measures, obtaining accurate data is difficult (Morgan 1995, Millington 1993, Pagiola 1995, Stocking 1995). Research is costly, often area-specific (sometimes even farm-specific), and time consuming. Even after research is completed the resultant data are often merely theoretical, and conservation strategies may be impractical for rural farmers without access to necessary technology, and the investment capital.

As discussed in Agenda 21, “local participation is essential in implementing any agricultural strategy […] and can act to ensure that rural populations have fair access to land, water, and

forest resources and to the necessary technologies, financing, marketing and distribution to adequately take advantage of such resources" (Sitarz 1994 p.84). One of the major steps in conserving the Mata Atlântica and halting land degradation in the region is to enable farmers to understand the processes at work behind the problems they face. Participatory rural appraisal methods have been used in rural development strategies since the 1970's and involve techniques that "use dialogue and participatory research to enhance people's awareness and confidence and to empower their action" (Chambers 1992, p.2).

The idea behind participatory rural appraisal is that while the scientific knowledge is available to correct land degradation and promote soil conservation measures, small-scale farmers have the opportunity to understand and take part in these processes that affect their production. EMATER and the Rural Farmers' Union are outlets for the dissemination of adaptive farming techniques in the region, and experimentation can be conducted with the involvement of farmers. In this manner all parties share in the knowledge process; the agricultural agencies can gain from the knowledge of the farmers, and the farmers can gain from the application of farming techniques (Pottier 1994).

So far, such a participatory rural appraisal scheme is missing from Rosário da Limeira. The Federal University of Vicosa, the largest nearby institution in Minas Gerais, has done some studies on management of native forest but with little practical application for small-scale rural farmers. The recommendations of EMATER, the state agricultural extension agency, focus on agronomic practices for individual crops, but not on land management practices that encourage economic use of the remaining primary forest. Technology to reduce land degradation exists on a general level, mainly developed in other states (see Da Costa 1994, and references cited therein), but it has not yet been incorporated in EMATER's recommendations. Part of the process of joint research/extension/farmer generation of technology should involve both the adaptation of appropriate practices from other areas and the direction of research towards the particular problems of land degradation by farmers (Le Breton 2000).

5.3 Case Study: Iracambi—A Sustainable Approach to Forest Conservation, Rural Development, and Community Education

This section looks at the work and progress Iracambi has made in Rosário da Limeira. The work includes conducting agricultural trials to improve soil fertility and decrease land degradation; the creation of forest preserves and encouraging forest regeneration. Additionally, the organization's farmer workshops (on combating soil erosion, growing food crops, and avoiding fertilizers), indirect incentives (looking over your neighbor's fence), and children's environmental education (valuing the rainforest and its biodiversity) have enhanced the development and education in Rosário da Limeira.

5.3.1 The Organization

Iracambi Recursos Naturais (Iracambi), in cooperation with sister organization Amigos de Iracambi, is a small natural resource management organization that manages 500 hectares of land in the municipality of Rosário da Limeira. Of this land, 200 hectares is forested in different stages of regeneration, including 70 hectares that have been legally declared as an RPPN private reserve (see section 2.2). This area is adjacent to another 13,200 hectares of protected forest managed by local and state governments. In addition to its commercial activities of dairy production, aquaculture, and a eucalyptus plantation, Iracambi works with rehabilitation of the rainforest through enrichment planting and reforestation of degraded

forest with indigenous plant and tree species. It is also developing income-generating activities consistent with the maintenance and improvement of forest biodiversity, such as apiculture and the cultivation of traditional and non-traditional forest products.

During the 10 years that Iracambi has been in operation, developing its agricultural operations, it has established links with the surrounding community and local government. The organization has set up a system of participative management of a kind that was unknown previously in a traditional rural area, still governed autocratically by large-scale landowners. Having achieved a wide-degree if local credibility, Iracambi has in the last few years begun to tackle some of the more pressing environmental problems of the region as a whole.

Currently all that Iracambi has accomplished has been done with the organization's own resources, much of it by volunteers, both local and foreign. Local volunteers have been mostly children, who have helped with rehabilitation of the main Research Center building. Foreign volunteers, mostly students of university age, have come to help with related aspects, such as laying out explanatory trails, making inventories of the flora and fauna, helping with the website, mapping, fund raising, environmental education, and the composition of the research databases. The two main foci of the Center's work are on development of technology for better land management, and the creation of value for biodiversity conservation.

Iracambi now seeks to make better use of its own forest resources and to take advantage of its proximity to other forest areas that have recently come under protection. In order to find out more about the potential value of biodiversity conservation, how forest ecosystems behave, and the process of forest degeneration and rehabilitation, Iracambi has established the Iracambi Rainforest Research Center. As a function of the Research Center, Iracambi has begun to develop partnerships with outside researchers and institutions in order to draw on their experiences and knowledge.

The Research Center provides services for researchers, offering them facilities to study forest ecology, forest degeneration and rehabilitation, and related topics. From the increased quantity and quality of research into methods of land management and forest biodiversity conservation, the goal is to develop sustainable and economically viable land management practices. These practices, in turn, can be translated into practical recommendations for landowners and coherent policies for administrators and government officials.

Taking into account the physical, historical, and socio-political circumstances of Rosário da Limeira, the organization's attempts at a sustainable land management approach in the Mata Atlântica include the following:

- Clear demonstration of the benefits of an action plan to the participants. Significant improvement to the quality of life must be assured to bring about changes in behavioral patterns.
- Devolution of responsibility to the people involved. Given the limitations of the state infrastructure, much of the implementation must be entrusted to the people most concerned. The extent to which they will be prepared to assume responsibilities is directly related to the extent to which they participate in the decision making process.
- The dissemination of the basic technological practices that help to reduce land degradation and improve soil fertility. These are not to be offered as a "package of

practices" but as a menu of technical options from which the farmers can choose elements that best meet their circumstances, or can adapt parts that are suitable and incorporate them into other practices.

The opportunity for Iracambi to make a practical contribution to regional development has arisen in the form of two regional development plans that are being implemented in the area of the Research Center's operation. In the nearby Belizário district of Muriaé a watershed protection program is being implemented under the leadership of the state agricultural extension agency, EMATER, and in Rosário da Limeira a sustainable development project is being implemented under the leadership of the Rural Workers Union. In both of these projects, Iracambi is being looked to as a resource provider and a local catalyst.

5.3.2 Land Management Projects

Starting from the premise that local problems are best solved by local action rather than waiting for an initiative from government, Iracambi has been undertaking a series of empirical trials on different technologies to find more sustainable land management methods. Since Iracambi is run by farmers who are impatient for results, not by methodical analytical scientists, the organization has designed a more systematic approach to finding these methods.

Perhaps the most successful method used by Iracambi is the "over the fence" technique. This means that Iracambi conducts its own trials and makes the results known to farmers, simply by demonstrating the effectiveness or ineffectiveness of certain practices in Iracambi's own fields, which are in plain view to other farmers living in the area. One such example was the planting of banana trees to stop soil erosion, which before Iracambi's arrival in Rosário da Limeira, was almost non-existent. After being used successfully by the organization the practice has spread through word of mouth to many of the neighboring farms.

Along with agricultural trials, the expectation is that the Research Center's researchers can use their knowledge to develop suitable technology for sustainable management of the forest and the lands around it. In order to accomplish this, the causes and effects of land degradation need to be understood. Iracambi believes it will be possible to develop strategies to tackle the problems at their root once the problems are better understood. The main focus is on the maintenance of soil fertility, and soil and water conservation; the objectives of which are to reduce soil loss through water run-off, and maintain water resources by improving the recharge aquifers and protecting watercourses.

Iracambi has given particular attention to several projects that it feels have the greatest potential for maintaining soil fertility—in particular the use of leguminous plants and vegetative barriers. The organization has successfully used *Mucuna* and *Canavalia*, two leguminous plants used elsewhere for maintaining soil fertility, as a green manure for corn and beans. Iracambi has begun more systematic trials to determine the best management practices for these legumes. Thus far attempts to use legumes as catch crops on residual moisture have not been very successful, particularly if the field is invaded by the common *Brachiaria* grasses that are very aggressive. Other legumes that Iracambi plans to run trials with are *Phaseolus heterophyllus* and *Arachis pintoi*.

Vegetative erosion barriers using *Vetiver zizanoides* (Vetiver grass) have been used very successfully in Central America and elsewhere, and have been tried successfully in the state of Espirito Santo, bordering Minas Gerais to the east. But so far Iracambi's own trials have

not been promising and the grass has not developed well. *Phalaris* is widely used by Brazil's national highways department though it has the disadvantage of spreading by seed dispersal, which vetiver grass does not. Iracambi intends to undertake more systematic trials of vegetative barriers in 2001.

Another project Iracambi is working with is intercropping. Intercropping is a recommended practice to improve crop diversity, spread risks, and reduce soil impoverishment. In Rosário da Limeira and elsewhere in Brazil, intercropping corn with beans is already the traditional practice. Since rice, corn, and beans are almost the only common annual field crops Iracambi does not see much potential for improving the traditional system. The potential for improving this is constrained by the rainfall patter that limits the times at which beans can be safely harvested without risk of rotting in the field. Intercropping of coffee with corn or beans is also common, and here there is good potential for developing alternatives. *Cajanus cajan* (Pigeon pea) is one potential plant that could be used for intercropping on coffee plantations in view of its high nutritional value, both for humans and cattle. Iracambi has determined that it grows well in the region, but it is little known in the region and farmers have not adopted it.

Other projects being examined by Iracambi include work with agroforestry and reforestation of gallery forests, composting, and minimum tillage direct seeding practices.

5.3.3 Working with the Mata Atlântica

Iracambi has experimented with three types of forest management in an attempt to determine the best way to begin reforestation projects. These experiments include: establishment of new forest in open fields, re-establishment of new forest under phased shading, and enrichment planting of sparse existing forest in various stages of regeneration. The open field method was an attempt to reforest a degraded pasture under *Brachiara* and *Melinus minutifolia* (Molasses grass). It was found that this was not a successful method as the depleted soils with very low organic material content are not a favorable environment for most plant and tree seedlings. Further, the competing grasses either hinder root development (*Brachiara*) or overgrow the seedlings (*Melinus minutifolia*) and the new seedlings are very susceptible to ant predation by Atta ants.

The experiments with pre-established shading using a mixture of *Schilozobium parahyba* (Guapuruvu) and *Psidium guajava* (Guava) are still young, and the organization believes it is too soon to make any evaluations. However, the most promising experimentation is with the enrichment planting under sparse forest in various stages of regeneration. The work with this project is less labor demanding and the survival rate of the seedlings is high.

These experiments are the first step of a larger project aimed at the long-term goal of reforesting many areas around Rosário da Limeira, particularly those areas that have been degraded by the cultivation of coffee plantations. Additionally, to reduce the effects of forest fragmentation and to try and save islands of forest that are too small to maintain viable flora and fauna populations, the areas can be reconnected by corridors. This has successfully been done at the Centro Sul Mineiro in Mote Belo, Minas Gerais, where studies have also been carried out on the most suitable tree species to be planted. In many places, a corridor could run along the boundary of two adjacent properties to reconnect islands, thereby sharing the burden of the land loss between landowners. A 20-meter wide corridor along wither side of a boundary line requires each landowner to give up 10 meters each, which is not a major sacrifice.

Of course, before any landowner will be willing to give up even 10 meters of land for the sake of the forest, value for biodiversity within the Mata Atlântica must be created. Developing the awareness of the value of biodiversity and of the rainforest is another major focus of Iracambi's Research Center. Due to the fact that small-scale rural farmers are most often more concerned about their subsistence than the theoretical values of saving the rainforest, Iracambi has focused its attention on two practical aspects of forest management and conservation. These are the value of forests through the conservation of water resources, and the potential value of biodiversity as a source of revenue, that is to say in generating income for small-scale landowners. The Iracambi Research Center's extension and education program therefore gives emphasis to the role forests have in water conservation and how deforestation damages the water cycle.

As part of its search for alternative sources of income, Iracambi has started research on the use of plants for medicinal purposes. A database is being established to record local plants that have been used traditionally to heal various ailments. Five species have thus far been identified as having particular potential. The next phase of this work is to identify possible markets and commercial partners, and Iracambi has contacted various commercial companies that market medicinal plants with a goal to start pilot production that might later be taken up by interested farmers as an alternative source of income.

Iracambi believes that there are undoubtedly many other possibilities for using the Mata Atlântica's biodiversity as a source of revenue. These possibilities include, but are certainly not limited to, hearts of palm, honey, and eucalyptus based products, and the potential of ecotourism in the region. However, these potential projects will be investigated as the funds and human resources at Iracambi allow.

Future projects include the creation of a center for the breeding of endangered species, partly to raise awareness of the value of local fauna in terms of biodiversity and partly with a long-term view of restoring native populations. Iracambi has been legally recognized as an "endangered species point of release" and has worked with a few species including sloths and primates. At present, the organization is identifying other species as suitable with which to work.

5.3.4 Extension and Education Program

Without embarking on any systematic publicity campaign, Iracambi has found itself pressured from local interests to play a part in other environmental initiatives that have arisen in and around Rosário da Limeira. The organization has developed a role in the community itself and does not work in isolation from the same problems the residents themselves must face. Therefore, the Iracambi Research Center broadened its original focus on pure research to take on the role of a local conservation center, a focus point for education and extension programs.

Working with schools and local farmers' groups, the Research Center has field days for teachers, schoolchildren, and farmers' associations, when they can come and visit Iracambi and learn about the importance of environmental conservation and what they can do about it. Iracambi has prepared a basic set of education materials that will be developed more over the course of time with input from visiting school children and local community volunteers. The Research Center hosts field trips for schoolchildren, who are give a basic introduction to the concept of conservation in their daily lives showing why biodiversity conservation matters. The visitors are also asked to write some material of their own or draw a colorful picture that

can be used for other children in the future. Schoolchildren also get involved to participate in various activities, such as planting tree seedlings or building nature trails through the rainforest.

Similar field visits are in development for community leaders and farmer's groups. These visits will focus more on the practical values of conservation in the Mata Atlântica, and will also include land management workshops. These workshops include explanations and demonstrations of various agricultural techniques including methods for combating soil erosion, the values of growing food crops, and ways to avoiding harmful fertilizers.

Facilitated by Iracambi's partnership with the organization Partners of the Americas, a small farmer loan fund is in the works. Partners of the Americas works with resources between North American and South and Central America to provide assistance to underdeveloped areas. The loan fund would be available to farmers with less than 28 hectares of land, with three main objectives: to encourage cooperation amongst local farmers for improved land management techniques (sharing of knowledge and equipment), develop alternative markets for diversified production, and watershed management. The loan fund will draw primarily on the monetary resources of the local government, Partners of the Americas, and Iracambi.

As Iracambi develops its capacity, it plans to embark on the second phase of this extension and education program, which will include:

- A publicity campaign using advertisements, the existing local community radio, school visits, and farmer field days to publicize the existence of Iracambi and its objectives, raise awareness about conservation issues, and their relation to land use, and to identify local activists and volunteers.
- Using community and foreign volunteers to develop education materials, designed and executed by the volunteers themselves, about problems of land management and land degradation, for use in schools and community groups.
- Using primarily community activists and volunteers, but also supplemented with professional help from whatever resources can be found (such as help with the nearby University of Vicosa) to work with farmers groups in identifying land management problems. Additionally, helping the farmers to propose their own possible solutions using technical support based on research conducted at the Iracambi Research Center as well as joining farmers in trying new practices that are recommended locally and by research findings.

6. Conclusion

Forest is cleared for agricultural land, farmers are encouraged to grow mono-cultured coffee and receive little income for their labor, and the problem of land degradation is not solved, but exacerbated. The cycle is continuous and will not stop without change. The chances of change or progress within the Brazilian government are slim. Farmers will continue in the cycle of deforestation, coffee cultivation, and land degradation before government or bank aid is available for change. Likewise, waiting for government action to preserve the rainforest will not be enough to slow the rates of deforestation and protect a globally exceptional ecosystem on the brink of disappearance. As noted in the Brundtland Report, thus far "government's response to the speed and scale of global changes has been a reluctance to recognize sufficiently the need to change themselves" (WCED 1997 p.282).

Already forest conservation laws go unheeded, and farmers will continue to clear the forest so long as their livelihoods demand it. The pressure for increased production on rapidly degrading land forces farmers to push their resources to the maximum. In response to their needs a locally based action plan is necessary in order to solve the problems at their root. This report suggests a land management strategy involving improved land management and soil conservation techniques, diversified production and the development of alternative markets, and continued forest conservation and community education. Such a plan for sustainable development is underway at Iracambi—whose approach is to make the conservation of the Mata Atlântica more attractive than its destruction.

6.1 Suggested Areas for Further Research

As a result of the work and research conducted with Iracambi, the following recommendations have been made for further research needed within the organization and in Rosário da Limeira:

- Specific research into the opportunities for the diversification of production within the area and the means for such production. Areas of special concern include methods of obtaining credit for farmers through non-governmental assistance domestically and internationally; and the methods of further infrastructure development such as development of farmers' cooperatives (for products other than coffee).
- Examination of the effectiveness of various participatory programs in regards to increases in productivity for the region. This would include a thorough look at the work of the Rural Farmers' Union, EMATER, the University of Vicosa, and Iracambi. Which methods are most effective? How can methods be improved and adapted to compensate the needs of the area?
- An area-specific look at the relationships between soil erosion, land degradation, and decreasing yields and land value for the region. This could involve a comparative analysis of other regions of Brazil and Latin America with similar environmental, agricultural, and physical characteristics. A cost-benefit analysis of soil conservation and resultant yield appraisals, in cooperation with participatory rural appraisal techniques, would be valuable.
- Methods for forest conservation, reforestation, and development of forest corridors to link forest islands. This could possibly involve a detailed look at a reward-based system for encouraging forest conservation efforts (establishment of RPPN's) both publicly and privately. One example would be the steps necessary for a conservation program that would "buy up" land that has lost profitability through land degradation.
- Further research into agroforestry, ecotourism, and other "forest friendly" activities that would promote forest conservation while providing an income to small-scale farmers.

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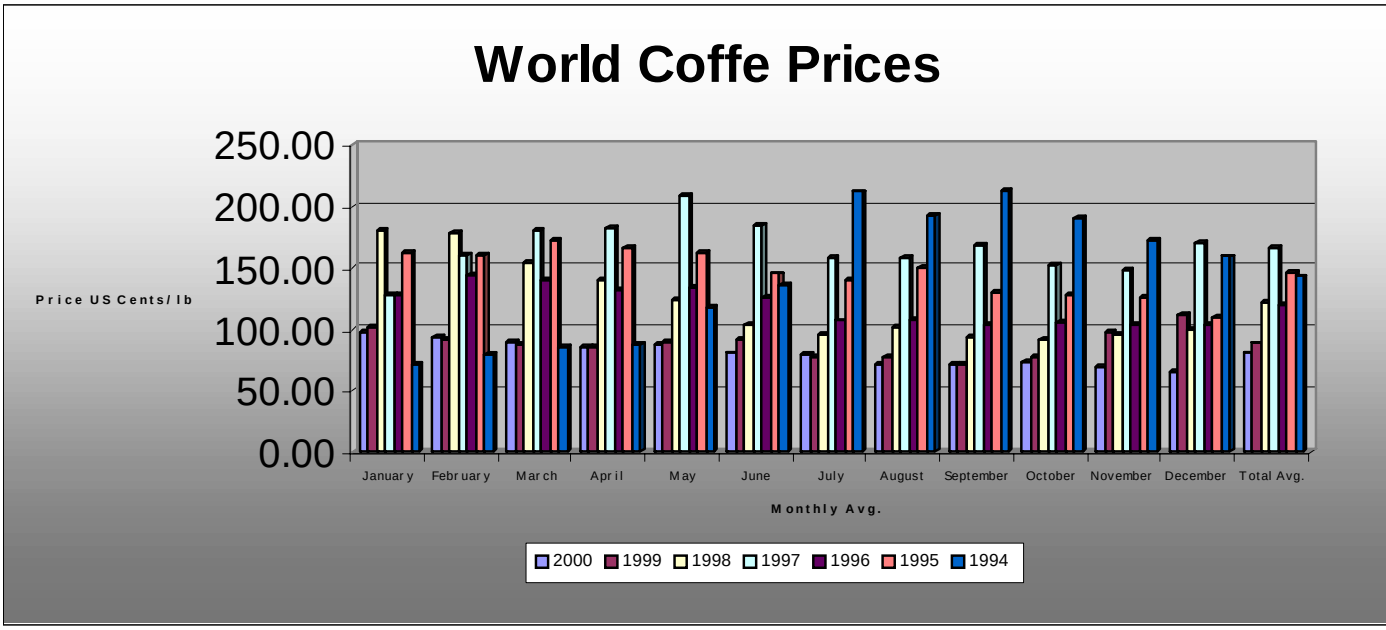
8. Appendices

Appendix 1: Declining Coffee Prices on the World Market

Figures 5 and 6: Table and corresponding graph showing declining coffee prices on the world market between 1994-2000.

World Market Prices (Monthly Averages)

Year	2000	1999	1998	1997	1996	1995	1994	Total Avg.
January	98.59	100.97	179.80	127.30	127.50	162.80	71.40	124.05
February	93.75	91.88	177.80	160.20	144.10	161.10	80.10	129.85
March	89.88	88.38	154.80	179.80	141.00	171.90	84.70	130.07
April	86.46	86.52	140.90	182.90	132.90	166.50	87.10	126.18
May	86.82	90.19	124.90	209.60	134.80	161.70	118.40	132.34
June	80.63	91.69	104.20	184.20	125.40	145.20	136.40	123.96
July	79.38	78.13	96.20	158.50	106.90	139.70	211.80	124.37
August	71.57	77.22	101.90	158.30	108.30	149.50	192.40	122.74
September	71.14	70.57	92.80	167.80	103.10	130.30	212.70	121.20
October	74.10	77.92	91.45	152.20	105.80	127.20	191.20	117.12
November	69.46	97.78	96.39	149.10	103.80	125.30	172.80	116.38
December	64.98	111.86	99.10	171.10	103.40	110.50	159.40	117.19
Total Avg.	**80.56**	**88.59**	**121.69**	**166.75**	**119.75**	**145.98**	**143.20**	**123.79**



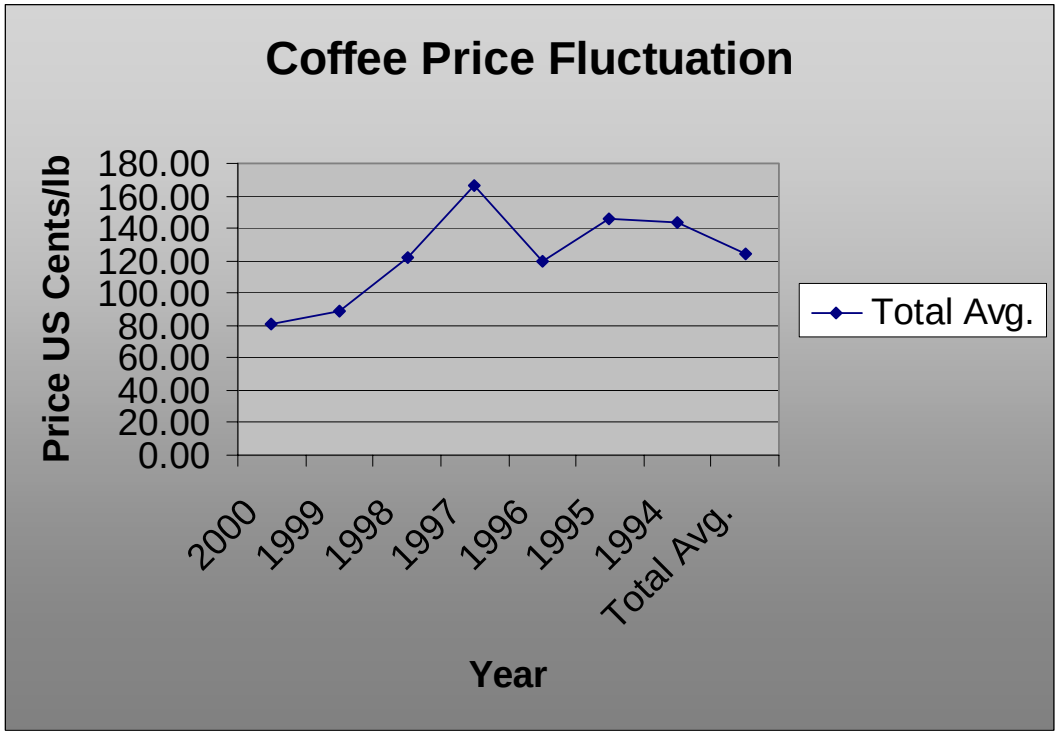
Data taken from ICO statistics as found in Ahlfeld 2001.

Appendix 2: Price Fluctuations of Coffee on the World Market

Figures 7 and 8: Table and corresponding graph showing the average total price fluctuations for coffee on the world market between 1994 and 2000.

Average Total Price Fluctuations

Year	2000	1999	1998	1997	1996	1995	1994	Total Avg.
Total Avg.	**80.56**	**88.59**	**121.69**	**166.75**	**119.75**	**145.98**	**143.20**	**123.79**



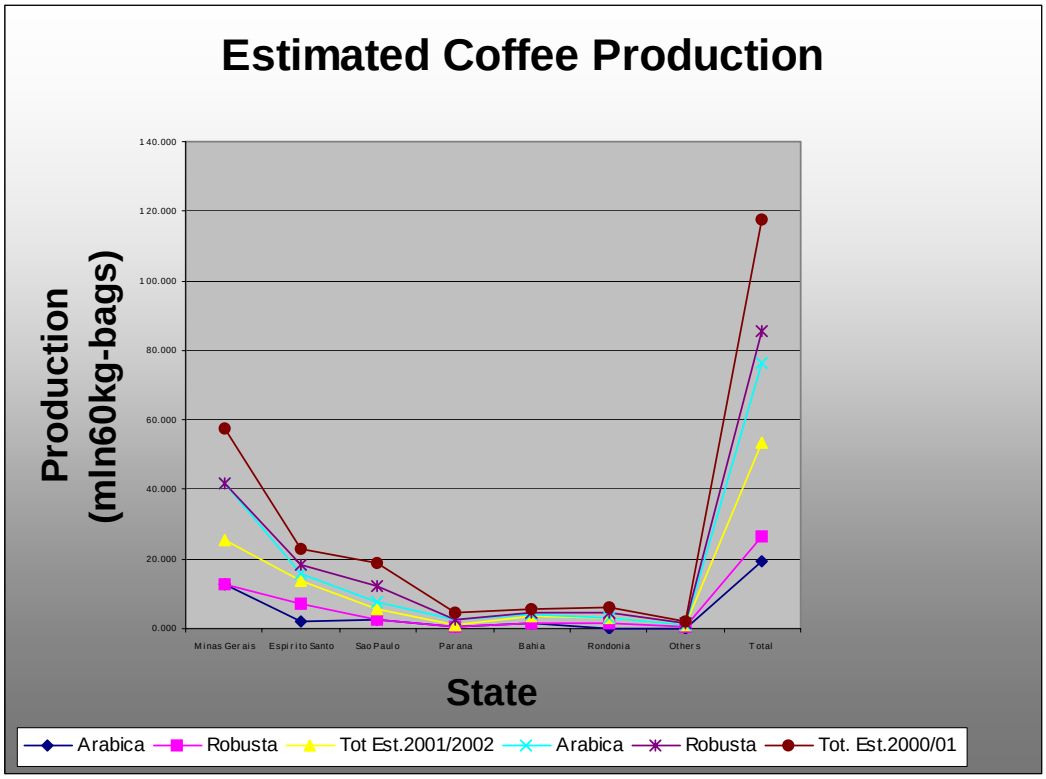
Data taken from ICO statistics as found in Ahlfeld 2001.

Appendix 3: Trends in Coffee Production Increases for Brazil

Figures 9 and 10: Table and corresponding graph showing Brazil's estimated 2000/2001 coffee production by state and coffee bean as forecasted by the ICO.

Brazil Estimated 2000/2001 Coffee Production(mln60-kg bags)

State		Arabica	Robusta	Tot Est.200	Arabica	Robusta	Tot. Est.2000/01
Minas Gerais		12.760	0.040	12.800	15.900	-	15.900
Espirito Santo		1.900	5.000	6.900	1.790	2.690	4.480
Sao Paulo		2.800	-	2.800	2.200	4.500	6.700
Parana		0.400	-	0.400	1.900	-	1.900
Bahia		1.350	0.350	1.700	0.900	0.300	1.200
Rondonia		-	1.600	1.600	0.010	1.390	1.400
Others		0.200	0.300	0.500	0.200	0.200	0.400
Total		**19.410**	**7.290**	**26.700**	**22.900**	**9.080**	**31.980**



Data taken from ICO statistics as found in Ahlfeld 2001.

Appendix 4: ICO Indicator Prices for Coffee Falling

Figure 11: Graph showing the downward trend of coffee prices on the world market based upon ICO indicator prices.