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A Comparison of Anuran Species Richness Between Primary and Secondary Forest in São Francisco do Pará

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SIT Study Abroad

A COMPARISON OF ANURAN SPECIES RICHNESS BETWEEN PRIMARY AND SECONDARY FOREST IN SÃO FRANCISCO DO PARÁ

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Abstract

Deforestation in the Amazon has become a serious conservation issue. The process of destruction of primary forest results in the creation of secondary forest that differs from primary forest in a number of important ways. Anurans (frogs and toads) are one group that may be affected by the loss of primary forest and creation of secondary forest areas, and are an important focus for conservation efforts. Previous studies on anuran reactions to loss of primary forest have been few and inconclusive. This study examined anuran species richness in an area of primary and secondary forest in order to determine whether the successional state of a forest affects the number of species and the types of species present in each area. The methods of audio-strip transects and visual encounter surveys were used to sample anuran species richness in primary and secondary forest in the municipality of São Francisco do Pará, Brazil. A total of 16 species were found in 28 man-hours of sampling, of which ten were found in the primary forest and eight in the secondary forest, resulting in no significant difference between the two forest areas in terms of species numbers. There was however a very low index of similarity between the two sites, suggesting that, although the total number of species was similar, the sites differed in terms of which species were present. Thus, anurans may be affected by the increasing destruction of primary forest and its replacement by secondary forest, and this must be kept in mind for future conservation efforts.

Resumo

O desmatamento na região da Amazônia é uma questão seria para esforços conservações. O processo de desmatamento da floresta primaria cria a floresta secundaria, também se chama capoeira, que é diferente da floresta primaria em muitas maneiras importantes. Anuros (sapos) são um foco importante para esforços conservações, e são um grupo que pode ser afetado pela perda da floresta primaria e a criação das zonas da floresta secundaria. Estudos anteriores das reações dos anuros à perda da floresta primaria são poucos e não conclusivos. Este estudo examinou a riqueza das espécies dos anuros numa zona da floresta primaria e secundaria para determinar se o estado sucessional afeta o numero das espécies e o tipo de espécies presente em cada zona. Os métodos de transetos de áudio e inspeções visuais foram usados para amostrar a riqueza das espécies dos anuros na floresta primaria e secundaria na municipalidade de São Francisco do Pará, Brasil. Foram encontrados em 28 horas de investigação, 16 espécies; dez espécies foram encontradas na floresta primaria e oito espécies foram encontradas na floresta secundaria. Não era diferencia significativa entre os dois tipos de floresta. Mas, a índice da similaridade entre os dois tipos de floresta era muita baixa. Isto indica que, embora seja similar o numero dos anuros, os dois tipos da floresta são diferentes nas espécies especificas que contêm. Assim, anuros podem ser afeitos pela destruição da floresta primaria e a substituição dela com a floresta secundaria, que está acontecendo progressivamente na região da Amazônia Brasileira. Os resultados deste estudo devem ser levados em consideração pelos esforços futuros da conservação.

ISP synopsis

Deforestation in the Amazon has become a serious conservation issue. Deforestation occurs for many reasons including: destruction of forest for logging, cattle ranching, mining, and resettlement of people from poor, overpopulated urban areas. These areas that have been deforested are very often abandoned after a period of a few years due to the generally low productivity of Amazonian soils and their unsuitability for agriculture. This abandonment results in the development of secondary forest that differs from primary forest in a number of important ways including vegetation structure and density and overall biomass. Studies of secondary forests are few and it is important to determine how both flora and fauna react to this change in forest structure, as secondary forest continues to occupy a larger percentage of the total forested area of Brazilian Amazonia.

Anurans are a very diverse taxa in Amazonia, with at least 256 species being described in Brazilian Amazonia, and as many as 80 species have been reported at single field sites. Anurans live complicated life cycles that require the presence of several specific habitats in order to grow and reproduce. Anurans are an important focus for conservation efforts for a number of reasons, including their sensitivity to changes in the local environment, their apparent worldwide decline in numbers, their ability to be used as charismatic species in support of future conservation efforts, and their importance in different ecological cycles, and are one group that may be affected by the loss of primary forest and creation of secondary forest areas. Previous studies on anuran reactions to loss of primary forest have been few, restricted to a few areas and disagree as to whether anurans are heavily affected by the process of habitat loss or alteration. This study examined anuran species richness in an area of primary and secondary forest in order to determine whether the successional state of a forest affects the number of species and the types of species present in each area.

The methods of audio-strip transects and visual encounter surveys were used to sample anuran species richness and compare the numbers and types of species present in primary and secondary forest in the municipality of São Francisco do Pará. Transects were established along trails in a fragment of primary forest and an area of secondary forest that had been left uncultivated for eight years and anurans were procured visually and by

listening for their advertisement calls. Species were recorded calling if possible, as well as photographed in order to be identified later by experts. This method was used because the identification of Amazonian anurans is extremely difficult in the field without visual or auditory evidence, but voucher specimens (frogs that are sacrificed in order to be further studied in the laboratory in order to confirm species identity) were unable to be taken in this study.

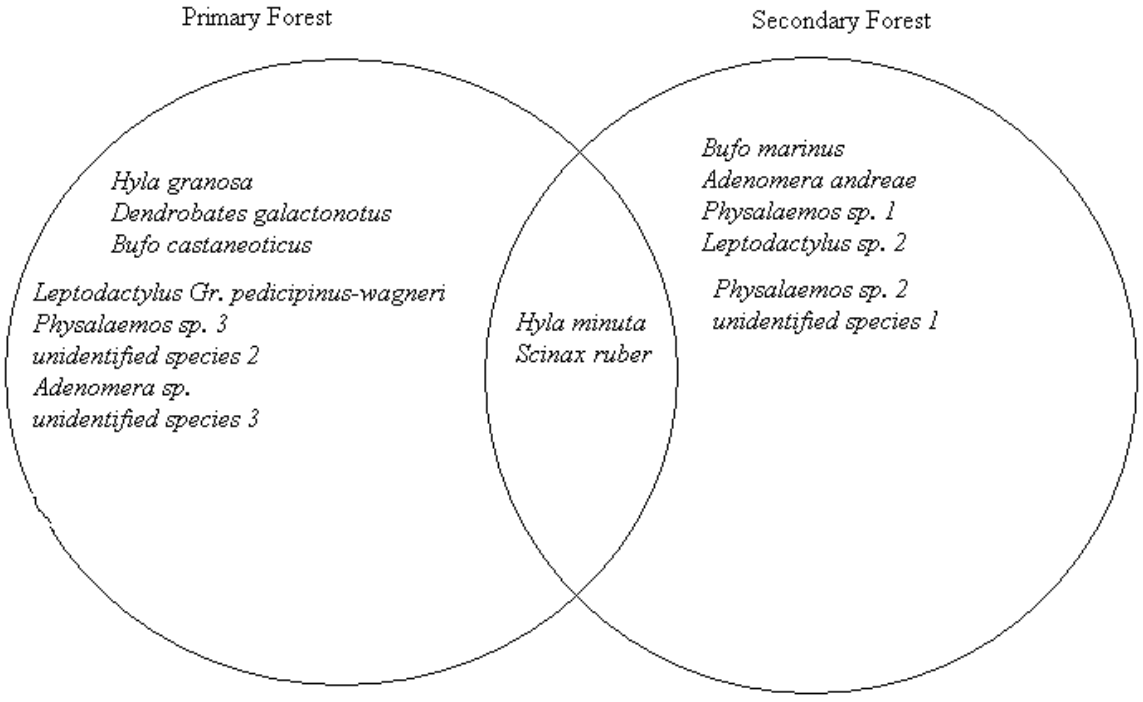
A total of 16 species in seven genera were found in a total of 28 man-hours of sampling, of which ten were found in the primary forest area and eight in the secondary forest area, resulting in no significant difference between the two forest areas in terms of species numbers (Table 1). This may be due to the small sample time, although the number of species found compares favorably to past studies. More likely explanations for the lack of difference between the two areas are the presence of appropriate anuran breeding areas in both regions, and that the primary forest studied differs from continuous primary forest in a number of ways including size and level of disturbance.

There was found, however, a very low (0.125) Jaccard's index of similarity (a measure of the number of species held in common by two different locales) between the two sites, suggesting that, although the total number of species was similar, the sites differed strongly in terms of which species were present (figure 1). Thus, this study suggests that anurans may be affected by the increasing destruction of primary forest and its replacement by secondary forest, and this must be kept in mind for future conservation efforts.

Table 1: Total numbers of species found in each type of forest as well as the number of species unique to each area, the number of species in common between the two areas, the numbers of species found at different times of day, and the number of species found calling.

Area	Number of Species
Primary Forest	10
Unique to primary forest	8
Secondary Forest	8
Unique to secondary forest	6
Total species found	16
Total species in common between two forest areas	2
Total found in morning	6
Total found at night	10
Total found calling	8

Figure 1: An illustration of the difference between the primary and secondary forest in terms of which species were found in which areas. The left circle represents the species unique to the primary forest area, the right circle represents species unique to the secondary forest area, and those anuran species contained in both circles were common to both forest types.



Introduction

I. Deforestation and Forest Succession in the Amazon

The deforestation of tropical forests has become one of the most important and most intensely discussed environmental issues. This discussion has had a strong focus on the nation of Brazil because it holds the largest remaining stands of tropical forest in the world, approximately four million km^2 of Amazon forest (Skole & Tucker 1993). Around one million km^2 of this forest is located in the Brazilian state of Pará (Skole & Tucker 1993). The Amazon forest is considered to be an important ecosystem for conservation as it is home to a large amount of the planet's biodiversity, much of which remains unknown to science, and has also been implicated as a major factor in regulating global climate and nutrient cycles.

Deforestation is occurring at a large scale in the Brazilian Amazon, and has been a major focus of conservation efforts, especially from the 1970s to the present (Kricher 1997). Rates of deforestation in the Amazon are varied and difficult to obtain with accuracy, one study has suggested a range of between 1.5 and 2 million hectares per year as of 1994 (Skole et. al 1994). Another study gives the extent of deforestation in terms of percentages, stating that as of 1993, 9.3% of the Brazilian rainforest has been deforested (Fearnside 1993). Although a relatively large amount of Amazonian forest remains intact compared to tropical forests in other areas of the world, the increasing destruction and fragmentation of Amazon forest remains a concern to conservationists and is expected to have severe negative environmental effects in the future if allowed to continue unabated and unmanaged.

Many factors have been implicated in the deforestation of the Amazon tropical forests. Among these are destruction of forest for logging, cattle ranching, mining, and resettlement of people from poor, overpopulated urban areas. In many cases, after areas of forest that have been cut are used for a period of time, they become unproductive and are left uncultivated (Uhl et. al 1988). When areas that have been deforested are left uncultivated and unmanaged, the resultant forest structure that develops is termed secondary forest. Secondary forest is a term used to contrast with primary forest, which is mature, old-growth forest that has reached an equilibrial climax state in vegetation and has not been cut or destroyed for several decades (Uhl et. al 1988). After a pasture is

abandoned, the regrowth of the forest is dominated by light-tolerant very rapidly growing species, especially shrubs and light tolerant trees such as *cecropia*, that make up the initial secondary vegetation. After around five years, the forest reaches such a height that undergrowth develops on the floor of the forest. After many years species that are long-lived and shade-tolerant begin to dominate and take over the forest structure, eventually reaching the mature climax equilibrium state that is termed a primary forest (Uhl et. al 1988).

Secondary forest differs from primary forest in a number of ways, including: climate (humidity, light and wind penetration, temperature), height and density of vegetation, vertical stratification of vegetation, evenness of canopy, species composition, relative abundance and diversity of species, and biomass (Uhl et. al 1990). Changes in species composition and biodiversity are of particular concern to most conservation efforts working with tropical deforestation. As primary forests become increasingly destroyed or fragmented into smaller, unconnected tracts of forest, and secondary forests come to occupy a larger percentage of the total forested area of the Brazilian Amazon, these differences in species composition and diversity of both flora and fauna between primary and secondary forests must be understood in order to implement adequate conservation measures.

II. Anuran Biology and Conservation Issues in the Amazon

Among the more diverse taxa of animals occurring in the tropical forest are the anurans (frogs and toads). Anurans occur in large numbers throughout the humid tropics. Of the estimated 4,000 species of anurans in the world, approximately 1,600 are found in the New World tropics (Kricher 1997). Of these, around 600 are found in Brazil, and at least 256 have been recorded in the Brazilian Amazon (Bernardi 1999). Single sites in the Amazon can contain a large number of species; Bernardi (1999) reported 41 species present in the Cáxuianã national forest in Pará state in eastern Amazonia, Tocher et. al (2001) found 61 species in the INPA/WWF reserves near Manaus, while some studies in western Amazonia have suggested up to 80 species found within a single area (Duellman 1992). This diversity is largely attributed to a large number of microhabitats that allow for high

levels of diversification of lifestyles, and a number of favorable climatic conditions; anurans require high moisture levels in order to survive, and the high humidity levels characteristic of the tropical forest provide this moisture. This high species diversity is supplemented by a high diversity of lifestyles including such aspects as habitat utilization, nutrition and courtship and reproduction (Duellman 1992). An important part of anuran courtship is the production of advertisement calls, which are species-specific vocalizations that serve to attract females, and may also serve to defend their territories and communicate with other calling males (Wells 1977).

Anurans are being increasingly recognized as an important taxonomic group for conservation. Anurans are considered to be important to conservation for many reasons including: (1) they are highly sensitive to changes in the physical environment and microclimate, (2) their diverse lifestyles involving both aquatic and terrestrial stages require the presence of many specific habitats for reproduction and development, (3) they make up an important part of tropical forest ecosystem processes – especially food webs, by consuming invertebrates and by being the prey of many higher order vertebrates, (4) because there has been a general worldwide trend of declining amphibian populations, and (5) because anurans are charismatic animals which can be used by conservation efforts to appeal to the general public for support (Bernardi 1999, Blaustein & Wake 1990, Pearman 1997).

The sensitivity of anurans to environmental changes suggests that they may be strongly affected by habitat disturbance and change in the successional state of a given area along with the concurrent changes in local environmental parameters, as is occurring in many areas of the Brazilian Amazon today. Previous studies, however, have been mixed as to whether anurans are heavily affected by the loss and fragmentation of primary forest (e.g. Bernardi 1999, Oliveira 2002, Schlaepfer and Gavin 2001, Tocher et. al 1997). The number of such studies, however, has been small, and restricted to a small number of sites, mostly in western Amazonia. Additional studies in more areas of Brazilian Amazonia of how anurans are affected by deforestation and secondary forest regrowth are needed in order to improve conservation initiatives aimed at these species. The aim of this study is to document the effects of loss of primary forest on anuran species. In this study an area of primary forest and an eight year old tract of secondary forest were surveyed for anuran

species in order to compare the number of species found in each area, and which specific species were present or absent in each area, using a measure of similarity between the two sites. It was predicted that a larger number of species would be found in the area of primary forest.

Materials and Methods

The study was conducted in the municipality of São Francisco do Pará near the community of Grande Marathon. The municipality is located in the Bragantina zone of Northeastern Pará state (Almeida 2000). Most of the land is either used for agricultural production of manioc, beans, rice and corn, or is being left to grow as secondary forest, with only a small amount of the municipality, 1,42%, being primary terra firme forest. Additional details on the characteristics of the municipality and the forested areas contained within it are given in Almeida (2000). The region contains a fragment of old-growth *terra firme* primary forest as well as several patches of secondary forest, locally known as *capoeira*. The tract of secondary forest selected to be studied had been left uncultivated for eight years, and was previously used as an agricultural field for agricultural production. This tract was chosen due to its large size and presence of a long length of trails running through the area. The location of the primary forest and approximate location of the secondary forest are shown in figure 1.

The species richness of anuran populations was sampled in the primary forest and in the tract of secondary forest using the method of audio strip transects (Zimmerman 1994) supplemented by light-intensity visual encounter surveys (Crump & Scott 1994). Transects were placed along pre-existing trails in the primary forest and the secondary forest areas. Five transects of one kilometer in length were demarcated linearly in each of the forest areas; thus five kilometers total of trail in each fragment were available to be studied. The first transect was placed at a distance of at least 60 meters from the beginning of the trail in order to avoid edge effects (Laurance et. al 1997). The width of the transect depended on whether the audio strip transect or visual encounter survey method was being used, as described below. A visual description of the transects is shown in figure 2.

Figure 1: A black and white landsat satellite image of the São Francisco do Pará municipality with the approximate locations of the study areas of primary and secondary forest being noted by white arrows (figure taken from Almeida 2000).

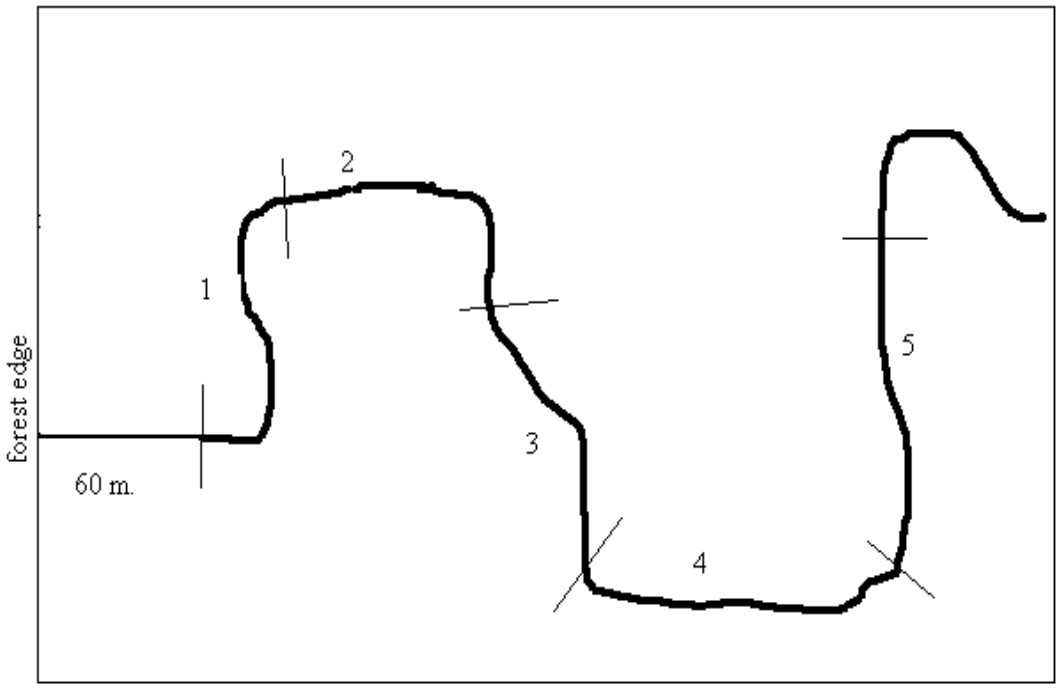


Figure 2. An illustration of how transects were laid out. Illustrated is the 60 m. distance between the beginning of the first transect and the forest edge. Transects of 1 km. each are shown numbered 1-5. Sampling was begun at a randomly chosen end of the transect: near (closest end of transect to forest edge) or far (farthest end of transect to forest edge). Note: this figure is not drawn to scale and does not represent the actual layout of the trails in either forest area studied.

One transect from the primary forest and one transect from the secondary forest were sampled each day. Sampling took place in two sessions, the first taking place from 0600 to 0800 hours and the second from 1830 hours to 2030 hours. These times were chosen because dusk and dawn are the times when most frogs are active and when most advertisement calling occurs (Zimmerman 1991). Which forest was sampled at which time was determined randomly, as was the specific transect to be sampled, and the end of transect from which sampling started. The locations of the samples carried out are given in Table 1. Sampling began at the one end of one of the transects, with the audio strip transects method being the first method employed during each sampling session. The path was walked to the other end, and all frogs heard producing advertisement calls within five meters of the trail had their calls recorded using a portable audio-cassette recorder and were briefly captured to be photographed using a digital camera (Nikon Coolpix) in order to be able to later identify the species. Frogs heard producing advertisement calls but that were

unable to be photographed (i.e. frogs that could not be located or that escaped from their calling site before being captured, or frogs calling from above three meters in the vegetation or in inaccessible bodies of water) had their vocalizations recorded although species identification was not always possible in these cases. Non-calling frogs were not actively procured visually in this stage of sampling, although any frog come across during this stage of sampling was captured in order to be photographed for possible species identification.

Table 1: A description of the areas sampled each day. Both primary and secondary forest were sampled each day, with the time of day of sampling being chosen randomly. In addition the transect sampled (1-5) and the end of the transect from which sampling was begun (near or far, see figure 2) were chosen at random. Samples were not taken in the morning of May 26, May 30, and the evening of June 3.

Date	Dawn sample	Dawn transect	Dawn transect end	Dusk sample	Dusk transect	Dusk transect end
26 May	none	none	none	secondary	5	far
27 May	primary	2	far	secondary	2	far
28 May	primary	2	far	secondary	1	far
29 May	secondary	1	near	primary	5	far
30 May	none	none	none	none	none	none
31 May	secondary	4	far	primary	2	far
1 June	primary	1	far	secondary	4	near
2 June	secondary	4	near	primary	4	far
3 June	primary	4	near	none	none	none

Once the transect had been walked in its entirety from one end to the other, if the two hour sampling period had not yet expired, the method of low-intensity visual encounter surveys was employed. The trail was again walked, with any frogs encountered being briefly captured to be photographed for species identification. Vegetation was searched and large logs and rocks were overturned within two meters of the forest trail during this stage of sampling. The trail was walked until the designated two hour sampling time had expired.

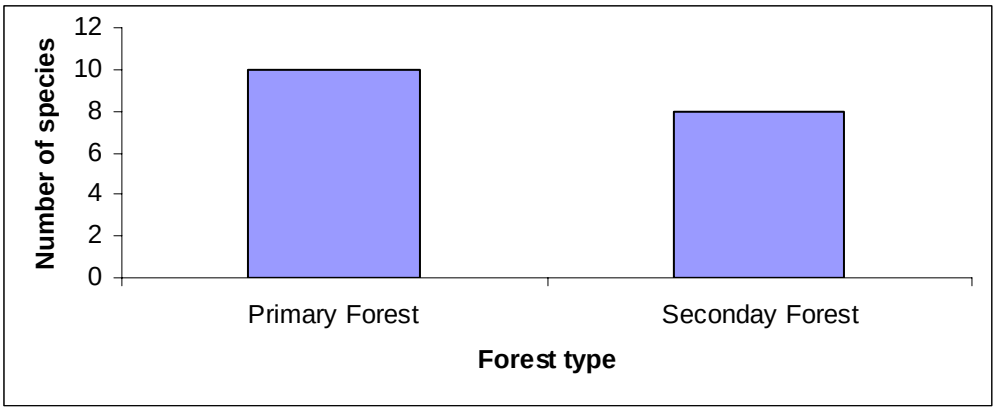
A total of fourteen sampling sessions took place from 26 May through 3 June 2004, a time of the year characterized in this region by a transition from the rainy to the dry season. This resulted in seven samples in each type of forest, and a total of 28 hours of

search time. The surveys resulted in a list of species found in each forest area as well as a total list of species found in either forest area in the São Francisco do Pará region. The differences in the number of species in each area were compared using a chi-square test. In addition, the similarity between the two areas was compared. Similarity is an index of the level of species common to two different areas. Similarity in this study was measured by the Jaccard Similarity Index (sensu Bernardi 1999) and is denoted by S_j, which is given by the formula: $S_j = a/(a + b + c)$ where a is the number of species common to both areas, b is the number of species unique to area 1, and c is the number of species unique to area 2. S_j values vary between zero and one with a large S_j value indicating a large number of shared species between the two areas.

Results

A total of 16 species in seven genera were found in 28 total hours of surveys (Table 2). Of these, ten were found in the area of primary forest and eight found in the secondary forest (Table 3, Figure 3). A chi-squared value of 0.5 (df=1) suggests that there is no significant difference between the numbers of anuran species in primary and secondary forest. Only two of sixteen species were found in both primary and secondary forest areas; the Jaccard Similarity Index was found to be 0.125, a very low value suggesting that few species are common to both primary and secondary forest sites. An illustration of the anuran species common to both areas and the anuran species unique to just one area is shown below in figure 4.

a.



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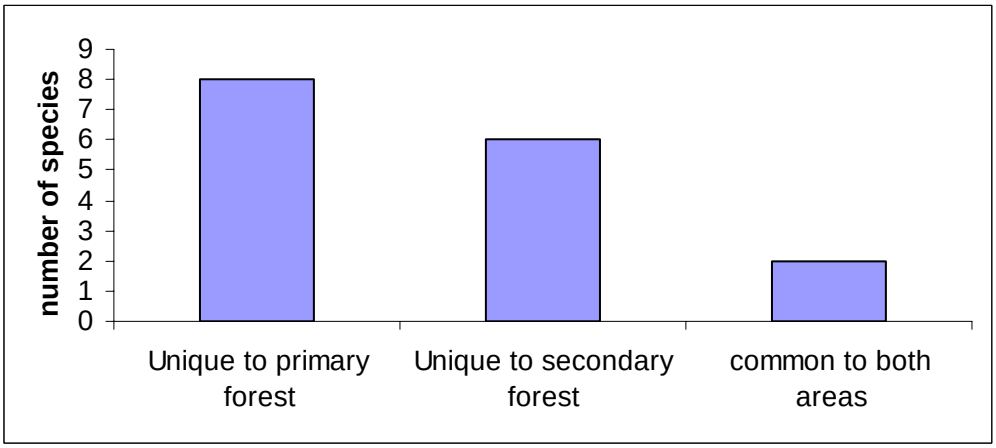

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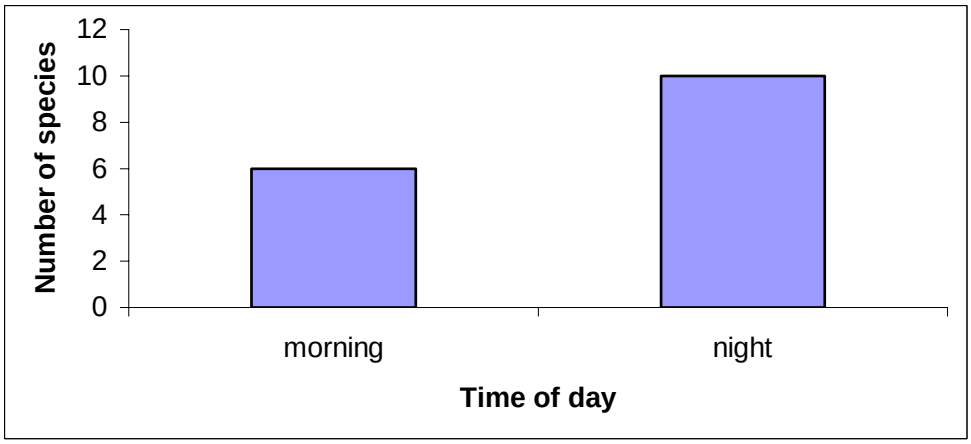


Figure 3: Graphical representations of the study results. (a) A comparison of the number of anuran species found in each forest type, (b), A comparison of the number of species unique to each forest type, as well as the species common to both types, (c), a comparison of the number of species encountered in morning and night sampling sessions.

Table 2: A list of anuran species encountered during the study period. The location(s) in which each species was found is noted as well as whether it was found during the day or night, and whether or not it was recorded calling. Not all anurans could be identified to the level of species, but all unidentified species were confirmed as being distinct from one another.

Species	Present in Primary Forest	Present in Secondary Forest	Time of day	Calling?
Adenomera andreae		X	morning	no
Adenomera sp.	X		morning	no
Bufo castaneoticus	X		morning	no
Bufo marinus		X	night	yes
Dendrobates galactonotus	X		morning	no
Hyla granosa	X		night	yes
Hyla minuta	X	X	night	yes
Leptodactylus Gr. podicipinus-wagneri	X		night	yes
Leptodactylus sp.		X	night	no
Physalaemos sp. 1		X	night	yes
Physalaemos sp. 2		X	morning	no
Physalaemos sp. 3	X		morning	no
Scinax ruber	X	X	night	yes
Unidentified 1		X	night	yes
Unidentified 2	X		night	yes
Unidentified 3	X		night	no

Table 3: Total numbers of species found in each forest as well as the number of species unique to each area, the number of species in common between the two areas, the numbers of species found at different times of day, and the number of species found calling.

Area	Number of Species
Primary Forest	10
Unique to primary forest	8
Secondary Forest	8
Unique to secondary forest	6
Total species found	16
Total species in common between two forest areas	2
Total found in morning	6
Total found at night	10
Total found calling	8

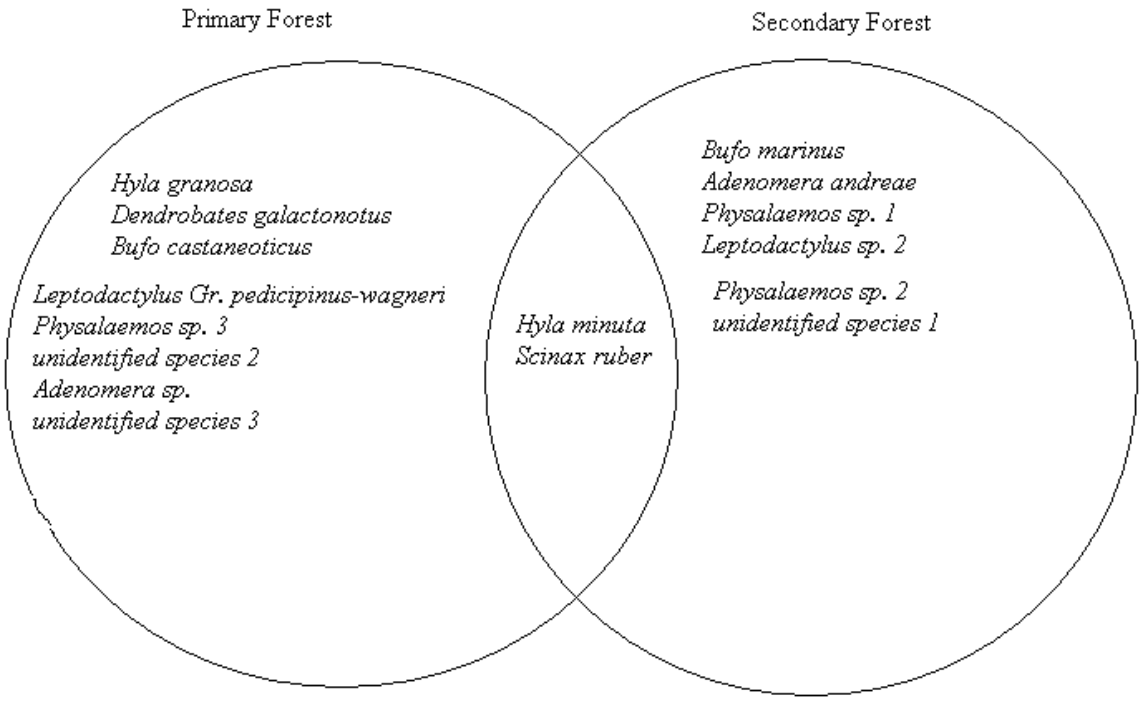


Figure 4: An illustration of the difference between the primary and secondary forest in terms of which species were found in which areas. The left circle represents the species unique to the primary forest area, the right circle represents species unique to the secondary forest area, and those anuran species contained in both circles were common to both forest types.

More species were found during the night surveys, a total of ten species, compared with six species found during the morning surveys. No species were found both in the morning and at night. A total of eight species were found while producing advertisement calls, with the same number of species being encountered only visually and were not producing any advertisement calls at the time of encounter. The majority of species, including all calling species, were found either in the water or within a few meters of the waters edge (personal observation).

Discussion

There was no significant difference found between the number of anuran species located in the primary forest and those located in the secondary forest. Although a complete inventory was not taken, these results conform with a number of studies that have shown that anurans are more resilient than previously expected to habitat modification and the differences in forest structure that are associated with primary and secondary tracts of forest (Tocher et. al 2001, Tocher et. al 1997).

There are several possibilities as to why there was no difference in the number of anuran species between sites in this particular study. The first of these is that, although the area of forest studied is a primary forest, it is not true disturbance-free, continuous forest. The forest area studied is a small fragment, and previous studies have indicated that some species are lost when once continuous primary forest is turned into a fragmented forest (Tocher et. al 1997, Tocher et. al 2001). This loss of species appears to be especially valid for small fragments, which is the case for the São Francisco do Pará area. Additionally, the fragment of primary forest is not completely protected from outside interferences, and the presence of such disturbances as hunting trails and occasional timber extraction does prevent the São Francisco do Pará forest fragment from being considered a truly pristine primary forest.

A second explanation as to why there was no significant difference in the number of frog species between primary and secondary forest is that both locations contained areas of suitable anuran breeding habitat. Anurans require aquatic habitats in order to reproduce, and small shallow ponds, puddles along the trail, as well as several streams were located along the transects in both the primary and the secondary forest. A majority of the species encountered in this study, especially those species found calling, were either found in the water or calling within a few meters of the waters' edge. It has been suggested that what limits the presence or absence of anuran species in an area is not the level of disturbance, but rather the presence of appropriate habitats for reproduction; thus, although secondary forest may drastically differ structurally from primary forest, anuran species will not be heavily affected provided there are appropriate areas for reproduction (Tocher et. al 2001). In many cases of the cutting down of primary forest and the creation of secondary forest, the aquatic habitats are in fact preserved, which suggests that anurans will not be heavily affected by the process of replacement of primary forest by secondary forest. Although anurans may not be heavily affected in the short run by habitat destruction, fragmentation or succession, it is cautioned that, subject to repeated levels of destruction, or heavily intense disturbances, anuran populations will be affected, and the number of species located in these areas will decline sharply (Tocher et. al 2001). Thus, more studies of the effects of disturbance, especially over the long term and in areas in which appropriate breeding habitat is either absent or lost due to the process of deforestation, are needed to gain a true

understanding of how anurans are affected by the processes of deforestation that are currently occurring in the Amazon.

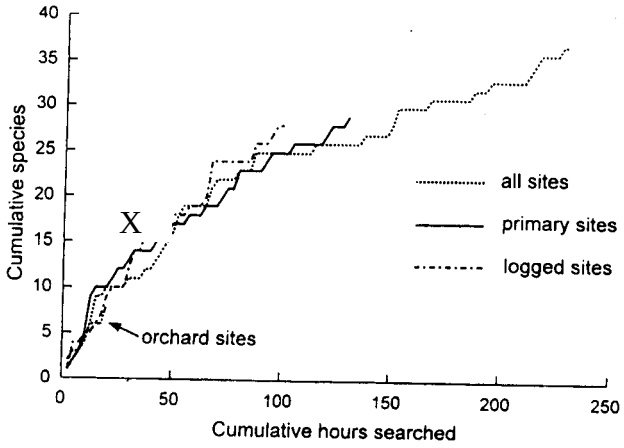
More anuran species were found during the night sampling sessions than during the morning. No anuran advertisement calls were ever recorded during the morning sampling sessions, and thus, all anuran species found during the morning samples were found visually, while most (eight out of ten) of the anuran species found at night were found while producing advertisement calls. The larger amount of anuran species found at night can partially be attributed to the anurans producing advertisement calls being much easier to locate, although an equal number of calling and non-calling frogs was recorded for this study.

An interesting result of this study was the very low levels of similarity between the two sites. A Jaccard Index of Similarity value of 0.125, on a scale that ranges from 0 (no species in common) to 1 (all species in common), is very low and suggests that there does exist a difference between the primary and secondary forest in terms of anuran species. This contrasts with the results suggested by the counts of the numbers of species, which showed no significant difference between the two sites. Although additional sampling may increase the level of similarity between the two sites, this result remains interesting. If primary and secondary forests differ strongly in the types of species that can inhabit these areas, it will be important to know which species are limited to a forest of a certain successional state, and what specific characteristics of the habitat are required for each species to be present or absent. This will require detailed study of habitat differences between different forest types, as well as an increase in the limited knowledge of the life histories of most Amazonian anurans. If additional studies confirm that there is a low level of similarity between primary and secondary forests in terms of anuran species composition, future conservation efforts will have to keep in mind the protection of appropriate anuran habitat.

The total number of species found during all samples was 16, a relatively low number compared to the amount of species many other studies have found in other areas of the Brazilian Amazon (i.e. Bernardi 1999, Duellman 1992, Tocher et. al 1997). However, the goal was not a complete species inventory, and such a complete inventory would be impossible given the short amount of time in which samples were taken, and also that

samples were taken during only one part of the year; different parts of the year have different climate conditions and different species of frogs would be expected to be active during these time periods. In addition, the number of species found per man-hour of searching is quite comparable to those of other studies of anuran species richness in the Amazon (see figure 5). This suggests that, using the methods that were used in this study, an accurate assessment of frog species richness would be reached with additional sample time, thus suggesting that the methods used in this study were valid.

a.



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b.

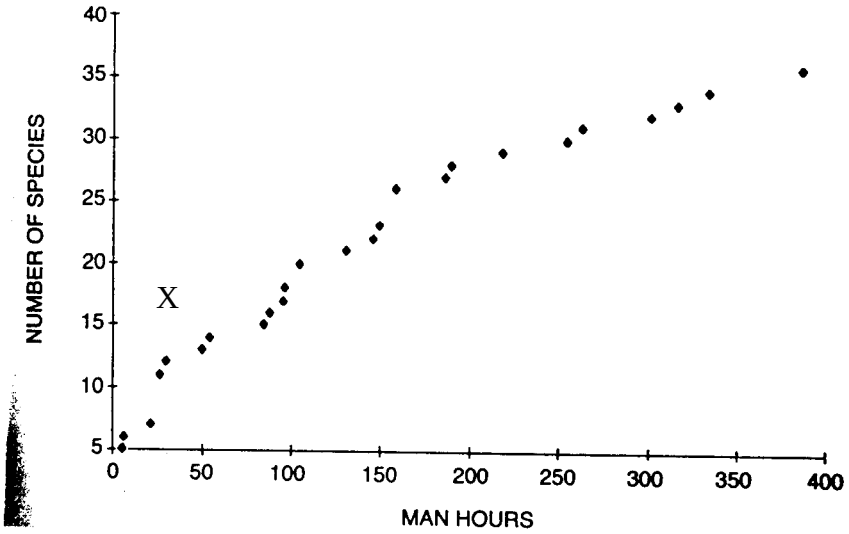

Figure 5: A comparison of the number of anuran species encountered per man-hour of searching in the current study with those of previous counts of anuran species in other areas of the Amazon. A total of 16 species were found in 28 hours in this study and is marked by an X on each graph. This is compared to (a) Jatun Sacha Biological Station in Amazonian Ecuador (figure reproduced from Pearman 1997) and (b) the INPA-WWF reserves near Manaus, Brazil (figure reproduced from Zimmerman and Rodrigues 1990).

It is recognized that the method of audio-strip transects used in this study as the primary way of finding and identifying frogs is biased towards the identification of those species whose mating season falls during the period of the study, and thus some species were much more or much less likely to be found than others. The method used is justified, however, given the circumstances of the study. First, anuran species identification in the field can be extremely difficult even for experts because no standardized key exists and many species are very poorly known (U. Galatti-personal communication). Secondly, the standard method used in cases in which species cannot be easily identified in the field, the collection of voucher specimens to be analyzed later in the laboratory (Reynolds et. al 1994), could not be carried out in this study due to time constraints and lack of legal permission to take such specimens. In cases where voucher specimens cannot be taken, audio recordings and photographs are considered to be the first alternative (Reynolds et. al 1994). In addition, the goal of this study was not a complete inventory of the anuran species of São Francisco do Pará, and given an equal sampling effort, a comparison of the numbers of species found in each area should be valid, and the presences or absences of certain species in the two areas remains important information for describing the effects of loss of primary forest on anurans.

This study compared an area of primary forest with an area of secondary forest to determine whether or not the level of forest succession and maturity had an effect on the anuran species present in that area. Although the total numbers of species did not differ significantly between the two sites, the level of similarity was extremely low, which suggests that there does exist a difference in which species prefer the primary and which prefer the secondary forest. Priorities for future research should include monitoring of anuran species presences, and comparisons between primary and secondary forest in more areas of the Amazon. Currently only a very small number of locations covering a very small area are well studied enough to describe the effects of habitat disturbance or loss on anuran amphibians in the Amazon. In addition, the focus of most of these studies has been on understory level frogs that are easily located by call or visual identification. These studies may overlook important species such as canopy-dwelling frogs that may be heavily

affected by the loss of primary forest habitat and the concurrent extreme changes in canopy structure and difficulty of dispersal.

Additional information could be also be gained by comparing the anuran species richnesses and similarity indices between primary forest and between secondary forests of different ages, sizes, species compositions and disturbance histories, and at different times of the year. Similar work is taking place in the INPA-WWF reserves (Tocher et. al 2001), although the focus of these studies are the fragments of primary forest that remain. If anurans are indeed effected by very heavy or repeated levels of disturbance, the threshold at which this occurs could be identified. Identification of the ecological parameters that allow certain species to survive in a disturbed forest habitat or that confine them to the primary forest would be extremely useful for reserve design and for the conservation of specific threatened species. Studies of dispersal and behavior could shed light on why some species are present in secondary habitat, as this habitat is most often populated by migrants, the original inhabitants being killed off when the land was burned as part of the slash-and-burn agriculture cycle (Tocher et. al 2001). This study represents a small example of the types of studies that are needed in order to understand how anurans will be affected by the increasing amounts of deforestation taking place in the Brazilian Amazon today. With additional research in these areas, the conservation of anurans will be greatly aided.

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Comments on my ISP

This ISP was a combination of the enjoyable and the frustrating. I'll take care of the latter first. First, you should try to pick a place to work as soon as possible. I spent too long thinking up plans in places I wouldn't ever be able to get to (PDBFF), and when I finally figured that out I lost a bit of time in trying to find an alternate place to do my work. Second, if the person you think you want to be your advisor isn't able to be contacted, find out as soon as possible why. Mine was out of town for a long time and I wasted a few days trying to track him down not knowing this. If he or she is not there, try to talk to one of their students, if they have any. They are very friendly and knowledgeable as well, and should be able to help you out quite a bit. Next, if you are going to São Francisco, do your absolute best to try to get there without using the mechanisms of the official bureaucracy. The actual time I had to carry out my samples was severely cut short because of this. Of course part could be blamed on me for not coming up with a valid idea quickly enough, but the bureaucracy was still extremely costly in terms of both time and money. There is absolutely no reason you should have to spend almost 500 reais (to hire a driver and pay a diario to the person helping you get there) and wait around an entire week to get to a place that is a 4 reais and about 3 hour bus ride from Belém. I did it because I had to and was running short on time. Now that there is a successful precedent for a SIT student staying there, this is completely unnecessary. Just get on the bus to São Francisco, get a cab to the village of Grande Marathon and ask for Osmar & Benedita or their neighbor. That's it.

But enough of this negativity, there are plenty of good things. First of all, Ulisses is a good advisor. Be sure to give him plenty of warning about what you'd like to do, and reassure him that you aren't planning on killing any frogs. He has lots of cool field sites that unfortunately they don't go to during the month of May but maybe you fall semester students could go out there. It's worth a shot. Also he speaks very good English, but really prefers Portuguese, so if at all possible keep the dialogue in that language. While you're there, even if you don't end up working with amphibians, have him or Alessandra show you the herpetology collection of the museum. You have never seen so many dead animals in jars, they have just about every species there, it's quite impressive. São Francisco was an excellent place to work. I felt lucky because I got to experience both the forest and the rural community life, I feel like a lot of ISPs give you only one or the other. That being said, S.F. is definitely on the rural "lite" side. I appreciated the indoor plumbing but wasn't especially excited about watching TV all day. But the production system is very rural and there would be plenty of interesting things to study on the social/agricultural side. The forest itself is what drew me there though, and it is spectacular. True, it is only a fragment and the fauna is not complete (you won't be seeing any jaguars), but when you go a few kilometers down the forest trail and run into a nice little igarapé, you forget all that and become immersed in the beauty of the tropics. Frogs are abundant there, and this would be a good place to continue studying frogs, my study was by no means definitive. The problem with the forest is this: it is located very far from the community where you will probably end up staying. If possible, try to get in a house that is closer to the forest. I didn't communicate that desire well enough and thus ended up living about 5 km away. This meant an extremely long bike ride to and from every day, and also getting up pretty damn early since frogs don't come out at noon. The bike rides were beautiful and really cool but also way too tiring for the physically unfit. So in conclusion, if you'd like a fairly accessible place to work in the actual Amazon forest, São Francisco is worth looking into.