

IRACAMBI COMMUNITY FOREST MONITORING

Project Overview

The Atlantic Forest in southeastern Brazil has suffered such extreme deforestation that many researchers think it is one of the most threatened ecosystems on the planet. Only seven percent of the original forest remains (Galindo-Leal and de Gusmão Câmara 2003), and the original vegetation hardly exists (Magnanini 1984). Ecosystem monitoring is an important way to manage the health of threatened ecosystems like the Atlantic Forest. As the need for ecosystem management increases with continued degradation of the environment, monitoring projects are becoming more common. Participatory monitoring projects can involve community members local to areas being monitored in addition to researchers. This expands the ability of these projects to collect monitoring data and also be adaptive to areas being monitored. The Iracambi Community Forest Monitoring Project is designed to be a participatory monitoring project for the areas surrounding the Iracambi fazenda. It will involve community members and other volunteers to help design and conduct monitoring. The goal of the project is to establish and maintain community interest in the project and to monitor the forest overstory, understory, and fauna. This will determine how the Atlantic Forest ecosystem is growing in monitored areas.

Literature Review

Mata Atlântica

According to some of the most recent literature (Galindo-Leal and de Gusmão Câmara 2003), less than eight percent of the Atlantic Forest (Mata Atlântica) remains. Its original size prior to deforestation was larger than Italy or Great Britain (Magnanini 1984). Over one million square kilometers of the Atlantic Forest was originally destroyed for such uses as brazilwood, sugarcane, coffee, cocoa, and cattle grazing. Deterioration has continued for fuelwood harvesting, illegal logging, plant and animal poaching, and invasive species. Magnanini (1984) describes the destruction to such an extent that the original vegetation hardly exists. The once abundant epiphytes, vines, and dense understory vegetation have been cut down to make room for cities, wood, pastures, fruit plantations, coal, banana, and coffee. Before periods of such intense deforestation, the Atlantic Forest had many different fertile soil types that now have been depleted by the loss of trees and agriculture (Magnanini 1984). Soil erosion has also increased with the loss of trees. With the loss of probably more than a million species already in Mata Atlântica, the effects on the gene pool and genetic variability could be detrimental to mankind (Magnanini 1984). According to Galindo-Leal and de Gusmão Câmara (2003), this could be one of the most devastated and highly threatened ecosystems on the planet. Conservation of Mata Atlântica is therefore imperative.

The Atlantic Forest is unique because many of its fauna species are endemic (Magnanini 1984). More than 60 percent of the terrestrial species on the planet are in the Atlantic Forest in an area covering less than two percent of the earth's land surface (Galindo-Leal and Gusmão Câmara 2003). Beazley (1984) cites that of the 2,124 species of butterflies in Brazil, two thirds are found in the Atlantic Forest and 913 of these are endemic. Beazley also claims that 17 of the 21 primate species in Brazil are unique to the Atlantic Forest and half of the trees are specific to the region (1984). Unfortunately many of these endemic species have already been lost due to the extreme fragmentation of the forest, and we will never know just how many (Magnanini 1984). It is, however, Brazilian law that 20 percent of an individual's land must remain forested. According to Beazley, (1990) landowners are still able to make more money by continuing to cut down the forest and sell the wood, even after paying the fine. This only adds to the problem with forest fragmentation in Mata Atlântica. Just over a decade ago, only 0.1 percent of the Atlantic Forest was protected in the form of national parks, biological reserves, ecological stations, state parks, and private reserves (Beazley 1990). Many protected areas have difficulties receiving funding or any assistance with protection efforts. This only increases the need for management and monitoring of Mata Atlântica or any other ecosystem.

Monitoring Programs

Ecosystem monitoring is becoming more important and common as the need for ecosystem management increases worldwide. Monitoring is an integral component of any management plan. Without monitoring, management plans cannot be defined as successful and adapted for future improvement. Participatory monitoring is a form of ecosystem monitoring that is becoming increasingly common in many countries. It involves both scientists and the community in learning experiences to promote respect and care for the environment. It is now easy to find examples of these programs, such as Teachers in the Woods in the Pacific Northwest, United States. This program teaches middle and high school teachers participatory monitoring techniques they can bring back to the classroom (Teachers in the Woods - Programs 2004). These include methods for the monitoring of invertebrates, soil physical characteristics, soil food webs, and forest ecology. Biologists from the US Forest Service, Park Service, and universities work in teams with teachers to carry out monitoring and research tasks. Teachers are able to participate in a variety of monitoring projects in the Pacific Northwest, such as riparian vegetation monitoring in Columbia Gorge National Scenic Area, Oregon or forest restoration monitoring in the Mt Saint Helens Forest, Washington. This project brings more project-based, participatory science into the classroom. According to Teachers in the Woods (2004), vegetation surveying is the most essential part of studying the forest because the different growth requirements of plants are good indicators of environmental conditions.

The Teachers in the Woods program has good examples of how to bring monitoring into the classroom. The techniques demonstrated by this project are simple yet effective and offer good general ideas for forest monitoring. This project also shows that it is

extremely beneficial to include participatory learning as a part of course curriculums, as is the goal of the Iracambi Community Monitoring Project.

The Canadian Community Monitoring Network (CCMN) is another highly successful participatory monitoring program. CCMN focuses on community based monitoring across Canada to provide science for the purposes of policy and management decisions (The Canadian Community Monitoring Network - Home 2004). This project aims to determine how best to apply ecosystem monitoring to individual communities in order to better collect, deliver, and use ecological information to assist with moving these communities toward sustainability. The CCMN wants to increase involvement of communities in monitoring activities and coordinate monitoring initiatives at the national level. According to the CCMN (2004), a key part of environmental monitoring is the use of local information and identification of needs and community values. Effective communication is essential to educate people about monitoring and report back results, enabling the program to adapt to needed changes. Successful programs become permanent fixtures in the community and have more power for change (The Canadian Community Monitoring Network – Results 2004).

An example of a monitoring project in its beginning stages is one being designed by the Institute for Culture and Ecology (ICE) in Portland, Oregon. The ICE wants to improve sustainable forest management on US public and private lands by developing a biodiversity and participatory monitoring system. In the future, this project plans to create a manual and implementation handbook for forest biodiversity inventory and monitoring, create a curriculum to show those involved with the project how to use this handbook, and also create additional participatory monitoring programs. Workshops will be held to obtain input on and pilot test the manual (Institute for Culture and Ecology 2004).

In addition to participatory projects in the US, there are also many monitoring projects in Brazil (the location of the Iracambi Community Monitoring Project). The Centro de Tecnologias Alternativas-Zona de Mata, a Brazilian NGO, is directing a participatory monitoring project in the Serra do Brigadeiro National Park, adjacent to Iracambi (Centro de Tecnologias Alternativas 2004). This project works with local communities to help them adjust to changes resulting from the establishment of the park. These include the altered use of resources and changes in attitude toward use of resources. Members of communities surrounding the park will be participating in the monitoring and inventory of resources to improve resource management in the area. They will focus on the use of fuel wood, aiming to determine how much wood is used and what implications this has for resource management. Residents' perceptions toward the establishment of the park and their feelings on environmental conservation will also be determined. Hopefully, if the park is viewed as a positive change, residents will be more willing to adapt more sustainable resource use habits (Centro de Tecnologias Alternativas 2004). The Serra do Brigadeira monitoring project includes both qualitative and quantitative indicators, similar in design to the Iracambi Community Monitoring Project.

Fazenda Bulçao, near Baixo Guandu in Mata Atlântica, Brazil is the project site of Instituto Terra for the restoration of native forest. The projects on this fazenda are quite

similar to those at fazenda Iracambi. Instituto Terra uses adaptive management strategies and native seedlings for restoration, while aiming to encourage community participation and to monitor and assess forest recovery methods (2004). Instituto Terra also wants to restore native forest cover and ecological processes in a cost effective fashion and develop more sustainable ways of living for local communities. Similar to Iracambi, the fazenda contains a nursery to grow seedlings for restoration, an evaluation and monitoring program for the assessment of restoration, using vegetation, water, soil, and species as indicators, and an environmental education program (Instituto Terra 2004).

The above examples of monitoring projects are just a few of many. These prove that it should not be difficult to design a participatory monitoring system for an ecosystem such as the Atlantic Forest. Using information from other monitoring projects and drawing from local resources, it should be possible to design a simple system to involve the community and determine how the health of monitored areas is changing over time.

Goals and Objectives

Goals

1. Develop a participatory monitoring system for community and forest inventory monitoring to determine if the Atlantic Forest ecosystem is still growing and at what rate.
2. Design a system with simple monitoring techniques that are inexpensive and will yield quick results.

Objectives

1. Determine the community interest in the project. This includes questioning landowners about their land and determining the amount of community members that would like to be involved. (Beginning November/December 2004).
 - a. Discuss the project with members of surrounding communities (Graminha, APAs, Pedra Alta, etc.). This will be a valuable resource to learn about the components (land use, species, etc.) of each property, and can be used as a form of monitoring. This also will determine the interest and involvement capabilities of these communities (Beginning December 2004 and continuing into 2005).
 - b. Meet with Limeira and Muriae schoolteachers to determine the interest and involvement potential of local school communities (Beginning November/December 2004).
 - c. Contact University of Viçosa to determine if there is any interest or involvement potential from the university (November/December 2004).
2. Design sampling methodologies that can be applied to the Atlantic Forest ecosystems and are able to be completed by inexperienced volunteers.
 - a. Develop timely, inexpensive sampling methodologies for the Atlantic Forest overstory, understory, and fauna (December 2004).

- b. Develop sampling methodologies that can be completed by a variety of participants, including local schoolchildren, landowners, experienced and inexperienced volunteers, and university students (December 2004).
3. Make a GIS map of the areas that are monitored for the project (2005?).
4. Determine if it is possible to design a forest monitoring system that will meet the above stated objectives based on resource availability (2005?).

Clientele

1. Community Members – these include:
 - a. The landowners of the areas selected for monitoring.
 - b. Schoolchildren in local areas surrounding the Iracambi fazenda, including those from Limeira, Muriae, and other smaller communities in the area.
2. Iracambi Volunteers
 - a. Volunteers hosted by the Iracambi research center on a continual long and short term basis who are able to participate in the monitoring project. Some volunteers will hopefully be able to invest research efforts into the project.

Note: Should a description of Iracambi be included here or somewhere else in the proposal? (i.e. the lit review, project overview)
3. University students of the surrounding area

These include students from the Universities of Viçosa and any other universities in the surrounding area that would like to participate.

Clientele Support

Previous research for the forest corridors project has proved that landowners should be successful in participating in monitoring, according to Charlie Evans, the primary researcher of this project:

The ease with which farmers appeared to grasp the forest corridor concept as presented suggests that education programmes could successfully discuss other ecological concepts, such as edge effects. It also supports the notion that farmers could contribute to the design and/or implementation of research and monitoring. Such research could benefit from local knowledge and from a larger body of field workers, and could generate dialogue between farmers and conservationists. For example, farmers' observations of forest animal movements through the agricultural matrix could be especially useful, given farmers' knowledge of the matrix. Also, their knowledge of forest biota could lay the foundations of inventories...Environmental education would have to precede participatory research.

Evan's research shows promising interest and contributions of the farmers he interviewed for the corridors project. The educational aspect of this can be started at the elementary school level.

Fernanda Carrizo, a science teacher in Muriae, has expressed interest in participating in the project. Unfortunately there was not time to converse with her beyond e-mail during

the writing of this proposal. Hopefully, contact will be maintained with this school to further the schools' interest and involvement in the project. Also, the establishment of contact with Limeira or any other schools in surrounding communities and the University of Viçosa will be quite beneficial to the project.

Methods

Community Monitoring –

This monitoring system is meant to be participatory. At the point of its completion, it will involve landowners, local schoolchildren, university students, and volunteers (mostly from Iracambi). It is therefore a necessary preliminary step of this project to determine the community interest. At the beginning stages, there are steps that can be taken to determine the initial involvement potential of the community. It is best that Iracambi volunteers complete these steps. They include:

1. Visits (individual or group) with community members to communities local to Iracambi to determine landowners' interest in the project and knowledge of their own land (such communities may include Graminha, Pedra Alta, and the APA).
2. Meetings with Fernanda, a Muriae environmental science teacher, to determine the interest of the Muriae School, ideas the school has for monitoring, and its involvement potential for the project.
3. Meetings with the environmental education teachers at the Limeira school to determine the school's interest in the project, ideas the school has for monitoring, and its involvement capabilities.
4. Establishing contacts with University of Viçosa professors/students to determine the involvement capabilities of the university (probably in the form of e-mail and telephone conversations, although visits to the university are better).

Landowner Visits:

Landowner visits will hopefully provide information useful for land use classification for these areas and also ideas for monitoring based on landowners' knowledge of the ecosystems present on their land. Considering landowners spend the most time on their land, it should be more useful to question them for monitoring information than to have outsiders decide where and what to monitor without any knowledge of the land. See the appendices (page 2) for questions to ask landowners.

Outcomes of landowner visits:

- Map individual properties with landowners and volunteers to determine land use characteristics. Initial maps can be hand-drawn to later be incorporated into the GIS database.
- Determine monitoring priorities of each property based on the landowner's knowledge of the property and the land use characteristics determined from mapping the property.

- It is likely landowners will have ideas about how to monitor their properties in the form of visual observations and monitoring they perform as part of their daily routines. This will help establish the best areas for forest inventory monitoring in the future to be completed hopefully by landowners themselves and other volunteers.
- Determine to what extent landowners would like to be involved in monitoring of their land.

School Visits:

Visits to local schools are important to determine the interest of schoolteachers and students in participating in the project. Considering this monitoring system is meant to be participatory, this is an integral part of the project. In similar ways to landowners, it is possible schools will have monitoring ideas beneficial to the project.

Outcomes of school visits (Muriae, Limeira):

- Determine the extent to which students and professors are able to participate in forest monitoring.
- Question professors and students to determine any ideas they might have for monitoring techniques.
- Maximize school interest and involvement in project. More contact with schools will increase the likelihood of school interest and involvement in the project.

University contact:

The involvement of universities is extremely valuable to this project or any project at Iracambi because of the wealth of knowledge and resources they can provide. University students and professors can also use Iracambi projects for their own research purposes making the work at Iracambi beneficial to universities as well.

Outcomes of university contact:

- Determine if the universities contacted would like to be involved with the monitoring project and to what extent.
- If universities would like to be involved, establish the best ways for this and at what level (conversations with landowners, forest inventorying, etc.).

Forest Inventory Monitoring System –

Site Selection:

The forest inventory system is universal in its application to Atlantic Forest ecosystems when applied at smaller scales and formulated from information obtained from landowners about the land use characteristics and monitoring priorities of individual properties. It will monitor the forest overstory, understory, and fauna (see glossary, page 1 of Appendices, for definitions). Because this system is universal in its application, site selection must be adaptive to each monitoring area. Obviously, more sites that are

monitored and more data that is collected will yield more results indicating more information about the health of the forest.

The use of results from community monitoring will help determine areas for forest inventory sampling on individual properties. In addition to the selection of sites based on landowner knowledge, it is also important that sites for the purposes of comparison are selected to collect inventory data. Monitoring different types of forested areas inside the Iracambi fazenda (probably completed by Iracambi volunteers) is a good place to start this type of monitoring. Data collected from these sites will also be good to compare with fazendas areas surrounding Iracambi. It is important that all sites be named and numbered, and their locations marked with the GPS to contribute to a map of the areas monitored. All data collected should be recorded on data sheets (see Appendices, page 5).

Forest Inventory - Overstory

Monitoring within each selected area will depend on the forest composition of each sampling location and the land use classifications determined by landowners and volunteers. There are many ways to take forest inventories, permanent sample plots being one of the most common methods. This method will unfortunately be quite difficult with this project because most sampling will be occurring on private properties. The Forest Inventory and Analysis (FIA) and Forest Health and Monitoring Programs (FHM), developed by the USDA Forest Service for the monitoring and inventory of US forests, contains general protocol and methodologies that also are useful for designing monitoring systems (Appendices, page 6) (National Park Service 2004). It is also possible to select areas for sampling on each site using less permanent methods, such as the point quarter method. See the appendices, pages 11-15 for more information on the point quarter method (page 1 of *The Plant Ecology Laboratory, Vegetation Sampling and Analysis I and IV*).

Tree Dynamics – Diameter at Breast Height

1. The point quarter method places random or systematic points along transects to determine where each area is to be sampled. For the purposes of this project, a “transect” could be an actual meter tape laid out for a certain distance (i.e. 100 meters), a trail, or an edge zone, for example. Transects will vary between sites and should be established with the assistance of landowners to determine the best parts of each land for monitoring. It is important that transects are the same length on each site for consistency and are somewhat easily accessible for future monitoring. The beginning and end of each transect should be marked to enable future sampling. It is also beneficial to repeatedly sample the same points when transects are re-sampled in the future.
2. If points are generated systematically, they should be selected at equal intervals (every 20 meters for example). Random points are at unequal intervals using any sort of random number selection. When points are selected, they also can be

- selected at a certain distance from transects, as long as this distance is uniform for the entire transect. Selected points should be marked in a way to enable future sampling (plastic pvc pipe or flagging).
3. The area around each point can then be divided into four 90-degree quadrants, and the nearest tree to the center point (with diameter at breast height (dbh) greater than 5 cm) in each quadrant is measured (see glossary, page 1 of the appendices, for dbh definition). Flag selected trees so they can be relocated in the future. It is possible that it will be difficult to locate trees with a dbh greater than 5cm in some sampling locations. If this happens, the dbh can be lowered to adjust to site conditions.
 4. Diameter at breast height should be measured at a height of 1.37 meters on each tree, on the uphill side, and using a dbh tape to obtain the correct measurement (dbh tapes measure the diameter of trees rather than the circumference). It is best that these measurements are taken every six months or once a year by landowners or other project participants if landowners are not interested. Volunteers also can record the GPS (Global Positioning System) location of each tree sampled to be used in a GIS (Geographic Information System) map of the project. All points and trees should be labeled and all data recorded on data sheets. Develop a system to number points and trees on each section of land to avoid confusion when measuring trees on multiple areas of land.

Tree Dynamics – Health

Other tree characteristics can be sampled more frequently than diameter at breast height, if time and resources allow, giving an indication of forest health. For the purposes of this project, it is probably more convenient for this sampling to be done by local schoolchildren or other volunteers than landowners. Information obtained from meetings with landowners should be useful in this part of the monitoring as well to determine how and what to sample. Below is a general list of typical areas of tree health that are sampled, with more information for each in the appendices.

1. Crown diameter, live crown ratio, crown density, crown dieback, foliage transparency, and crown vigor are a few examples of the FIA's health measurements (Appendices, page 15) (National Park Service 2004). These characteristics can be sampled as often as every three months, or at the same time as dbh sampling if needed.
2. Different types of tree damage also can be sampled, such as open wounds, cankers, and broken boles. Page 17 in the appendices provides a list from the FIA of different tree damage types (U.S. Forest Service Department of Agriculture 2004). These are only examples of different types of tree damage that can be observed and recorded, and may need to be adapted to tropical ecosystems. It is important to record types and location of damage on each tree to see how tree damage changes over time.

Understory

Quadrangles – Herbaceous Species

There are multiple components to understory monitoring. Some ideas for understory monitoring for this monitoring system include the sampling of understory vegetation, soil, and coarse woody debris (CWD) (Appendices, page 1). Understory monitoring is best completed by schoolchildren and other volunteers (participants with more time to dedicate) as it is more time consuming than overstory sampling. The FHM Monitoring Protocols (Appendices, page 6) include good general understory monitoring methodologies, as does the point quarter method (Appendices page 11) (National Park Service 2004). As with overstory monitoring, it will most likely be easiest to sample the understory using the point quarter method and information from landowners (such as where and what to sample). Be sure to label all quadrangles and record all information on data sheets.

1. At each of the selected points along transects (where trees are measured), measure understory characteristics in one meter square quadrangles centered around each point. Understory characteristics that can be sampled will depend on each site characteristics, and therefore may vary between sites. It is important, however that some characteristics are uniformly sampled between sites to maintain consistency.
2. *Vegetation Sampling and Analysis* and *Plant Ecology Laboratory* (Appendices, page 11 and 13) and have some good sampling examples. Below are some other ideas for vegetative sampling in quadrangles:
 1. In each quadrangle, sample the percent of live and dead herbaceous species cover. This is done by standing above each quadrangle and simply estimating the percent of species covering the ground that are live and that are dead. Another, more detailed method is to observe one quarter of each quadrangle, and count the number of times one's fist covers either the live or dead vegetation in that quarter. A fist is equal to one percent cover of the area of the quadrangle; therefore, multiply the number of live/dead cover for a quarter of the quadrangle by four to obtain the entire percent cover of the quadrangle.
 2. Record the amount of exposed soil/rock in each quadrangle the same way live and dead species are recorded.
 3. Measure the height of the tallest woody and nonwoody stem in each quadrangle.
 4. Record if there are more woody or nonwoody stems in each quadrangle.
 5. If it is possible to identify any of the species in the quadrangles, this will be a very useful addition to the project, but it is likely this will be difficult.

Quadrangles - Soil

Soil samples can also be collected at some of the selected sample points. It may not be necessary to sample every point, but at least four should be collected to adequately characterize the soil on the site. Landowners also may have areas they would like to

focus on for sampling, such as agricultural or pasture areas, which would be interesting to compare with forested areas.

1. Sample soil next to quadrangles around each point at each sampling location, making sure to record which quadrangle each sample is taken from. GPS the location of each soil sample for later use in the GIS map. Select sample sites with similar dominant vegetation and successional characteristics. If the site transitions between multiple forest types, sample from the middle of one forest type and not in an area that transitions between forest types (Teachers in the Woods 2004).
2. Additional samples could be taken from farmland on sites to be compared with soil in the forest and also to provide information for landowners about soil health. This could be a possible incentive for the involvement of landowners in the project. If soil sample results provide information leading to better management of their land, landowners may be more inclined to participate in the monitoring aspects of the project.
3. There are many soil tests that can be completed, including litter layer, horizon depths, texture, mineral content, water infiltration rate, bulk density, and soil compaction. To perform all of these would unfortunately be too time and resource consuming for this project. A few soil tests that may be important to this monitoring system are the depths of the litter layer, and the O soil horizon (Appendices, page 1 for definitions) depth and mineral content. Samples will most likely need to be analyzed at the University of Viçosa or in Muriae.
4. To measure the litter layer of the soil, gently stick a meter stick through the litter layer to the soil surface and record the size of the litter layer.
5. To measure the depth of the O horizon, use a soil probe or core. Brush away the litter layer and push the soil core straight down into the soil. Twist and apply pressure to the core until it has been inserted between 10 and 15 centimeters into the soil, and twist the core while removing.
6. Leave the soil in the core to examine the transition between the O and A horizons. The point at which the soil color noticeably changes from darker to lighter brown is the transition from the O to the A horizon. Measure and record the size of the O horizon (the darkest layer at the top of the core). It is possible that this layer will be very thin or even nonexistent at some sites.
7. Determine the average depths of the litter layer and O horizons at each site.
8. Collect soil samples for mineral analysis from each area sampled on each site. Use a shovel or trowel to fill half a Ziploc bag with soil and label each bag with site name and sample number. These will be analyzed at a later time in a laboratory. If laboratory analysis is costly, fewer samples can be collected from each site (one instead of four).

Other Potential Areas for Understory Sampling:

Coarse Woody Debris

Coarse woody debris (Appendices, page 1 for definition) is a critical part of forest ecosystems. It indicates wildlife habitat quality, forest structural diversity, fuel loading, fire behavior, carbon sequestration, and nutrient and water storage and cycling (2.0 Phase 3 Field Guide – Down Woody Materials 2004). It would therefore be very beneficial to this monitoring system to measure coarse woody debris (CWD).

Coarse woody debris is composed of downed, dead trees, shrub boles (mainstems), and large limbs on the ground. It includes dead trees at an angle greater than 45 degrees from standing vertically upright. CWD can be sampled along point quarter transects at each site. The diameter of any piece with a diameter greater or equal to 5.0 centimeters and greater than one meter in length should be measured at the point where it intersects the transect. Stumps that are still rooted in the ground are not included as CWD. If more than one piece of the same piece of wood intersects a transect, total the diameters of all pieces that intersect that transect with diameters greater or equal to 5.0 centimeters at point of intersection. For all CWD measured, record the decay class of each piece (see appendices, page 19 for CWD decay classes).

Seedlings and Saplings

Seedlings are important indicators of forest regeneration but can unfortunately be difficult to identify (at the species level and also to differentiate between a seedling and an herbaceous species). Seedlings could be counted along defined segments of each transect (three ten-meter segments, for example), and simply the number of seedlings recorded at each site. The same transect segment should be sampled each time and the differences in numbers of seedlings can be compared.

Saplings are defined as trees greater than one meter in height with a dbh less than 5cm. Saplings also indicate forest regeneration, but at a later stage. The number of saplings could be counted in a defined area around each point (5 m² for example), or simply the nearest distance to each sapling can be recorded like with trees.

Fauna

Monitoring of fauna will be best completed by information gained from visits with landowners. Landowners are the most knowledgeable of the species on their land, and species use of their land. Information obtained from visits with landowners can be used to determine the best ways to monitor species on each property (see Appendices, page 2, for framework of questions asked of landowners during visits). It will therefore be easiest to begin fauna monitoring using visual observations.

Aside from visits with landowners, during all forest inventorying, visual observations of fauna can be recorded. When all other sampling is completed, all project participants can

record observations of fauna. Digital cameras will be useful for these observations if available (Iracambi has one camera), and trip cameras will also be quite useful if funding is available for their purchase. Some examples of visual observations include any fauna species sighted, evidence of animals in the area (nests, holes, etc.), and animals heard while sampling (birds, etc.). If the type of animal is not known, describe the animal to the best of one's ability. It is very important here to determine and focus on indicator species for monitoring.

GIS Map

The GPS points collected during monitoring in this project will ultimately form a GIS map of all monitoring locations. This will be a useful visual representation of monitoring work completed. It is necessary that a person with prior knowledge of GPS units and the GIS programs (ArcView/ArcMap) complete this part of the project. This will most likely be an Iracambi volunteer or University student. It will be difficult to GPS all sampling locations, although more GPS points collected will create a more comprehensive map.

It may be useful to begin monitoring inside Iracambi. Farmers within the fazenda can be questioned similarly to landowners in surrounding communities to help determine the best areas to sample. Areas of different forest and land use types can be sampled for comparison and a separate GIS map could be created for this part of the project.

Available Resources

Due to limited resource availability, this project is designed to maximize use of available resources. Local community members, volunteers, and university students compose the majority of available staffing resources for the project. Some interest in participating in the monitoring project has already been demonstrated by local schools and landowners. The next step is to inform participants of the design of the monitoring system, demonstrate how to perform the monitoring, and do so in a way that is agreeable with participants' time availability. The contributions of Iracambi volunteers will hopefully be ongoing, and depend on volunteer staffing at the research center.

Needed Resources

The primary resources needed for this project are commitment from its participants and equipment. Staffing needs should be minimal because the project is designed to be completed by community members and volunteers, unless there is a lack of participation from these people. If resources are available, additional personnel can be hired to assist with site selection and sampling locations. These include dendrologists, botanists, or others with background knowledge of the sampling areas. Soil sample analyses will also be needed to determine the mineral content of soil samples. These samples can hopefully be analyzed locally, either at the University of Viçosa or in Muriae.

Project Materials

Below is a list of project materials for overstory, understory, and fauna monitoring. This list is quite general at this point, and simply provides an idea of the basic materials that might be needed for this project. Equipment highlighted in blue is already available at Iracambi. Equipment highlighted in green overlaps from one monitoring section to the next (the four dbh tapes needed for overstory monitoring can also be used for understory monitoring, for example). Equipment highlighted in purple will probably be difficult to obtain for the purposes of this project, therefore isn't described in much detail in the methods section.

Overstory Monitoring	
Equipment	Quantity
100-meter measuring tape	2
DBH tape	4
tree marking tape (rolls)	2
tree identification books	2
data sheets	20
GPS	1
GIS	1

Understory Monitoring	
Equipment	Quantity
100-meter measuring tape	2
DBH tape	4
PVC pipe (1-meter pieces with elbows for quadrangles)	12
PVC pipe (0.5-meter pieces to mark quadrangle locations)	10
Soil core/probe	2
Plastic bags (0.5 or 1.0 L box)	1
Meter stick	2
Shovel/trowel	2
Data sheets	20
GPS	1
GIS	1

Fauna	
Equipment	Quantity
Digital Camera	1 or as many are available
Trip Camera	1
Data sheets	20

Budget

A budget has not been decided upon for this monitoring system. Some items to consider when making the budget for this project include:

(Levine 2004)

Direct costs - personnel and nonpersonnel (equipment, supplies, travel)

Indirect costs – space and equipment, money for time spent preparing proposal, project administration

Categories:

- Personnel
- Consultants
- Equipment
- Supplies
- Communication (telephone/postage)
- Materials preparation
- Travel
- Rental of facilities
- Evaluation
- Other expenses
- Indirect costs

Evaluation

The evaluation of this project will be adaptive over time, following the design of the rest of the project. It is necessary to evaluate the monitoring to determine its success and what changes need to be made to make it more successful to obtain the desired results. It is not possible to design a permanent evaluation system until specific monitoring techniques have been decided upon. This will most likely be an ongoing project for this monitoring system because it is meant to be adaptive and many of the monitoring techniques will be based on information obtained from meetings with community members. An evaluation of this project will benefit those participating in the monitoring and any people affected by the monitoring areas.

Community Monitoring – Interest

The evaluation of community interest in the project this will depend on the response from meetings with community members. These include meetings with landowners, local schools, and any contact with universities. This may be a slightly time-consuming process due to difficulties in contacting certain community members. Community response is also subject to change over the course of completion of the project. A framework of questions provides a good method for evaluating community monitoring over the duration of the project. If these questions are used regularly, they can consistently check the progress of the project and areas where changes are needed. Some examples of questions for this framework include:

- Is there enough potential interest in the project to enable it to be participatory?
- How much time and resources are interested community members able to allocate?
- Is enough information being obtained from meetings with landowners in areas that are beneficial to the project?
 - What changes can be made to gain more information, if needed?
- Are regular meetings with community members a possibility in the future?
- Will community members be able to participate in monitoring and inventory continually in the future?
- Who will the results of this project benefit the most and what is the best way to communicate these results?

Also see the questions for landowner interviews (Appendices, page 2) for ideas for other questions.

Forest Inventory – Methodologies

The sampling methodologies for this monitoring system are designed to yield timely results and be completed by a variety of participants, both experienced and inexperienced. The determination of which methodologies to use depends on site characteristics and meetings with landowners. Therefore the specific inventory evaluation methodologies will develop as the project itself develops. It is important to determine ways to quantify inventory data collected so the results can be applied to the ecosystems from which they were collected. Below are some quantification recommendations for evaluation for each part of the forest inventory monitoring system:

Overstory:

Determine if tree data collected shows if the forest is growing and at what rate.

- Tree growth can be grouped into growth classes, (see Swiecki 2001 for example growth classes), or basal area and other growth characteristics can be calculated. Sections I and IV of *Vegetation Sampling and Analysis* (Appendices, page 13) have equations that could be used to analyze data collected from monitoring, determining such characteristics as basal area, density, dominance, etc.
- Tree dynamics observations can also be generally grouped into classes, and depending on how tree health changes over time, this will directly indicate how the health of the forest is changing.

Understory:

Data collected from understory monitoring can be evaluated in ways similar to that of overstory monitoring. These will also be useful to help indicate forest growth rates:

- Sections II and III of *Vegetation Sampling and Analysis* have equations that could be used for the analysis of herbaceous species data collected. These

sections also contain additional ideas for sampling of herbaceous species that may be useful to this monitoring project.

- Laboratories local to the project area will complete the evaluation of soil samples. Soil test results will affect the locations of future sampling and should provide useful management information for landowners.
- Seedlings and saplings can be quantified similarly to herbaceous species (see *Vegetation Sampling and Analysis*). Also when counting seedlings, the amount of seedlings recorded between years will indicate how well the forest is regenerating (whether there is an increase or decrease in seedlings between years).

Fauna:

To evaluate results from fauna monitoring, criterion need to be defined establishing whether fauna's use of each monitoring area is successful. Below are some questions that may be helpful in establishing this criterion:

- With what frequency are fauna using each site?
- What types of fauna are using each site and how does this vary among sites?
 - Are any of these species indicator species?
- Are fauna more abundant in sites that are less fragmented?
 - Would forest corridors improve fauna usage of the site?
 - How can/should the system be adjusted to monitor for this?
- How can the site be managed to improve fauna usage of the site?
- How should the current monitoring of fauna be adapted to be more effective?