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High altitude cloud forest: a suitable habitat for sloths?

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High altitude cloud forest: a suitable habitat for sloths?

A field research on the suitability of a high altitude cloud forest in Costa Rica as a habitat for sloths.

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Abstract

Protected areas play an important role in the conservation of biodiversity worldwide (Bruner, Gullison, Rice and da Fonseca 2000). Sloths (*Bradypus variegatus* and *Choloepus hoffmanni*) play a meaningful role in the ecosystems of the tropical forests of Costa Rica. This research focuses on Cloudbridge Nature Reserve (Cloudbridge NR), a protected area of 250 hectare tropical forest in South Central Costa Rica. The management of Cloudbridge NR wants to get back to the original state of the forest. Sloths used to live in and around Cloudbridge NR, but are not seen nowadays. That is why there is a wish to get sloths back in the area of Cloudbridge NR. This research is designed to investigate the possibilities for sloths to live again in Cloudbridge NR. The research question to investigate this is:

Can Cloudbridge NR sustain an independent and healthy population of sloths?

The methodology of this research consists of in depth interviews, literature reviews and a tree inventory using plots. Interviews and the literature study are used to identify the preferences of sloths and the possible threats to sloths. The interviews are also used to investigate the situation in the past, regarding to sloths in and around Cloudbridge NR. The tree inventory is used to get a picture of the actual situation of the suitability of the habitat of Cloudbridge NR for sloths.

There are almost certainly no sloths present in and around Cloudbridge NR at the moment. The disappearing of the sloths cannot directly be linked to the deforestation which occurred in the area of Cloudbridge NR up to forty years ago. This is because the reforestation of Cloudbridge NR was already started before the sloths completely disappeared ten years ago. Factors which limit sloths to reach Cloudbridge NR are the Talamanca Range, Pan-American Highway and urban areas like San Isidro de El General. Predators which are threats to sloths and which are present in Cloudbridge NR are pumas and coyotes. Based on the size of Cloudbridge NR and the estimated food intake it is expected that there is enough food available for sloths. But it is not sure if the specific trees used by sloths are adequately available to meet the food demand of the sloths. Based on the information known so far primary forest is the most suitable habitat for sloths, but also secondary forest and regrowth areas have a good potential for sloths.

Some of the results are insufficient to answer all of the research questions adequately. Because of the missing information this research became more an exploratory study. Further research is necessary to get more complete information about the tree species used by sloths on higher altitudes and about the introduction of sloths to a new area. Additional research on the vegetation in Cloudbridge NR is necessary to get a higher sampling intensity. For creating a more suitable area for sloths it is maybe good to stop the replanting of the areas with primary species and leave the area for natural regrowth or start planting secondary species, to get a good mix between primary and secondary species.

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Wouter Meijboom

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List of abbreviations

Biodiversity Law	Biodiversity Law 7788
CBD	Convention on Biological Diversity
Chirripo NP	Chirripo National Park
Cloudbridge NR	Cloudbridge Nature Reserve
DBH	diameter breast height
FAO	Food and Agriculture Organization
Forestry Act	Forestry Act 7575
IFP	Intergovernmental Panel on Forests
MCFP	Monteverde Cloud Forest Preserve
MDG	Millennium Development Goals
MINAE	Ministerio de Ambiente y Energía
NFPs	National forest programmes
REDD	Reducing Emissions from Deforestation and Forest Degradation
San Gerardo	San Gerardo de Rivas
SFM	Sustainable forest management
SINAC	Sistema Nacional de Areas de Conservacion
TFAP	Tropical Forest Action Plan
UNDP	United Nations Development Programme
Wildlife Law	Wildlife Conservation Law 7317

1. Introduction

Costa Rica is considered one of the countries with the highest biodiversity of the world. Its geographic position, its two coasts and its mountainous system - which provides numerous and varied (micro) climates - are some of the contributing factors for this rich biodiversity. The more than 500,000 species that are found in this country represent nearly four per cent of the total species estimated worldwide. This is a lot compared with the size of the country 51.100 km^2 (0,03 per cent of the world's surface) (INBio, 2013).

Protected areas play an important role in the conservation of biodiversity worldwide (Bruner, Gullison, Rice and da Fonseca, 2000; Zedan, 2005). Globally, the number of protected areas has been increasing significantly over the last few decades, covering about 21 per cent of the world's land surface in 2010 (The World Bank, 2012). In Costa Rica also about 21 per cent of the land is protected (The World Bank, 2012; Obando, 2000). The land in Costa Rica is protected by Sistema Nacional de Areas de Conservacion (SINAC). The protected areas in Costa Rica do not only increase the biological diversity, but they also reduce the poverty in Costa Rica and it forms the backbone of their ecotourism (Andam, et al., 2010; Buchsbaum, 2004). Sloths are only found in South and Central America. There are two sloth species living in Cost Rica, namely *Bradypus variegatus* (three-toed sloth) and *Choloepus hoffmanni* (two-toed sloth).

1.1 Cloudbridge NR

This research focuses on the protected area Cloudbridge Nature Reserve (Cloudbridge NR) in South Central Costa Rica (Map 1). The size of Cloudbridge NR is approximately 250 hectares. As appendix 1 a map of the area is included. Cloudbridge NR is located on an altitude between 1600 and 2800 meters. The area is partly reforested and partly regrown naturally to restore the natural vegetation; the oak-dominated lower montane cloud forest. Before the start of Cloudbridge NR in 2002 the area was mainly used as pasture land (Cloudbridge Nature Reserve, 2013). Most animals which lived 40-50 years ago in Cloudbridge NR are back due to the reforestation. It is told that in former days sloths occurred in Cloudbridge NR, but since the start of Cloudbridge NR until today they have not been seen (Gode, personal communication, 2013). The management of Cloudbridge NR recognizes the preciousness of the tropical forest of Costa Rica and wants to protect and preserve Cloudbridge NR and the biodiversity in it (Cloudbridge Nature Reserve, 2013). The management want to get close to the original state of the cloud forest. Therefore there is a wish to get sloths back in the area of Cloudbridge NR.

Map 1. Location Cloudbridge NR (Cloudbridge NR, 2013)

1.2 Problem description

Next to the fact that the management of Cloudbridge NR wants sloths back in the area, getting sloths back to Cloudbridge NR has also an aesthetical function as a ecotourism 'attraction' for people visiting Cloudbridge NR. But the most important reason to get sloths back in an area like Cloudbridge NR is that sloths play a role in the ecosystem of a tropical forest. Sloths play a role as leaf eater, prey and even their fur is a habitat for other animals (see also subparagraph 4.1.2). Alongside it is also an ethical duty to take good care of a nature area and to welcome animals who can live there. Therefore it is important to get sloths back to Cloudbridge NR and create a habitat which can sustain an independent and healthy population of sloths. In that way the sloths can fulfil their role in the ecosystem and help to restore the rich biodiversity of the area.

1.3 Research questions

This research is designed to investigate the possibilities for sloths to live again in Cloudbridge NR. Therefore research is done to determine the preferences of the sloths, determine the reasons that there are no sloths in Cloudbridge NR, determine the suitability of Cloudbridge NR as a habitat for the sloths and determine the possibilities of introducing the sloths in Cloudbridge NR. The research questions are as listed below.

Research question

Can Cloudbridge NR sustain an independent and healthy population of sloths?

Sub questions

- What are the preferences of sloths regarding their diet and their habitat in a natural area?
- What are the threats to sloths in a natural area?
- What are the limitations for sloths to live in Cloudbridge NR?
- Is the habitat of Cloudbridge NR suitable for sloths?
- Can sloths be introduced in Cloudbridge NR?

1.4 Reading guide

The following chapters give a report of the research undertaken to answer the research questions. The next chapter gives an insight into the current situation, regarding the socio-economic situation, the environmental situation and the policy and law. Chapter 3 describes the methodology used to answer the research questions. In chapter 4 results of the research are presented, after which a conclusion of the research is given in chapter 5. The methodology, results and recommendations for management are discussed in chapter 6.

2. Situation analysis

Cloudbridge NR is a private protected area. It is located on the hillside of the Cordillera Talamanca range, Costa Rica's highest mountain chain, and it borders the Chirripo National Park (Chirripo NP). The area is divided in Cloudbridge North and Cloudbridge South and they both cover about fifty per cent of the area (see appendix 1). This chapter gives a short analysis of the current situation in and around Cloudbridge NR. This analysis is divided in the socio-economic situation, the environmental situation and the policy and law.

2.1 Socio-economic situation

The average annual income per capita is about 6.500 euro in Costa Rica (The World Bank, 2012). Poverty affects 21.3% of households in the country, of whom 6.0% are in extreme poverty. Rural areas, such as the areas around Cloudbridge NR, have higher unemployment, lower incomes and more poverty than the urban areas (Oliver, 2010). Cloudbridge NR is located in the province of San Jose, the canton of Peréz Zeledón and the district Rivas. The district Rivas has an area of about 310 km^2 and a population of about 8.700 inhabitants. The capital of the district is Rivas (Costaricadatabase.com, 2013). San Gerardo de Rivas (San Gerardo) is the closest town to Cloudbridge NR and is located two km southeast from the entrance of the reserve. An unpaved road leads to San Gerardo which continues all the way down to the town Rivas where it becomes a paved road. A map of the area indicating the most important towns close to Cloudbridge NR is included as appendix 2.

The region around Cloudbridge NR is traditionally an agricultural economy. Nowadays tourism is getting more important. Farmers live mostly from the coffee, the sugar, the vegetables, the fruit and the dairy products. The mountain Chirripo attracts many hikers and nature lovers to the area of Cloudbridge NR and San Gerardo. In this way the community generates income also from guides, hotels, restaurants, bars and tourist activities (San Gerardo, 2009). In the Chirripo valley there live a number of indigenous people. They are the Cabécar Indians, who live in reserves in remote areas. The members of these communities visit San Gerardo for work, to buy supplies, and to participate in social activities (Cabécar, n.d.). The most dominant religion in the area is, like in in the rest of Cost Rica, Catholicism.

2.2 Environmental situation

In this chapter the following aspects are described regarding the situation in and around Cloudbridge NR: weather and climate, soil, water and geology and the vegetation classes.

2.2.1 Weather and climate

In Costa Rica there is a tropical and subtropical climate. The subtropical climate is found in the higher mountains, like Chirripo. There is a dry season from December to April and a rainy season from May to November (Climatezone.com, 2004). In Cloudbridge NR there is a dryer period and a wetter period, but it rains all year round. The average annual rainfall is about 4370 mm. The average minimum temperature is 13,4 degrees Celsius and the average maximum temperature is 23,1 degrees Celsius (Giddy, 2006).

2.2.2 Soil and water

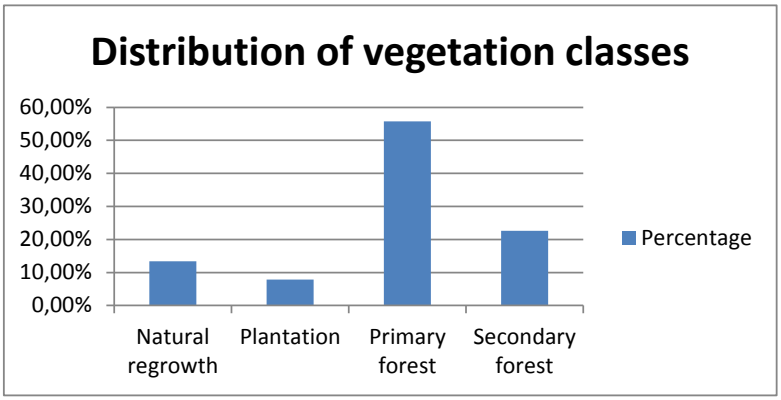
The two soil types found in Cloudbridge are Dystrudepts (Humic-Dystrudepts, and Sombric-Humic Dystrudepts) and Kandihumults (Schembre, 2009). Dystrudepts are fertile inceptisols. Kandihumults

are ultisols which means that they are leached and non-fertile (Pedosphere.com, 2002). Soil texture of A and B-horizons are primarily Silty Loam, Loam, Sandy Loam, and Sandy Clay Loam. Soil texture of C-horizons is primarily Silty Loam, Sandy Loam, Loamy Sand and Sand with common rock fragments. Slopes range between ten per cent and 65 per cent. The landscape is commonly subject to landslides, both natural and human induced (Schembre, 2009). Two main rivers run through Cloudbridge: the Rio Chirripo Pacifico and the Rio Urán (see appendix 1). Next to those rivers lots of smaller streams which are flowing through Cloudbridge NR into the two bigger rivers. One of these streams is used for the (drinking) water supply for the volunteers and researchers living in Cloudbridge NR.

2.2.3 Vegetation classes

There are four different classes of vegetation found in Cloudbridge NR (see appendix 3). The distribution of the different vegetation classes is shown in Graph 1. The different vegetation classes are:

- Plantation forest;
- Natural regrowth;
- Secondary forest; and
- Primary forest.



Graph 1. Distribution of the vegetation classes

About eight per cent of Cloudbridge NR is plantation forest. The planting started in 2002 and continues until today. Many different tree species are planted, like *Quercus* spp., *Ulmus mexicana* and *Persea caerulea* (Cloudbridge, 2004). Some areas had to be replanted - some several times -, because the initial plants did not survive. These are mainly the steeper parts of the plantation forest.

About 14 per cent of Cloudbridge NR is natural regrowth. This land is purchased between 1998 and 2002 and left for natural regeneration. The term natural regrowth is in this research only used for forest which was barren or/and pasture land when Cloudbridge NR bought the land.

About 23 per cent of Cloudbridge NR is secondary forest. Forest is called secondary forest when the original vegetation was removed and/or disturbed and is regenerated with different canopy species as opposed to the original forest (Chokkalingam and de Jong 2001). The term secondary forest is in this research only used for land which was already forest when Cloudbridge NR bought the land.

About 56 per cent of Cloudbridge NR is primary forest. The term primary forest is in this research only used for the climax stage of the forest with related climax species in the canopy and which is relatively stable (Chokkalingam and de Jong 2001).

2.3 Policy and law

Costa Rica has signed several international agreements for the protection of the environment including the Reducing Emissions from Deforestation and Forest Degradation (REDD), Millennium Development Goals (MDG), Kyoto protocol, Convention on Biological Diversity (CBD) and the national forest programmes (NFPs). This paragraph describes the NFPs, the national policy SINAC and the

relevant national laws. Relevant national laws are the Forestry Act 7575 (Forestry Act), the Wildlife Conservation Law 7317 (Wildlife Law) and the Biodiversity Law 7788 (Biodiversity Law). It is unknown how the (inter)national policies operate exactly in regional and local policy making. This paragraph ends with a description of the local management targets.

2.3.1 National forest programmes

The national forest programmes (NFPs) are an outcome of the Intergovernmental Panel on Forests (IFP) which was into practice from 1995-1997. Costa Rica is participating in the programmes designed by the Food and Agricultural Organization (FAO). NFPs are a framework for developing and implementing comprehensive forest policies in pursuit of sustainable forest management (SFM) at the country level. The framework is built on specific principles that can be clustered in three groups: national sovereignty and country leadership; consistency within and integration beyond the forest sector; and participation and partnership (FAO, 2013). The difference with the previous Tropical Forest Action Plan (TFAP) was the fact that the NFP is more country-driven instead of donor-driven (Contreras, 1988).

2.3.2 SINAC

As the name says Cloudbridge NR is a Nature Reserve. Nature Reserves differ from National Parks in the fact that community and conservationist groups manage their land. Visitor revenues are used to maintain the trail system, pay park staff, and purchase surrounding land for protected zone expansion. The protected areas or Nature Reserves and National Parks are regulated by SINAC. SINAC is a department of Costa Rica's Ministerio de Ambiente y Energía (MINAE), the Costa Rican ministry of environment and energy (MINAE, 2013). The definition they use for a conservation area is (translated from Spanish):

"A defined geographical space and an officially designated management category on the bases of their natural significance, cultural and/or socioeconomic status, to meet with specific conservation objectives and management targets (SINAC, 2013)."

2.3.3 Costa Rican Forestry Act 7575

The Forestry Act came into force in 1996. The Forestry Act includes the regulation of forest certification and type of forests, the authorization for the cut down of trees, the promotion of forest plantations and the control of forestry activities, offences and penalties. The Forestry Acts practically prohibits the cut down of trees on privately owned protected areas (Burnet, 2008).

2.3.4 Wildlife Conservation Law 7317

The Wildlife Law is designed for the conservation of wildlife. The Wildlife Law forbids the removal and disruption of any plant life and the attempt to engage, feed or remove any animal from their habitat (Anywhere Costa Rica, 2012). Nowadays the Wildlife Law forbids also the hunting on sloths (Agence France-Presse, 2012).

2.3.5 Biodiversity law 7788

The Biodiversity Law is put into force in 1998. The Biodiversity Law is the national implementation of the CBD. The Biodiversity Law creates a legal framework in line with the principles and themes outlined in the CBD. Its goals are promoting the conservation and sustainable use of biodiversity and ensuring the fair and equitable sharing of benefits derived therefrom (Cabrera, et al., 2011).

2.3.6 Management targets

Cloudbridge NR wants to reforest the pasture lands and preserve and protect the biodiversity of the tropical forest. They therefor give opportunities for volunteers and scientific researchers to contribute to the well-being of the planet by helping the reforestation of the area of Cloudbridge NR, conduct research studies and educate the public. Nowadays there are just a few areas where reforestation is done. These are the areas where the natural regeneration is very slow or the initial planting did not survive. The work in Cloudbridge NR is funded by revenues of volunteers and scientific researchers staying in Cloudbridge NR, gifts from visitors and a carbon offsetting program.

3. Methods and project approach

This chapter describes the research methodology used to answer the research questions. It also indicates which approach and activities have been carried out to get to the answers on these questions. The project approach consists mainly of in depth interviews (further named interviews), literature reviews and fieldwork in the form of the establishment of plots for doing a tree inventory.

Interviews are used, because it provides knowledge about sloths and sloth behaviour and it places other derived knowledge, from literature and fieldwork, in a context. Next to that it provides the opportunity to obtain detailed information which is not available through other sources (Boyce and Neale 2013). A literature review is firstly done to create a base for this research, secondly to derive general and specific knowledge about sloths and thirdly to make sure that no work is done twice (University of Western Sydney 2013; Unitec, 2013). With a literature review secondary sources are used, to save time. Fieldwork is carried out to collect specific data from the area of Cloudbridge NR. By using different research methods triangulation of the data is possible to check the different results.

3.1 Preferences and impacts of sloths.

First of all it is important to determine what the preferences and impacts of sloths are in a natural area. Therefore it is examined what the desired diet and habitat is of sloths and what the impact is of sloths on nature areas.

To get a clear picture of the preferences of sloths information is required from areas comparable with Cloudbridge NR. A comparable area is for example Monteverde Cloud Forest Preserve (MCFP). Interviews are done with the biologist of MCFP to get to know the preferences of sloths. Questions are asked about the presence of sloths in their area, the preferences of sloths in a cloud forest, the threats to sloths and the impact of sloths on a cloud forest. Next to the interviews literature is reviewed to determine the preferences of sloths. From literature of other areas in and around Costa Rica where sloths are found data about the tree species and habitats where the sloths live in is derived. Attention is paid to the specific habitat, tree species and the shape and size of the trees. This data is later compared with data about tree species in Cloudbridge NR.

The impact of sloths on an area is determined based on their food intake and home range. Other aspects that are taken into account are the place of sloths in the ecosystem and the effect this can have on the ecosystem of Cloudbridge NR, for example the predation of animals on sloths. The food intake and home range of sloths is based on researches on sloths. The place of sloths in the ecosystem is based on the interviews mentioned before supported with literature.

3.2 Threats to sloths

To determine the threats to sloths a literature review and information from the interview with the biologist of MCFP is used. Regarding the threats attention is paid to predators, human based threats and other threats.

3.3 Limitations for sloths to live in Cloudbridge NR

Sloths occurred in Cloudbridge NR until about ten years ago. To determine why sloths are not present in Cloudbridge NR anymore, the situation regarding sloths in and around Cloudbridge NR 40 to 50 years ago and what happened since that time is examined. The period since 50 years ago is

interesting because it is long enough to distinguish different events like deforestation and the effects of these events and there are still people who clearly remember this period. After that it is investigated which threats to sloths occur in Cloudbridge NR and which limitations there are for sloths to reach Cloudbridge NR. Five farmers between 60 and 80 years old are interviewed to get a picture of the situation 40 to 50 years ago. Questions are asked about the occurrence and preferences of sloths in that time. The interview is included as appendix 4.They say that there are living about ten farmers older than 60 years around Cloudbridge NR. The farmers are selected who have lived all of their live in and around the area of Cloudbridge NR and live the closest to Cloudbridge NR. This information is used to determine why the sloths are not present in Cloudbridge NR and if the factors caused this are still present in and around Cloudbridge NR.

The factors that threaten sloths in other areas are compared with the actual situation in Cloudbridge NR. It is examined what predators and other threats are present in Cloudbridge NR and estimated what the impact the threats could have on sloths in Cloudbridge NR.

It's unsure if sloths are still present in the neighbourhood (+- ten km) of de Cloudbridge NR. To get to know the location of these sloths leaflets are put up in two shops and seven hotels near Cloudbridge NR. In appendix 2 a map of the area is included indicating most of the town where the leaflets are put up.

On these leaflets people are asked to get in contact with Cloudbridge NR when they spot a sloth. If sloths would be found the location of the sloth is visited and the information about their location like vegetation type and tree species would be recorded. When the locations of the sloths are know they would be plotted on a map. This map is examined to see if there are any barriers or other factors that limit sloths to come to Cloudbridge NR (for example roads, towns and fragmentation of forest).

3.4 Suitability of the habitat of Cloudbridge NR for sloths

The suitability of the habitat of Cloudbridge NR for sloths is examined by determining the different vegetation classes and there location, the tree species composition in the different vegetation classes and the comparison available space and food supply with the needed home range and food intake.

The different vegetation classes in Cloudbridge NR are needed to be known to determine if sloths can live in Cloudbridge NR. The vegetation classes researched are:

- Plantation forest;
- Natural regrowth;
- Secondary forest; and
- Primary forest.

In 2006 a research has been done on the different vegetation classes (Culbreth, 2006). The resulting vegetation map of this research is included as appendix 3. This map and the division in vegetation classes of 2006 have been discussed with the director of Cloudbridge NR, Tom Gode. Based on the changes occurred since 2006 the map has been adjusted where needed.

The results of the preferred habitat and preferred tree species of sloths are compared with data about tree species which are present in Cloudbridge NR. A result of this is a list of tree species which are suitable for sloths and are present in Cloudbridge NR. This information is used later to estimate the suitability of Cloudbridge NR for sloths.

The tree species above a diameter breast height (DBH) of ten cm of the plantation forest and the natural regrowth forest has been inventoried in 2011 (Spek). In the research done in 2011 in the plantation forest and the natural regrowth eight research sites were selected. Four of the selected sites were in the plantation forest and four were in the natural regrowth. In these selected sites plots with a length of hundred meter and eight meter wide, 800m^2, were selected. A map with the location of these plots is included as appendix 5. The total amount of area inventoried in 2011 is 6400m^2. This was done to investigate the success of the regrowth and to compare the plantation forest with the natural regrowth (Spek, 2011).

The primary forest is inventoried using data derived from the 'Smithsonian Hectare' in Cloudbridge South and two plots in Cloudbridge North. The Smithsonian hectare has been inventoried in 2007. The Smithsonian hectare is a one hectare plot in primary forest (see appendix 6). This plot is divided in 25 subplots of twenty by twenty meter. In these subplots all trees above a DBH of ten cm are labelled and the height and the DBH are measured. From three subplots nearly all the names and DBH of the tree species are known. These three subplots have a total area of 1200m^2. The two plots in Cloudbridge North are inventoried using the methodology described in the next paragraphs. The data from the Smithsonian hectare combined with the data from the two plots in Cloudbridge North gives an indication of the different trees present and their growth development.

The secondary forest is researched using four plots, two in Cloudbridge North and two in Cloudbridge South. The plots are surveyed similar to the plots from the research in 2011. Trees with a DBH of 15 cm or more are considered to be interesting for sloths (Montgomery and Sunquist, 1978). Because this research is also focused on the future also the trees with a DBH of ten till 15 are included. The plots have a length of a hundred meter and a width of eight meter. An outline of the plots is shown in Figure 1. The begin point of the plot is shown as A and the end point of the plot as B. The total size of the four plots in the secondary forest is 3200 m^2. The plots are plotted using ArcGIS. A map with the location of the plots is included as appendix 7. The location of the plots is based on the revised vegetation map. The begin point of the plots is plotted, about ten meter from a trail to minimise disturbance and following contour lines to ensure accessibility

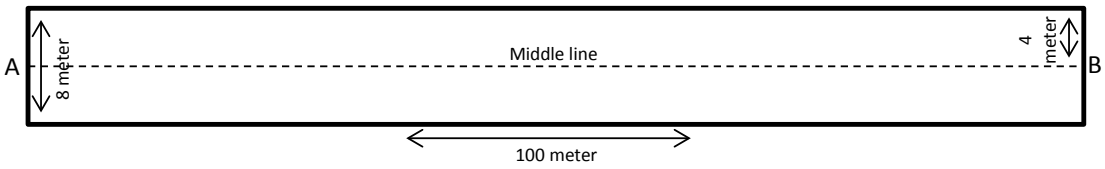


Figure 1. Outline of the plots.

The plots are created using a machete to mark the middle line. From all the trees above a DBH of ten cm the species name is determined; the DBH is measured using a measuring tape. Height, crown development (1-4**,** meaning small till big in comparison with the DBH) and liana development in the crown (1-4, meaning not/hardly developed till very well developed in comparison to the crown) are estimated. The tree species are determined with the help of an arborist. This data is filled in a field form (see appendix 8) and later entered into an excel sheet. In the excel sheet the calculations are done about the average height, DBH and crown- and liana development and about the total number of stems and basal area per hectare.

The total area inventoried in this research is 4800 m^2. The total area inventoried in earlier years and used for this research is 7600 m^2. An overview of the amount of plots and total size of the plots is shown in table 1. The total area covered in this research is 12.400 m^2 (1,24 hectare). This gives a sampling intensity of 0,5 per cent on a forest area of 250 hectare. This is too low to give absolute values about the area, but it gives an indication of the species composition and the suitability of the area for sloths in terms of crown development and liana development. There was not enough time to do a research that fully covered the area and there was no arborist available for such a long time to help determining the trees.

	Smithsonian hectare		2011		This research	
Vegetation type	**Amount of plots**	**Total size (m^2)**	**Amount of plots**	**Total size (m^2)**	**Amount of plots**	**Total size (m^2)**
Primary	3	1200	-	-	2	1600
Secondary	-	-	-	-	4	3200
Natural regrowth	-	-	4	3200	-	-
Plantation	-	-	4	3200	-	-
Total	3	1200	8	6400	6	4800

Table 1. Overview amount of plots and total size inventoried.

3.5 Introducing sloths in Cloudbridge NR

When Cloudbridge NR is a suitable area for sloths, but sloths come not to Cloudbridge NR by themselves it may be necessary to introduce sloths. With a literature review it is determined if that is possible for the different sloth species and what the challenges are. The expectation is that this question cannot be fully answered in this research, but it gives an insight into the possibilities and an onset for further research.

4. Results

This chapter describes the results of the research. The results are presented following the research questions.

4.1 Results of the preferences and impact of sloths

The results of research regarding the preferences and impact of sloths are described in this paragraph.

4.1.1 Preferred habitat and diet of sloths

Sloths are found in different areas from sea level to higher elevations (INBio, 2011). Neither of the two sloth species living in Costa Rica prefers cool temperature latitudes. Nevertheless they are both found in small numbers on altitudes above 2400 meter in Costa Rica. The coat of *Choloepus hoffmanni* is thicker at higher altitudes and has a dense woolly undercoat. Therefore *Choloepus hoffmanni* can stand colder temperatures than *Bradypus variegatus* (Gilmore, Da Costa and Duarte, 2000). At higher elevations they are present in lower montane forest as well as cloud forest. At these elevations they are found in small size forest fragments and also in continuous forest (Chinchilla-Romero, personal communication, 2013).

Sloths feed almost entirely on (young) leaves (Montgomery and Sunquist, 1978). In addition they also eat flower buds, fruits, insects, lizards and carrion (Chinchilla-Romero, personal communication, 2013; World Animal Foundation, n.d.). The tree species most frequently mentioned as food source for the sloths is the *Cecropia* spp. (5 farmers; F. A. Chinchilla-Romero, personal communication, 2013). But is has to be taken into account that the sloths are easy to spot in *Cecropia* spp. Next to that they use many different other trees. According to a research on sloths on Barro Colorado Island *Bradypus variegatus* are using at least ninety-seven different tree species (Montgomery and Sunquist, 1978). An overview of different tree species used by sloths is included as appendix 9. This overview is based on different researches on sloths, which are also mentioned in the appendix.

The information presented in this subparagraph is based on the research on Barro Colorado Island (Montgomery and Sunquist, 1978). *Bradypus variegatus* prefers trees from which the crown is more exposed to sunlight, while *Choloepus hoffmanni* prefers trees with masses of lianas in their crowns. The size of the crown is not of a significant influence on the choice of trees for *Choloepus hoffmanni*. A large crown tends to be more important for *Bradypus variegatus*. Sloths of both species tended to avoid using trees which lack lianas in their crowns, *Choloepus hoffmanni* selects trees with the most lianas, and *Bradypus variegatus* sloths tend to use trees with only moderate lianas. The tendency of *Bradypus variegatus* to use trees with crowns exposed to sunlight and which also contained masses of lianas, is related in part to vertical movements which the animals made into and out of direct sunlight as their body temperatures changed. *Choloepus hoffmanni* may choose trees with masses of lianas primarily to gain protection from predation. During the day they often sleep deep within mass of lianas. Small interlaced branches of the lianas are transmitting the motion caused by the presence of a predator which alarms the sloth. This gives the sloth the opportunity to flee or to attack. *Bradypus variegatus* on the other hand only attack when the predator, such as pumas, touches the sloth (Montgomery and Sunquist, 1978).

4.1.2 Impact of sloths on an area

The impact of sloths on a natural area is first determined by their place in the ecosystem. As mentioned before sloths eat leaves and flower buds, so they have a role as herbivores. In turn they are prey to the predators mentioned in the previous subparagraph. Other less obvious roles are their symbiotic relations with algae's in their fur. This turns the fur of the sloths into a micro habitat for some species of insects (mites, moths, beetles) as well as parasites (acari) (Gilmore, Da Costa and Duarte, 2000). The expectation is that there are also some phoretic relations with pseudoscorpions in the fur of the sloths (Chinchilla-Romero, personal communication, 2013).

According to McNab's (1978) and Montgomery and Sunquist (1975) the estimated food intake of sloths range between 5,1 g and 15 g of dry food per day. This is about half of what might be expected of a mammal of this size (4-7 kg) (Montgomery and Sunquist, 1975). It is a big range, but it is suggested that this is about two per cent of the expected yearly leaf production of a wet tropical forest. This figure is supported by a study in Panama, where the cropping of the sloths is also about two per cent of the annual leaf production (Montgomery and Sunquist, 1978).

Densities of *Bradypus variegatus* in nature areas may be about seven sloths per hectare but are usually about two to three per hectare. *Choloepus hoffmanni* occur at a lower density then *Bradypus variegatus*, about one animal per two to three hectares (Henderson, 2002). Each animal occupies a home range of less than two hectare and may use fifty trees of up to thirty species. Sloths descend from the canopy about once a week to defecate (Janzen, et al., 1983). Both species are also found in the same areas, like in Corcovado National Park and Santa Rosa National Park (Strieter, 2013a; 2013b).

4.2 Results of the major threats to sloths

The main threats to sloths are the threats caused by predators and the threats due to human activity. The main predators of sloths are pumas, ocelots, coyotes, tayras and harpy eagles (World Animal Foundation, n.d.; Moreno, 2006; Hayssen, 2011; Chinchilla-Romero, personal communication, 2013). Their arboreal life, their limited moving and weak dispersal abilities make sloths more vulnerable to deforestation and fragmentation of their habitat (Peery, n.d.). Other main threats to sloths are electrical lines (electrocution) and hunting (World Animal Foundation, n.d.; Chinchilla-Romero, personal communication, 2013).

4.3 Results of the limitations for sloths to live in Cloudbridge NR

This paragraph shows the results of the research done to the limitations for sloths to live in Cloudbridge NR.

4.3.1 Situation 40-50 years ago

The elaboration of the interviews of five farmers can be found as appendix 10. Table 2 gives an overview of what happened regarding the sloths in the area of Cloudbridge in the past 50 years. This is based on the interviews and other sources.

Time	Event	Source
1930-1950	Cut down of forest by farmers.	(Gode, personal communication, 2013).
40 to 50 years ago	You could hear and see them a lot in and around the area of Cloudbridge.	Two farmers
1975	Establishment Chirripo NP	(SINAC, n.d.)
30 years ago	It was possible to see sloths every day in the area of Cloudbridge NR.	One farmer
Before the reforestation started.	There were a lot of sloths. Even more than twenty individuals. The sloths where especially seen close to the river. Mostly more down than in the area of Cloudbridge NR. Also in the area of the Talamanca Reserve.	Three farmers
2002	Establishment of Cloudbridge Nature Reserve.	(Cloudbridge Nature Reserve 2013)
Ten years ago	Last ones seen close to the river and the Chirripo trail. Sloths disappeared.	Three farmers
6 or 7 years ago	Two sloths seen close to the road from San Gerardo to Cloudbridge.	One farmer
10 April 2013	One two-toed sloth seen close to Rivas 13 km from Cloudbridge.	(Store owner, personal communication, 2013)

Table 2. Time schedule regarding to the presence of sloths in and around Cloudbridge NR.

Two farmers do not think the sloths disappeared due to deforestation, but one other farmer thinks that it was because of the destruction of the habitat. All famers say that the sloths preferred secondary or open forest. Three farmers say that the sloths did not disappear due to hunting for food, because sloths are not nice to eat. One other farmer suggests that there is maybe some hunting done on sloths for fun. Another reason mentioned by one farmer is the increase in population in the area. According to four farmers the biggest threats to sloths are pumas (leonsillo de Breñon) and coyotes.

4.3.2 Threats to sloths in Cloudbridge

The general threats to sloths are mentioned in paragraph 4.2. Traffic as a threat to sloths is described in subparagraph 4.3.4. This subparagraph describes the threats which occur in Cloudbridge NR. Of the predators of sloths the pumas, ocelots, coyotes and tayras are present in Cloudbridge NR. As mentioned in the paragraph before the impact of pumas and coyotes could be big in Cloudbridge NR. Electrical lines are not present in Cloudbridge NR and there are no cases of hunting on any animals known in Cloudbridge NR. Deforestation or fragmentation does not occur anymore in and around Cloudbridge NR. The connection of Cloudbridge NR with Chirripo NP and the Talamanca Reserve makes it a great combined forest area suitable for sloths. The size of the combined forest area is visible on the aerial picture included as appendix 11.

4.3.3 Sloths in the neighbourhood of Cloudbridge

There was no response regarding sloths on the leaflets which were put up in the villages. Only one store owner could tell that he spotted a two-toed sloth near the town Rivas on April 10th, 2013. He showed a picture of the sloth to confirm this. This cannot be seen as evidence for sighting. People living in the area and tourists confirmed that they had seen the leaflets but they did not see any sloths.

4.3.4 Factors limiting sloths to reach Cloudbridge

On a higher scale there are several barriers limiting sloths to reach Cloudbridge NR. This is in the north and the east of Cloudbridge NR the Talamanca Range including peaks over 3200 meter like Chirripo. In the west and the south of Cloudbridge NR the Pan-American Highway is found. This is a busy and congested highway with many buses and truck traffic (ASIRT, 2005). Traffic is a major cause of road kill of sloths and injuries to sloths (Sevcenko, 2013). To the southwest of Cloudbridge there is the town San Isidro de El General, with a population of 45,000 inhabitants, which forms a barrier (Lonely planet, 2013). An aerial picture of these barriers is included as appendix 11.

4.4 Results of the suitability of the habitat of Cloudbridge NR for sloths

This paragraph describes the results of the research about the suitability of Cloudbridge NR as a habitat for sloths.

4.4.1 Tree species in the different vegetation classes

A revised map with the different vegetation classes is included as appendix 7. The different vegetation classes are discussed in paragraph 2.2.The most dominant tree species in the secondary forest are (in order of frequency): *Rubiaceae* spp., *Heliocarpus americanus* and *Perrottetia longistylis*. The most dominant tree species in the Primary forest are (in order of frequency): *Quercus bumelioides* and *Clusia* spp. The most dominant tree species in natural regeneration are (in order of frequency): *Heliocarpus americanus* and *Solanum* spp. The most dominant tree species in replanted areas are (in order of frequency): *Heliocarpus americanus, Ulmus mexicana* and *Psychotria sylvivaga.*

There are seven different tree species occurring in Cloudbridge which are confirmed by literature as used by sloths (see appendix 9). This list of trees is not complete because there is not much research done on sloths in areas of higher altitudes. The seven species with their distribution is displayed in table 3.

	Estimated amount in Cloudbridge NR (per hectare)			
Tree species	**Natural regrowth**	**Plantation**	**Secondary**	**Primary**
Cestrum racemosum	0	0	3	0
Dendropanax arborens	0	0	0	7
Hyeronima alchornioides	0	0	0	4
Posoquena latifolia	0	0	0	4
Cecropia polyphlebia	6	9	13	0
Symphonia globulifera	0	0	0	4
Inga spp.	0	0	9	14
Inga oerstediana	6	0	0	0
Total	12	9	25	33
Percentage of the total amount of trees per hectare	10,4 %	2 %	5,3 %	5 %

Table 3. Distribution of trees used by sloths and present in Cloudbridge NR.

It is not sure if *Dendropanax arborens*, *Posoquena latifolia* and *Symphonia globulifera* are used by *Choloepus hoffmanni* and if *Cestrum racemosum* is used by *Bradypus variegatus* (see appendix 9). Primary forest has the highest total amount of trees per hectare used by sloths (33). Natural regrowth has the highest percentage of trees used by sloths per hectare (10,4 %).

4.4.2 Suitability of Cloudbridge NR for sloths

The leaf production of a primary tropical forest is about 1,8 till 12 tons per hectare (Ghazoul and Sheil 2010). In general cloud forests have a lower leaf production then other tropical forests. The expectation is that the leaf production in Cloudbridge NR is about 1,8 tons per hectare. A sloth eating 15 gram of leaf a day eats about 5,5 kilo of leaf a year. Seven sloths eat 38,5 kilo of leaf a year. This means that it is expected that seven sloths per hectare eat about 2 % of the primary forest leaf production in Cloudbridge NR. This is comparable with what is found in other researches (see subparagraph 4.1.2).

4.4.3 Stand characteristics

About 72 different species are found in Cloudbridge NR in this research. A list of the different species is included as appendix 12. The results of the inventory done for this research are included as appendix 13. The results of the researches can be found in the reports of the researches of Spek (2011) and Culbreth (2007). An overview of the different vegetation classes is shown in table 4.

	Natural regrowth	Plantation	Secondary forest	Primary forest
Area inventoried (m2)	3200	3200	3200	2800
Number of stems per hectare	125	356	472	643
Average height (m)	8,9	8,8	10,7	32
Average DBH (cm)	19,3	17,2	25,6	30,8
Basal area (m2/hectare)	4,3	10	35,8	43,1
Crown cover (1-4)	2,2	2,5	2,3	2,4*
Liana development (1-4)	-	-	1,5	1,3

*based only on the plots and not on the Smithsonian hectare

Table 4. Details of the different vegetation classes

A clear difference is visible between the different vegetation classes. With low values for the early succession stages: natural regrowth and high values later succession stages: secondary forest and even higher numbers for primary forest. The only fact which does not change much is the crown cover. This can be due to the fact that values are related to the DBH.

4.5 Results of introducing sloths in Cloudbridge NR

Not much is known about introducing sloths to an area. The dietary selectivity of sloths is responsible for the deaths of *Bradypus variegatus* in captivity and the deaths of sloths introduced into areas lacking the preferred tree species (Sunquist, personal communication, 2013). *Choloepus hoffmanni* could be more suitable to introduce in Cloudbridge NR, because he can stand colder temperatures (Gilmore, Da Costa and Duarte, 2000). When Cloudbridge NR decides to introduce sloths it is important to introduce them in a healthy ecosystem. The sloths should be healthy animals and should be introduced slowly to the new environment (Martin, personal communication, 2013). When introducing sloths it essential that MINAE agrees with the introduction of the sloths. To get permission to introduce sloths you need to have a definite prove that sloths ones lived in Cloudbridge NR. Definite proof has to be with a photo or a video (MINAE, 2013; Rainsong Wildlife Sanctuary, 2007).

5. Conclusion

As mentioned before the research question is:

Can Cloudbridge NR sustain an independent and healthy population of sloths?

Based on the size of Cloudbridge NR and the estimated food intake it is expected that there is enough food available for sloths. But it is not sure if the trees used by sloths are adequately available to meet the food demand of the sloths. When Cloudbridge NR (250 hectares) is completely a suitable and healthy area for sloths there could live up to 750 sloths of *Bradypus variegates* (three sloths per hectare) or up to 125 sloths of *Choloepus hoffmanni* (one sloth per two hectare). Because of the higher altitude and colder temperatures of Cloudbridge NR it is not expected that *Bradypus variegates* will occur in densities up to seven sloths per hectare. It is unknown in which densities they occur when they are both found in the same area.

The only threats to sloths which still occur in Cloudbridge NR are the predators (pumas, ocelots, tayras and coyotes). The expectation is that this is not a problem when there is enough food and enough hiding places in trees.

The facts that sloths are present at higher elevations in lower montane forests as well as cloud forests and the fact that they are present in small size forests and also in continuous forests suggests that they also can live in Cloudbridge NR. However there are almost certainly no sloths present in and around Cloudbridge NR at the moment. Factors which limit sloths to reach Cloudbridge are the Talamanca Range, Pan-American Highway and urban areas like San Isidro de El General. The disappearing of the sloths cannot directly be linked to the deforestation which occurred in the area of Cloudbridge NR up to forty years ago. This is because the reforestation of Cloudbridge NR was already started before the sloths completely disappeared ten years ago. Farmers blame the pumas and the coyotes for eating all the sloths in the area of Cloudbridge NR. Other threats like electrical lines and hunting do not occur in Cloudbridge NR. So the specific reason that sloths left and are not present at the moment is uncertain.

Based on the information known so far primary forest is the most suitable habitat for sloths. This is mostly due to the high amount of *Inga* spp. But it is unsure from other tree species used by sloths in the primary forest if they are used by both sloth species. Secondary forest is also interesting for sloths due to the high amount of *Cecropia polyphlebia. Inga* spp. and *Cecropia polyphlebia* are both secondary species. This means that disturbed areas could be interesting for sloths. The natural regrowth areas could have a good potential for the future due to the high percentage of tree species used by sloths per hectare. The replanted areas are the least interesting for sloths. The average crown development in the different vegetation classes does not vary a lot. The average crown development is in all the vegetation classes reasonable. The average liana development in de the secondary and primary forest is low. Based on the area and vegetation type the expectation is that the average leaf production of the primary forest can sustain up to seven sloths per hectare. But it is unsure if enough food is available of the right tree species.

Introducing sloths in Cloudbridge NR is a difficult thing to do. Aspects which have to be taken into account when introducing sloths are, the health of the sloths and the ecosystem, the speed of the introduction, the dietary selectivity of sloths and the legal permission. It looks like that *Choloepus hoffmanni* is the sloth species which is more suitable for the higher altitudes of Cloudbridge NR.

At the moment it is unsure if the habitat of Cloudbridge NR can sustain an independent and healthy. Aspects that limit sloths to come to Cloudbridge NR are their limited moving and weak dispersal abilities, the fact that they are not seen the last ten years within ten kilometres of Cloudbridge NR and the barriers around Cloudbridge NR. Therefore, it is not expected that sloths return by themselves in a short period of time (ten years) even when the habitat can sustain a population of sloths.

6. Discussion

This chapter discusses the methods and the results of this research. Lastly some recommendations for management are given.

6.1 Methods

Some of the results are not complete enough to answer all of the research questions adequately. There is no complete information about the tree species used by sloths on higher altitudes. Based on the interviews and the literature it is not possible to say why there are no sloths in Cloudbridge NR at the moment. As expected there is not enough information about the introduction of sloths. This is because introducing sloths in an area is not much done and there is not much documentation about the successful or not successful introduction of sloths.

As mentioned before the sampling intensity of the fieldwork is not high enough to conclude anything in absolute terms. To get a more accurate research it is needed to increase the sampling intensity. Therefore additional plots should be plotted and inventoried in Cloudbridge NR. The same research methods as used in this research should be used. At least five times at much area should be inventoried to get a sampling intensity of 2,5 per cent. The questions why the sloths disappeared will probably never be answered. By conducting the researches proposed in subparagraph 6.2.2 it is maybe possible to answer the question why the sloths disappeared, but this only when the reason is tree related. However the more important question is not, why they are not here, but actually how you can get them back.

6.2 Results

The results are discussed by comparing the results with the literature and to overview the needs for further research.

6.2.1 Comparison with literature

In the literature it is stated that deforestation is a major threat to sloths. In the area of Cloudbridge NR it looks like it went the other way around: when the reforestation began the sloths disappeared. The farmers in the area mostly related this to the presence of predators in the area, but it could also be due to the population growth and the effects of this population growth on the area, like more traffic and wider roads. The other results of this research where not contradicted by the literature.

6.2.2 Further research

Because of the missing information this research became more an exploratory study. This results in an advice for further research. This does not mean that the information provided by this research is not useful. The results of this research give a good insight in the preferences of sloths and give adequate information about missing information and the research methods which should be used for further research.

To get the complete information about the tree species used on higher altitudes it is necessary to do a research in a high altitude area with sloths. This should be an inventory in an area like MCFP of trees where sloths are present. This must be done by plotting transect using ArcGIS in the area of MCFP. This transects should be walked, preferably with a person familiar with the presence of sloths in MCFP. The goal of this transects is to gather information about the presence of sloths and their preferences regarding to tree and habitat choice. Information should be gathered about tree species, tree size, crown development, liana development and sloths activity (sleeping, moving or eating).

This information should be used to compare with the tree species in Cloudbridge NR to get a clear picture about which suitable tree species for sloths are present in Cloudbridge. This information should also be used to calculate the percentage of tree species used by sloths and present in an area with sloths. This should be compared with the percentage of preferable tree species present in Cloudbridge NR. With this information it can be determined if sloths can live in Cloudbridge NR and maybe how many.

The question if sloths can be introduced in the future could be an important but difficult question to answer. It is an important question, because if Cloudbridge NR wants to have them back in a short time it is not expected they come back by themselves. It is also a difficult question, because to answer this question it is necessary to review an actual introduction of sloths. Therefor an additional research should be designed.

6.3 Recommendation for management

For creating a more suitable area for sloths it is maybe good to stop the replanting of the areas, to get a good mix between primary and secondary species. Gaps remain in the forest when replanting is stopped. These gaps stimulate crown development and liana development (Ghazoul and Sheil 2010). Another management option for creating a suitable habitat for sloths is the planting of interesting trees for sloths. Trees that are interesting and native to Cloudbridge NR are shown in table 5. Another management options is to release the interesting trees for sloths by removing other vegetation around the young trees and weeding around saplings.

Interesting trees
Cestrum racemosum
Dendropanax arborens
Hyeronima alchornioides
Posoquena latifolia
Cecropia polyphlebia
Symphonia globulifera
Inga sp. (especially Inga oerstediana)

Table 5. Interesting trees for planting

An option for overcoming the roads as a barrier for sloths is ropes over the roads. In this way sloths can use the ropes to cross the roads instead of crawling over the road or using electricity cables.

Sources

Literature

Agence France-Presse (2012). *Costa Rica set to ban hunting, a first in the Americas.* Retrieved August 27th, 2013 from http://www.rawstory.com/rs/2012/10/03/costa-rica-set-to-ban-hunting-a-first-in-the-americas/

Andam, K.S., et al. (2010). *Protected areas reduced poverty in Costa Rica and Thailand.* Retrieved July 17th, 2013 from http://www.pnas.org/content/early/2010/05/19/0914177107

Anywhere Costa Rica (2012). *Important Laws of Costa Rica.* Retrieved September 4th, 2013 from http://www.anywherecostarica.com/sustainable/important-laws

Strieter, A (2013a). *Two-toed sloth*. Retrieved September 9th, 2013 from http://www.anywherecostarica.com/flora-fauna/mammal/two-toe-sloth

Strieter, A (2013b). *Three-toed sloth.* Retrieved September 9th, 2013 from http://www.anywherecostarica.com/flora-fauna/mammal/three-toed-sloth

ASIRT (2005). *Road travel report: Costa Rica.* Retrieved July 22th, 2013 from http://www.wpi.edu/Images/CMS/GPP/Costa_Rica.pdf

Boyce, C. and P. Neale (2013). *Conducting in-depth interviews: A Guide for Designing and Conducting In-Depth Interviews for Evaluation Input*. Retrieved May 25th, 2013 from http://www.cpc.unc.edu/measure/training/materials/data-quality-portuguese/m_e_tool_series_indepth_interviews.pdf

Bruner, A.G., R. E. Gullison, R. E. Rice, G. A. B. da Fonseca (2000). *Effectiveness of Parks in Protecting Tropical Biodiversity.* Science 5 January 2001: Vol. 291 no. 5501 pp. 125-128

Buchsbaum, B.D. (2004). *Ecotourism and Sustainable Development in Costa Rica.* Retrieved July 17th, 2013 from http://scholar.lib.vt.edu/theses/available/etd-05052004-171907/unrestricted/EcotourismCostRica.pdf

Burnet, F. (2008). *Summary of Forestry Act 7575 Costa Rica.* Retrieved September 4th, 2013 from http://www.climateparl.net/cpcontent/pdfs/080731%20Forestry%20Act%20content%20Costa%20Rica.pdf

Cabécar (n.d.). *Chirripó Cabécar.* Retrieved July 19th, 2013 from http://www.cabecar.net/

Cabrera, J., F. Perron-Welch, A. Keenan and A. Wandel (2011). *Crafting Visionary Biodiversity Laws: Costa Rica's Biodiversity Law 1998 – A best policy in implementing the UN Convention on Biodiversity.* Retrieved October 2th, 2013 from http://www.worldfuturecouncil.org/fileadmin/user_upload/PDF/WFC-CIDSL-Costa_Rica_BD_Paper-111114.pdf

Chokkalingam, U. and W. de Jong (2001). *Secondary forest: a working definition and typology.* Retrieved July 18th, 2013 from http://www.cifor.org/publications/pdf_files/secondaryforests.pdf

Climatezone.com (2004). *Costa Rica.* Retrieved July 17th, 2013 from http://www.climate-zone.com/climate/costa-rica/

Cloudbridge Nature Reserve (2013). *Cloudbridge Nature Reserve.* Retrieved 25th, May 2013 from www.cloudbridge.org

Contreras A. (1988). *A regional TFAP for Latin America and the Caribbean.* In Unasylva No. 159 Tropical forestry action plan for Latin America. Retrieved August 28th, 2013 from http://www.fao.org/docrep/s5780e/s5780e03.htm

Costaricadatabase.com (2013). *Welcome to Rivas.* Retrieved August 27th, 2013 from http://www.costaricadatabase.com/crdb/city.asp?action=2&q=RIVAS&b=P%C9REZ+ZELED%D3N&p=1

Culbreth, S. (2006). *Vegetation zones.*

Culbreth, S. (2007). *Smithsonian Hectare Map Layout*

FAO (2013). *National forest programme (NFP).* Retrieved October 2th, 2013 from http://www.fao.org/forestry/nfp/en/

Ghazoul, J. and Sheil, D. (2010). *Tropical Rain Forest Ecology, Diversity, and Conservation.* p. 151 Oxfort University Press.

Giddy, I. (2006). *Rainfall and Temperature.* Retrieved July 18th, 2013 from http://www.cloudbridge.org/wp-content/uploads/2011/11/rainfall-temperature-cloudbridge.pdf

Gilmore, D.P., C.P. Da Costa and D.P.F. Duarte (2000). *Sloth biology: an update on their physiological ecology, behaviour and role as vectors of arthropods and arboviruses.* Brazilian Journal of Medical and Biological Research (2001) 34: pp 9-25.

Google (2013). Google maps. Retrieved September 9th, 2013 from maps.google.nl

Hayssen, V. (2011). *Choloepus hoffmanni (Pilosa: Megalonychidae).* Mammalian Species 43 (1): 37–55. Retrieved May 15th, 2013 from http://www.bioone.org/doi/abs/10.1644/873.1

Henderson C.L. (2002). *Field Guide to the Wildlife of Costa Rica*

INBio (2011). *Especies de Costa Rica.* Retrieved May 15th, 2013 from http://darnis.inbio.ac.cr/ubis/FMPro?-DB=ubipub.fp3&-lay=WebAll&-error=norec.html&-Format=default2.htm&-SortField=nombre%20cientifico&-Op=eq&nueva=S&-Max=3&-Find

INBio (2013). *Biodiversity in Costa Rica.* Retrieved July 29th, 2013 from http://www2.inbio.ac.cr/en/biod/bio_biodiver.htm

Janzen, D.H. et al. (1983). *Costa Rican Natural History.* Pp. 435 and 453-455.

Lonely Planet (2013). *Introducing San Isidro de El General.* Retrieved July 22th, 2013 from http://www.lonelyplanet.com/costa-rica/southern-costa-rica/san-isidro-de-el-general

MINAE (2013). Ministerio de Ambiente y Energía retrieved. July 30th, 2013 from http://www.minae.go.cr/

McNab, B.K. (1978). *Energetics of arboreal folivores: Physiological problems and ecological consequences of feeding on a ubiquitous food supply.* In The ecology of arboreal folivores, ed. G. G. Montgomery, pp. 153-162. Washington, DC: Smithsonian Institution Press.

Montgomery, G.G., and Sunquist, M.E. (1975). *Impact of sloths on Neotropical energy flow and nutrient cycling.* In Ecological studies, vol. 2, ed. F.B. Golley and E. Medina, pp. 69-98. New York: Springer-Verlag.

Montgomery, G.G., and Sunquist, M.E. (1978). *Habitat selection and use by two-toed and three-toed sloths.* In The ecology of arboreal folivores, ed. G.G. Montgomery, pp. 329-359. Washington, DC.: Smithsonian Institution Press.

Moreno, R.S., et al. (2006). *Competitive release in diets of ocelot (Leopardus pardalis) and puma (Puma concolor) after jaguar (Panthera onca) decline.* Journal of Mammalogy 87 (4): 808–816. Retrieved May 15th, 2013 from http://www.bioone.org/doi/abs/10.1644/05-MAMM-A-360R2.1

Obando, V. (2000). *Estado de la biodiversidad en Costa Rica.* Retrieved July 15th, 2013 from http://www.inbio.ac.cr/es/biod/estrategia/Paginas/frame_estudio.htm

Oliver, S. (2010). *Costa Rica National Survey 2010 - Includes average income.* Retrieved on September 30th, 2013 from http://www.welovecostarica.com/public/Costa_Rica_Average_Income_2010.cfm

Peery M.Z. (n.d.). *Sustainable Agriculture and Sloths in Costa Rica.* Retrieved May 15th, 2013 from http://labs.russell.wisc.edu/peery/research/researchsloth-project/

Pedosphere.com (2002). *Searchable Online Version :: Keys to Soil Taxonomy, 8th. edition (2001).* Retrieved September 30th, 2013 from http://www.pedosphere.ca/resources/sg_usa/

Rainsong Wildlife Sanctuary (2007). *Searching for the last Sloths:* Retrieved July 30th, 2013 from http://www.rainsongsanctuary.com/slothsearch.htm

San Gerardo (2009). *The economy.* San Gerardo the Rivas. Retrieved July 19th, 2013 from http://www.sangerardocostarica.com/about/the-economy/

Sevcenko, M. (2013). *Sloth sanctuary nurtures animals back to health.* Retrieved September 5th, 2013 from http://www.dw.de/sloth-sanctuary-nurtures-animals-back-to-health/a-16750190

Schembre, C. (2009). Soil Types and Fundamental Soil Properties of a Costa Rican Tropical Montane Cloud Forest. Retrieved July 18th, 2013 from http://www.cloudbridge.org/wp-content/uploads/2011/11/soil-types-fundamental-soil-properties.pdf

SINAC (n.d.). *Parque Nacional Chirripo.* Areas Silvestres Protegidas. Retrieved July 12th, 2013 from http://web.archive.org/web/20070503043514/http://www.sinaccr.net/aclap_chirripo_general.php

SINAC (2013). *Sistema National de Áreas de Conservación.* Retrieved July 18th, 2013 from http://www.sinac.go.cr/Paginas/Inicio.aspx

Spek (2011). *Cloud Forest recovery* – evaluation at Cloudbridge Nature Reserve, Costa Rica. Retrieved May 24th, 2013 from http://www.cloudbridge.org/wp-content/uploads/2011/11/Cloud-Forest-Recovery-sm.pdf

The World Bank (2012). *Terrestrial protected areas (% of total land area).* Retrieved July 15th, 2013 from http://data.worldbank.org/indicator/ER.LND.PTLD.ZS

University of Western Sydney (2013). *Literature Review.* Retrieved May 25th, 2013 from http://library.uws.edu.au/infoGathering.php?case=litReview&s=litImportance

Unitec (2013). *The Literature Review.* Derived May 25th, 2013 from http://library.unitec.ac.nz/services/libraryinstruction/litreview.htm

World Animal Foundation (n.d.). *Sloth Fact Sheet.* Retrieved May 15th, 2013 from http://www.worldanimalfoundation.net/f/Sloth.pdf

Zedan, H. (2005). *Protected areas for achieving biodiversity targets.* CBD News special edition. Retrieved July 15th, 2013 from http://www.cbd.int/doc/publications/news-pa-supplement-en.pdf

List with personal communications

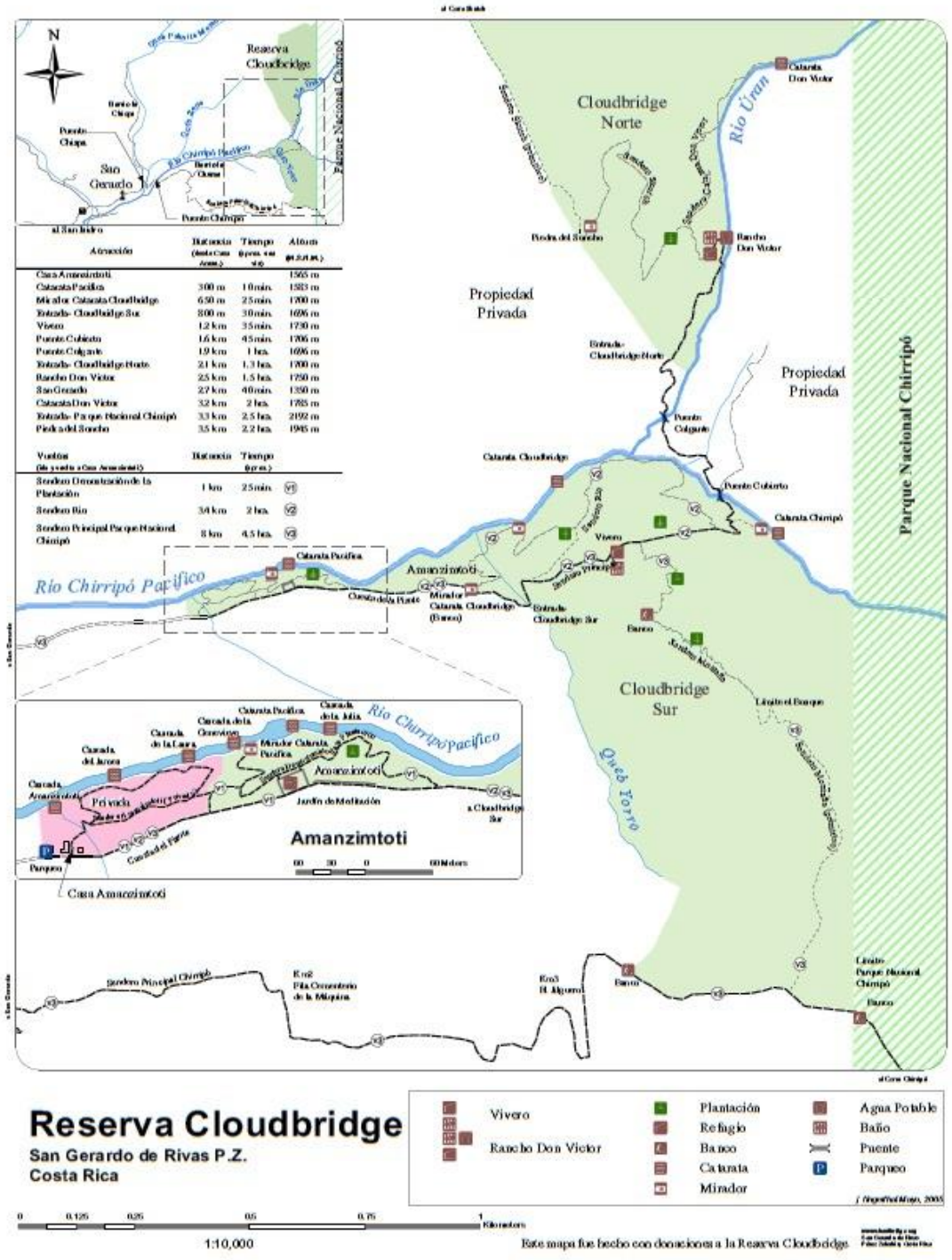
Chinchilla-Romero, F. A., Biologist Monteverde Institute UC-EAP, personal communication on April 24th, 2013

Sunquist, M.E., Program Director University of Florida, department Wildlife Ecology and Conservation, Personal communication on May 4th, 2013

Martin, M. P., vet Kids Saving the Rainforest, Personal communication on April 29th, 2013

Gode, T., Director Cloudbridge NR, Personal communication on April 24th, 2013

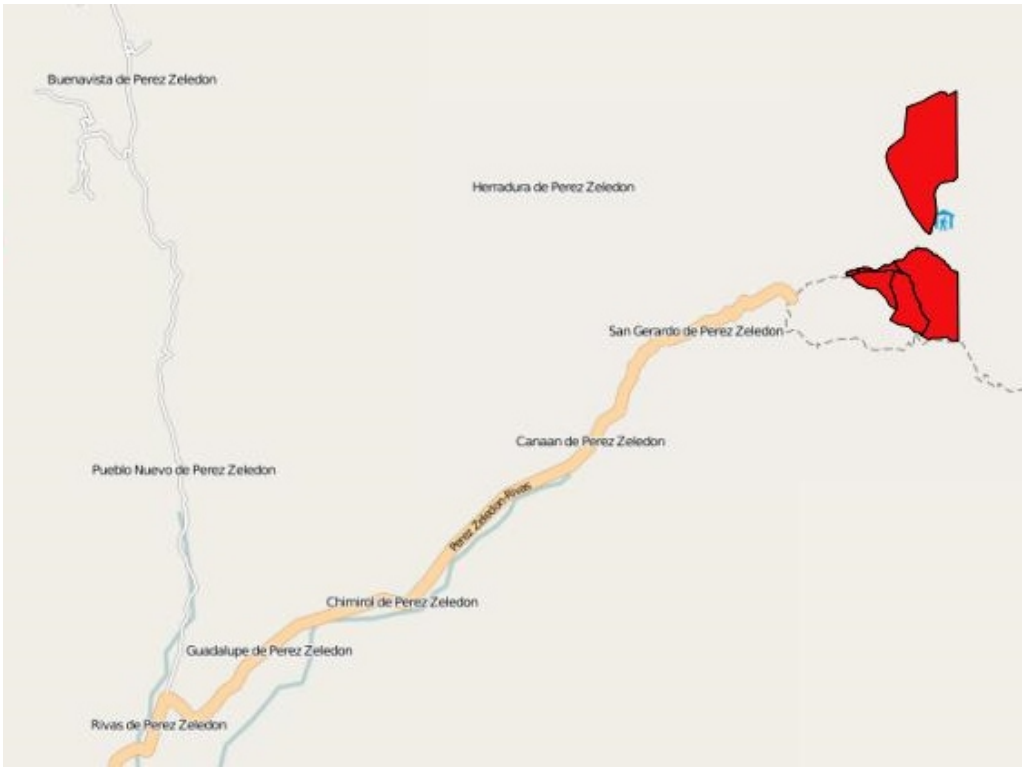
Appendix 1 Map of Cloudbridge NR



(Cloudbridge Nature Reserve, 2013)

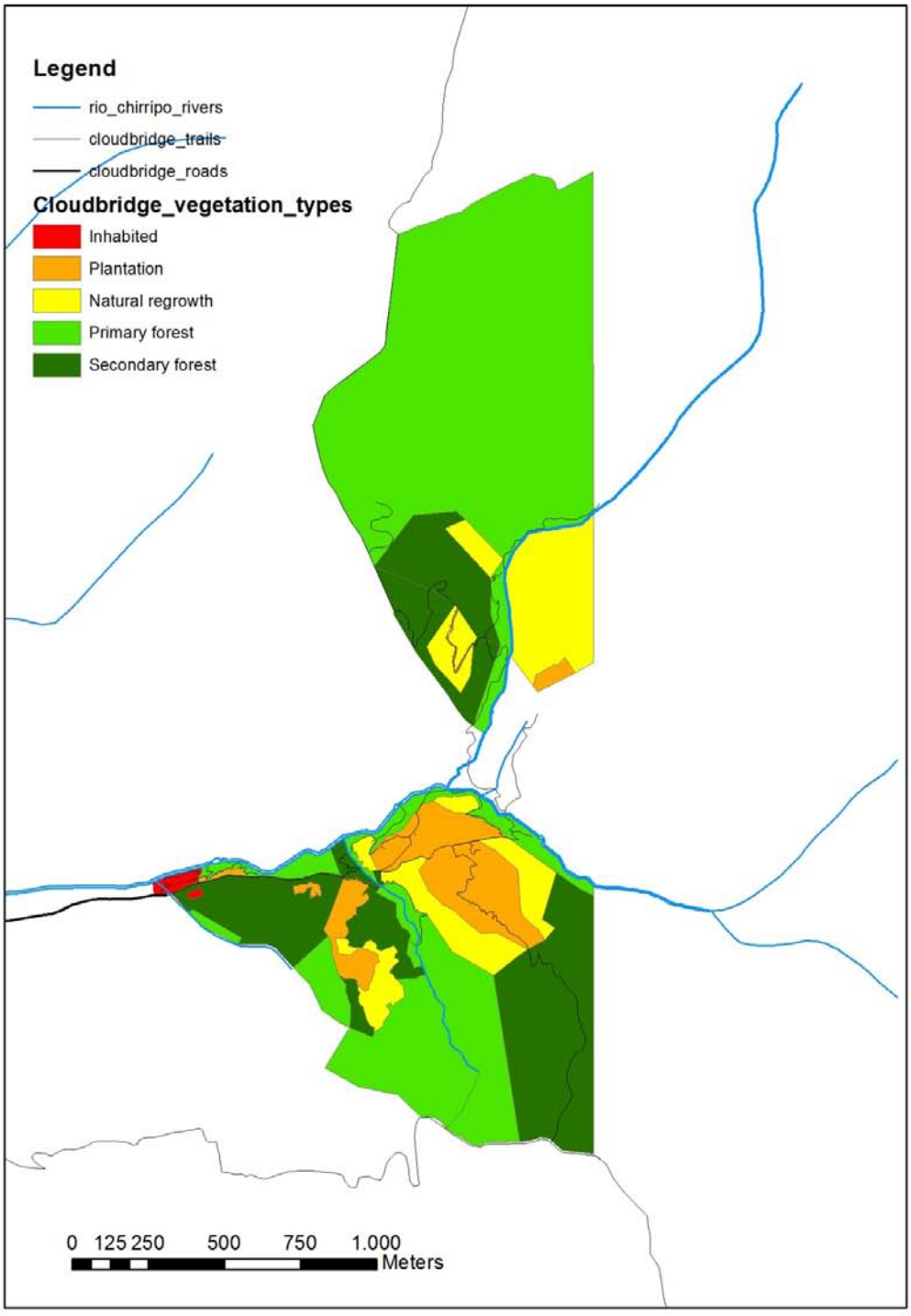
Appendix 2 Map of the towns near Cloudbridge NR

The area of Cloudbridge NR is indicated in red.



(Google, 2013)

Appendix 3 Vegetation map 2006

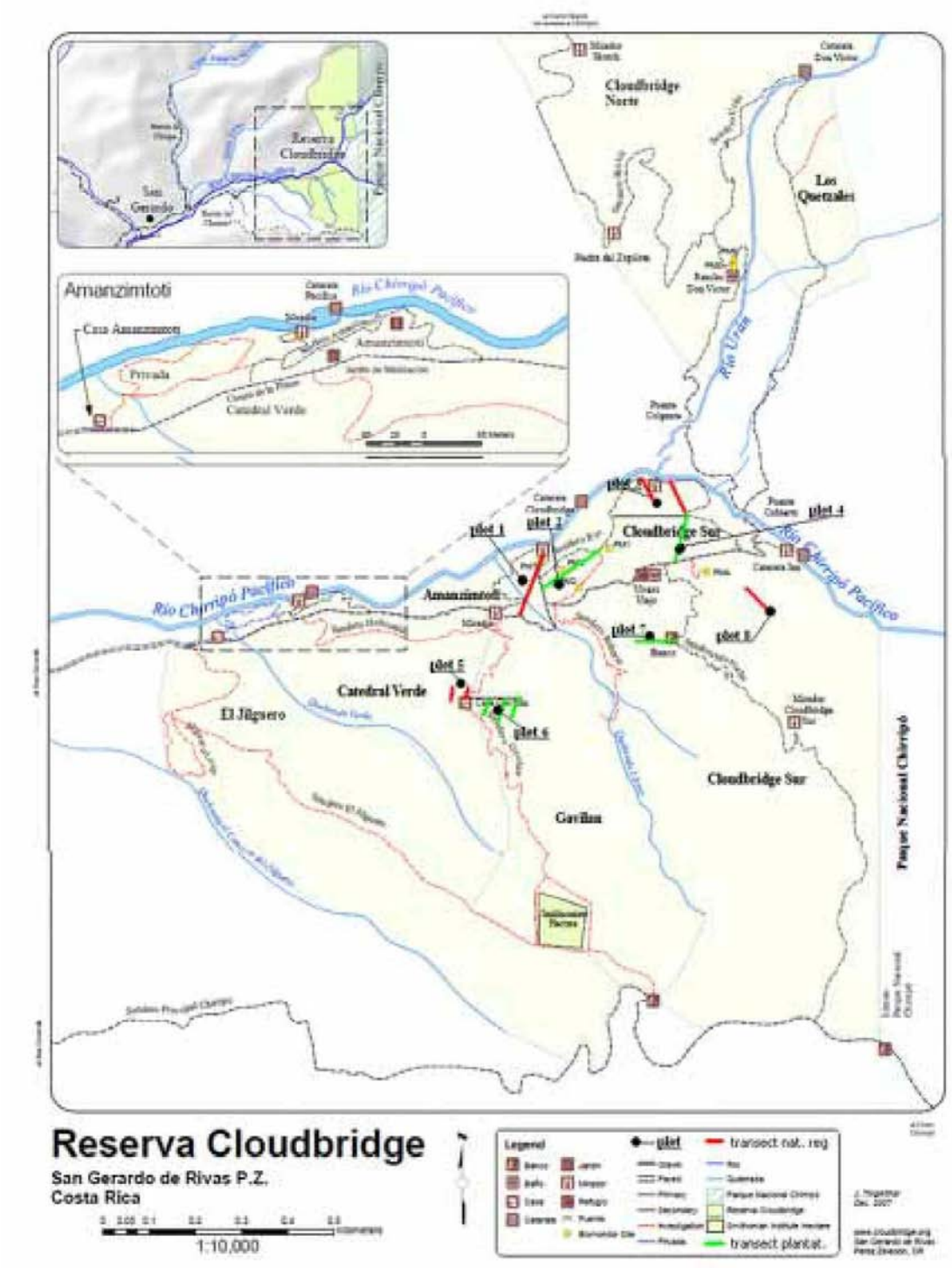


Appendix 4 Interview farmers

Name	
Date	
Place	
Subject	Sloths in and around Cloudbridge in earlier days
Question 1: What is your age and what is your profession?	
Question 2: How long have you lived in the San Gerardo area?	
Question 3: Have you ever seen a sloth in and around Cloudbridge NR?	
Question 4: If yes, when was this and where?	
Question 5: Which sloth species was present in and around Cloudbridge NR (two-toed or three-toed)?	
Question 6: What is the difference in the amount of sloths present now and 40-50 years ago?	
Question 7: Why do you think did the sloths disappear?	

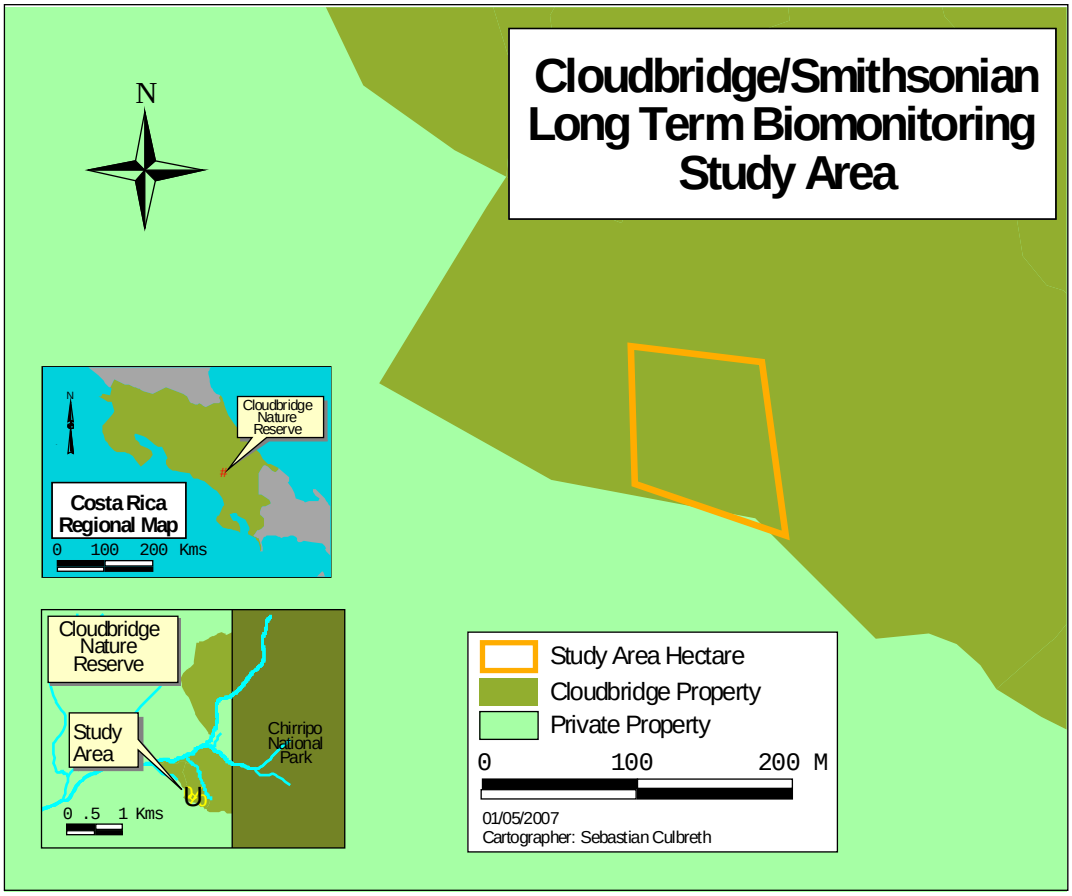
Question 8: What habitat and tree species did sloths prefer in and around Cloudbridge NR?
Question 9: What where the major threats to sloths in and around Cloudbridge NR?
Question 10: Do you have any other comments regarding this interview or my research?

Appendix 5 Map plots 2011



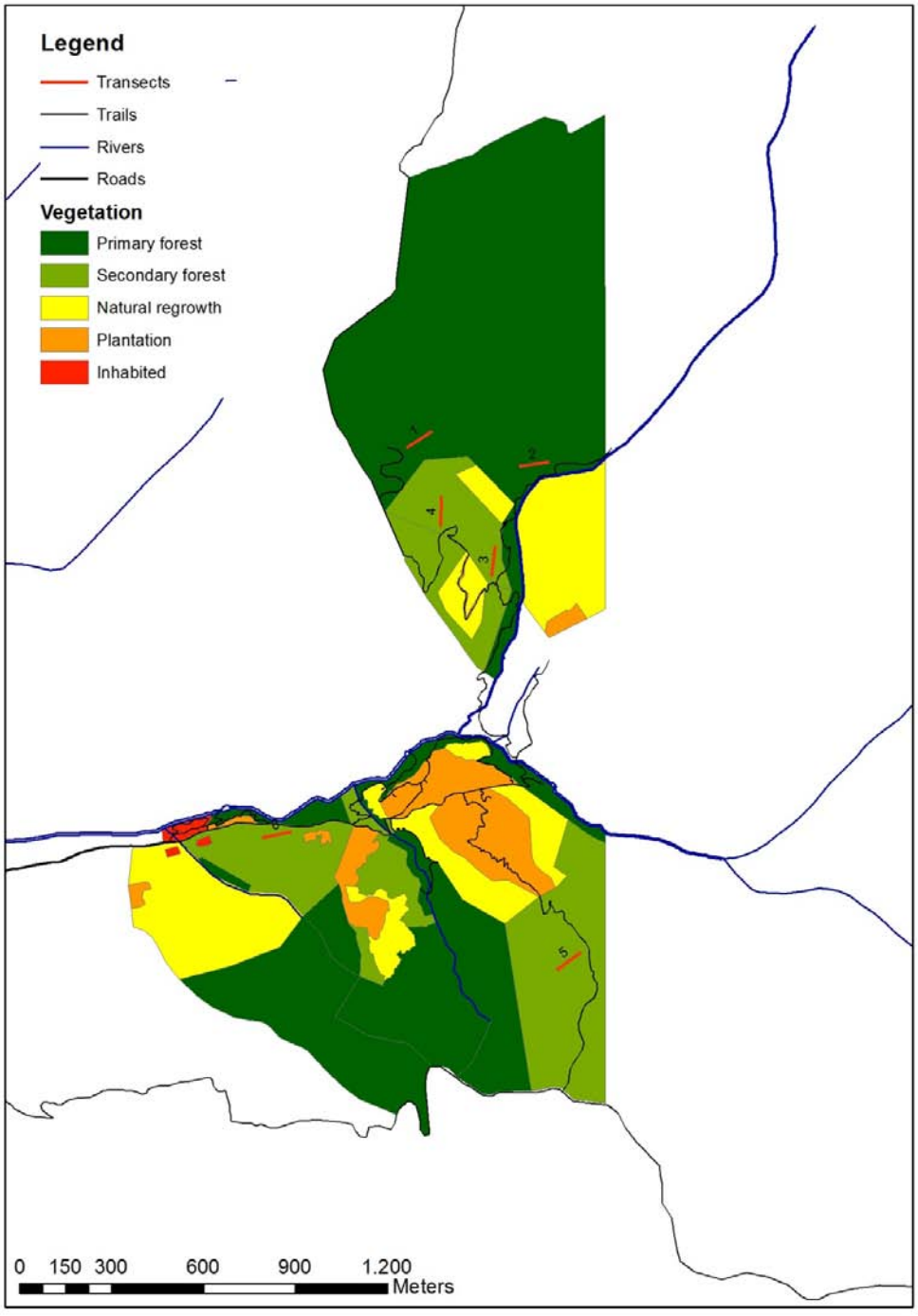
(Spek (2011)

Appendix 6 Map Smithsonian hectare



(Culbreth, 2007)

Appendix 7 Map of the vegetation classes 2013 and plot locations



Appendix 8 Field form

Name		**GPS coordinate begin**	N		W	
Date		**GPS coordinate end**	N		W	
Transect number		**Soil**				
Vegetation type		**Weather**				
Undergrowth		**Comments**				

Name species	**DBH**	**Height**	**Crown development 1-4**	**Liana development (1-4)**	**Comments**

Appendix 9 Tree species used by sloths

Above 1000 meter

Tree species	Use (% of the tree species/ f=feeding or R=Resting/ 1-3= level of significance)		Habitat
	Tree-toed	Two-toed	
Apeiba tibourbou	x	x	Wet to seasonally dry forest, Pacific slope, 0-1100m.[7]
Bamboo sp.	0,05%		0-1600m.[2]
Billia rosea		x	1750-2000m.[14]
Cecropia eximia (Cecropia insignis)	7,6%		Wet forest, below 1500m.[7]
Cecropia polyphlebia	x	x	800-2400m.[2]
Cecropia obtusifolia	0,7%		Wet areas below 1450m.[1]
Cedrela odorata	x	x	Both slopes 0-1200m.[6]
Cestrum racemosum		R	0-2650m.[2]
Cordia alliodora	0,5%	0,3%	Both slopes, 0-1100m. In secondary and older forest, wet and dry climates.[1]
Dendropanax arboreus	0,05%		0-1400m.[2]
Didymopanax morototoni	0,05%		Slopes 45 per cent or more. 0-1700m,[9]
Erythrina poeppigiana	R	F,R	500-1100m.[7]
Ficus costaricana	0,05%		Wet to seasonally dry forest, second growth, 0-1600m.[7]
Ficus insipida	0,6%	1,1%	Wet to seasonally dry lowlands. 0-1100m.[7]
Ficus obtusifolia	1,1%	0,1%	0-1050m.[2]
Ficus werckleana (Ficus insipida)	F,R	R	50-1100m.[2]
Ficus yoponensis	1%	0,3%	10-1500m.[2]
Genipa americana		2,6%	Wet to seasonally dry forests, second growth, 0-1100m.[7]
Hirtella triandra			Both slopes, mainly at low and medium elevations with (very) wet climates, 0-1100m.[12]
Inga marginata	0,05%		Secondary, wet to very wet, 0-1500m.[2]
Inga oerstediana	F,R	F,R	0-2050m. Mostly above 600m.[2]
Leucaena leucocephala	R	R	0-1000m.[18]
Licania hypoleuca	0,2%		Both slopes, 0-1150m.[12]
Macrocnenum glabrescens (Macrocnenum roseum)	0,3%	1,3%	Moist to seasonally dry forest, second growth and edges, 0-1600m.[7]
Mangifera indica	2, 0,1%	0,3%	Planted in Costa Rica, doing best in warm areas with a distinct dry period.0-1500m.[1,2]
Ochroma pyramidale	0,1%		Moist and wet lowlands, both slopes, 0-1200m.[1]
Posoqueria latifolia	0,1%		Understories of moist to wet forest, 0-

			1700m.[7]
Pterocarpus hayesii (Pterocarpus rohrii)	3	0,3%	100-1400m.[2]
Samanea saman	R		Mostly in seasonally dry forest, 0-1200m, mostly below 500m.[7]
Sapium caudatum (Sapium glandulosum)	0,3%	3, 1,1%	0-1800, more frequent above 1000m.[2]
Sloanea terniflora	0,1%	0,3%	80-1100m.[12]
Solanum umbellatum		F,R	Wet forest, 1300-1500m.[17]
Spondias nigrescens (Spondias mombin)	1,3%	3, 4,5%	0-1200m.[2]
Symphonia globulifera	0,4%		Wet to very wet rainforest, both slopes, 0-1700m.[12]
Tabebuia rosea	1%		0-1200m. wet to dry forest. Common in dry forest.[1]
Zanthoxylum procerum (Zanthoxylum acuminatum)		0,3%	Moist and wet forest, both slopes, 200-2000m.[2]

Below or equal to 1000 meter

Tree species	Use (% of the tree species/ f=feeding or R=Resting/ 1-3= level of significance)		Habitat
	Tree-toed	Two-toed	
Acalypha diversifolia	0,05%		Below 1000m.[5]
Alchornea costaricensis	1,7%	0,5%	In moist and wet forest, both slopes, 0-900m.[12]
Anacardium excelsum	2/3, 4,8%	3, 30,9%	From north to south, on both slopes but more common on Pacific, from lowlands to 900 m.[1]
Andira inermis	0,1%		0-900m.[2]
Apeiba membranacea	x	x	Wet forest, 0-900m.[7]
Artocarpus communis (Artocarpus altilis)	0,05%		Lowland.[1]
Astrocaryum standleyanum	3, 0,5%		Very wet lowland forest, 0-500m, Pacific slope.[7]
Astronium graveolens		1,3%	0-1000m. Dry to moist forest.[1]
Beilschmiedia pendula	0,5%	0,3%	350-900m.[14]
Bombacopsis quinata (Pachira quinata)	0,6%		0-900m.Dry to moist forest.[1]
Bombacopsis sessilis (Pachira sessilis)	0,7%	4%	Mostly along pacific coast, including dry forest, but also found in wet and lower montane forest.[10]
Brosium bernadetteae (Brosimum alicastrum subsp. Bolivarense)		0,8%	Wet to seasonal dry, 0-700m.[7]
Calophyllum longifolium	1,3%	0,3%	Wet to very wet forest, pacific slope, 0-400m.[12]
Cassipourea elliptica	0,1%		Below 1000m.[5]
Cavanillesia platanifolia		0,5%	A widely distributed species, occurring in lowland rainforest and in areas which have been disturbed or cleared of forest.[11]
Ceiba pentandra	1,5%	1,3%	0-1000m. dry to wet regions. Secondary and primary forest. [1]
Couratari panamensis (Couratari guianensis)	0,05%		Pacific lowlands.[2]
Coussapoa panamensis (Coussapoa villosa)	0,1%		Both slopes 0-800m.[2]
Croton billbergianus	0,05%		0-900m.[2]
Dipteryx panamensis	3, 3,8%	3, 4%	Atlantic lowlands in the north-east section of CR. 0-100m.[1]
Eriobotrya japonica	x		Below 1100m.[2]
Ficus popenoei	0,1%		50-1000m.[2]
Ficus tonduzii	0,1%		0-800m.[2]
Goethalsia meiantha	F,R		Moist to very wet lowlands, 0-600m.[7]
Guarea guidonia	0,1%		150-600m.[16]
Gustavia superba	3, 2%	0,8%	Up to 600m, very wet forest.[4]

Heisteria concinna	0,1%	1,4%	Lowland.[7]
Hirtella americana	0,1%		50-700m.[12]
Hura crepitans	2, 0,2%		Moist and wet forest, both slopes, 20-900m.[12]
Hyeronima laxiflora (Hyeronima alchorneoides)	3, 2,0%	2,1%	Both slopes, lowland humid and very humid mixed tropical forests. 0-900m.[3,6]
Inga goldmanii	3, 2,4%	0,5%	0-650m.[2]
Jacaranda copaia	1%		Wet lowlands.[2]
Lacmellea panamensis	3, 6,8%	0,3%	0-700m.[2]
Leucaena leucocephala	R	R	0-1000m.[18]
Licania platypus	1,3%	2, 1,8%	10-950m.[2]
Lonchocarpus sp.	0,2%		At low or moderate elevations. [7,15]
Luehea seemannii	2		10-900m.[2]
Platymiscium polystachyum (Platymiscium pinnatum var. polystachyum)	0,4%	0,8%	Wet forest, 0-600m.[2]
Platypodium elegans	0,5%	0,3%	In CR only on Barro Colorado Is.[10]
Poulsenia armata	3, 5,9%	2,6%	Below 1000m.[5]
Pourounia aspera (Pourouma bicolor)	0,1%		Both slopes, 0-900m.[2]
Prioria copaifera	0,1%	1,6%	Wet lowland forest, 0-300m.[7]
Protium costarricense	0,7%		Lowlands, in forest interior only.[10]
Protium panamense	x		Below 1000m.[5]
Protium tenuifolium	1,3%	1,1%	Lowlands. [10]
Pseudobombax septenatum	1,5%		Pacific lowlands, 0-600m. [1,2]
Pterocarpus officinalis	F,R	F,R	Wet lowlands, 0-200m.[7]
Quararibea asterolepis	0,2%	0,3%	0-700m.[2]
*Rheedia madruno (*Garcinia madruno)	0,5%		Wet forest, both slopes, 25-400m.[2]
Rollinia pittieri	F,R		0-700m.[2]
Sterculia apetala	2		Wet to seasonally dry, lowland forests. Altitude Pacific slope 0-400m.[7]
Terminalia amazonica	0,05%	3, 1,3%	30-1000m.[2]
Theobroma cacao	F,R	F,R	0-600m.[7]
Trichilia cipo (trichilia tuberculata)	2, 4,1%	0,3%	0-150m.[2]
Trophis racemosa	0,3%		Dry, wet and lower montane sites.[10]
Virola sebifera	1,4%	1,1%	Below 1000m.[5]
Zanthoxylum panamense	0,3%	0,3%	Both slopes, 50-600m.[2]
Zuelania guidonia	3		Below 1000m.[5]

Unknown

Tree species	Use (% of the tree species/ f=feeding or R=Resting/ 1-3= level of significance)		Habitat
	Tree-toed	Two-toed	
Alseis blackiana	3, 1,4%	1,8%	Only in the drier half of the Panama-isthmus.[8]
Casearia arborea	0,1%		Moist to wet and montane forest, species of natural clearings.[10]
Chrysophyllum panamensis	3	3	?
Eucalyptus globulus		R	Not native to Costa Rica.
Eugenia nesiotica	0,05%	0,3%	?
Eugenia sp.	0,1%		?
Ficus sp.	1%		Sea level to high elevations, wet and dry regions.[1]
Ficus trigonata (Ficus crassinervia)	3, 3,2%		?
Guapira standleyanum	0,1%		?
Guatteria dometorum	0,4%		?
Guettarda foliacea	0,05%		?
Hirtella sp.	0,1%		?
Inga guaternata	0,05%		?
Inga sp.	1,9%	x	?
Maguira costaricana	0,5%		?
Nectandra salicifolia	F,R		?
Nectandra sp.	0,2%		?
Ocotea sinuate	F,R	F,R	?
Protium sp.	0,9%	0,3%	?
Scheelia zonesis	0,05%		?
Tetragastris panamensis	4,1%	0,3%	Only sporadic records in Costa Rica.[10]
Tetrahylacium johansenii	0,1%		Uncommon.[7]
Trattinickia aspera		3, 2,9%	?
Trichanthera gigantea	0,8%		Streams and swampy areas and wet forests
Virola nobilis (Virola surinamensis)	3, 2,5%	3,4%	Only at a few sites.[10]
Zuelania guidonia	0,6%		Mostly Pacific slope, in dry zone, in secondary forest and edges.[10]

For the sake of clarity an additional list of sources is included in this appendix.

Sources

McKenzie, A., G. Ernst and Z. Taranu (2005). *Behavioural Studies and Rehabilitation of Sloths in Parque Natural Metropolitano.* Retreived May 5th,2013 from http://www.mcgill.ca/files/pfss/Sloths_Report.pdf

Montgomery, G.G., and Sunquist, M.E. (1975). *Impact of sloths on Neotropical energy flow and nutrient cycling.* In Ecological studies, vol. 2, ed. F.B. Golley and E. Medina, pp. 69-98. New York: Springer-Verlag.

Montgomery, G.G., and Sunquist, M.E. (1978). *Habitat selection and use by two-toed and three-toed sloths.* In The ecology of arboreal folivores, ed. G.G. Montegomery, pp. 329-359. Washington, DC.: Smithsonian Institution Press.

Ramirez, O., C. Vaughan, G. Herrera and R. Guries. (2007). *Spatial ecology and conservation of two sloths species in a cacao landscape in limón, Costa Rica.*

Urbani, B. and C. Bosque (2006). *Feeding ecology and postural behaviour of the three-toed sloth (Bradypus variegatus flaccidus) in northern Venezuela.*

1 Zuchowski, W. (2005). *A Guide to Tropical Plants of Costa Rica.*

2 INBio (2011). *Especies de Costa Rica.* Retrieved September 9th, 2013 from www.inbio.ac.cr

3 Orwa et al. (2009). *Hyeronima alchorneoides.* Agroforestry database 4.0. Retrieved April 29th, 2013 from http://www.worldagroforestry.org/treedb2/AFTPDFS/Hyeronima_alchorneoides.pdf

4 CIRAD-FLHOR/IPGRI (2001). *Gustavia superba H.B.K. (Lecythidaceae).* Project for Neotropical Fruits. Retrieved May 1st, 2013 from http://ciatweb.ciat.cgiar.org/ipgri/fruits_from_americas/frutales/Ficha%20Gustavia%20superba.htm

5 Smithsonian Institute (n.d.). *Bocas del Toro: Species Database.* Retrieved May 9th, 2013 from http://biogeodb.stri.si.edu/bocas_database/

6 Quírico J.M. et. All. (2002). *Timber trees of Costa Rica.*

7 Gargiullo M.B. (2008). *A Field Guide to Plants of Costa Rica.*

8 Center for tropical forest science. (2009). *Alseis blackiana* Trees, Shrubs, and Palms of Panama. Retrieved May 9th, 2013 from http://ctfs.arnarb.harvard.edu/webatlas/findinfo.php?leng=english&specid=234

9 Liegel, L. H. (1981). *Yagrumo Macho.* Retrieved May 6th,2013 from http://www.na.fs.fed.us/pubs/silvics_manual/volume_2/didymopanax/morototoni.htm

10 Condit, R, et.all. (2011). *Trees of Panama and Costa Rica.*

11 Mitré, M. (1998). *Cavanillesia platanifolia.* Retrieved May 6th, 2013 from http://www.iucnredlist.org/details/34748/0

12 Zamora, N. V. (2004). *Trees of Costa Rica.*Vol. III

13 Tropical Forages (n.d.). *Factsheet Trichanthera gigantean.* Retrieved May 6th, 2013 from http://www.tropicalforages.info/key/Forages/Media/Html/Trichanthera_gigantea.htm

14 Smithsonian Institute (n.d.). *STRI Herbarium.* Retrieved May 6th, 2013 from http://biogeodb.stri.si.edu/herbarium/

15 Chudnoff, Martin. (1984). *Tropical Timbers of the World.* USDA Forest Service. Ag. Handbook No. 607.

16 Weaver P.L. (1988). *Guarea Guidonia.* Retrieved May 9th, 2013 from http://www.fs.fed.us/global/iitf/Guareaguidonia.pdf

Appendix 10 Elaboration interviews farmers

Question 1: What is your age and what is your profession?

- 80 years, farmer
- 62 years, farmer 2x
- 68 years, farmer
- 60 years, farmer

Question 2: How long have you lived in the San Gerardo area?

- His whole live 5x

Question 3: Have you ever seen a sloth in and around Cloudbridge NR?

- Yes, in earlier days there were a lot.
- Yes 2x
- Only long ago.
- Yes, I saw a lot of them a long time ago. I used to live in Cloudbridge when I was a child and I saw them usually around there.

Question 4: If yes, when was this and where?

- 10 years ago the last ones. In his farm and on the Chirripo trail between kilometre 2 and 3.
- 2 behind his house 6 or 7 years ago. In his whole life he saw a lot of them.
- Last was 10 years ago close by his house.
- More than ten years ago down at the river.
- About 30 years ago and I used to live close to the vivero (close to the mountain trail).

Question 5: Which sloth species was present in and around Cloudbridge NR (two-toed or three-toed)?

- Only three-toed sloths. 3X
- ?
- Only two-toed sloth.

Question 6: What is the difference in the amount of sloths present now and 40-50 years ago?

- A long time ago at night in the summer he could hear them.
- When there was more pasture there were a lot of them. Now there is more protection of forest and they disappeared.
- Early a lot more than 20 individuals.
- There were a lot especially close to the river. Mostly more down than in the area of Cloudbridge. Also in the area of the Talamanca Reserve.
- I do not know exactly, but before it was possible to see them every day (around 30 years ago).

Question 7: Why do you think did the sloths disappear?

- First the lions came and after that the coyotes. There is no hunting done on sloths they preferred other animals.
- Due to Pumas and coyotes. Not due to deforestation or hunting (prefer tapir, pecari and deer).
- (1) Destruction of the habitat. (2) Puma eat a lot of sloths (sloth is slow so easy to catch). Not hunting because it is not nice to eat.
- Doesn't know exactly. Maybe hunting for fun. Not because of deforestation, because when he was a child there was a lot of pasture but more sloths. There live much more people now than before
- I think the leonsillo (Puma) ate all of them and the coyotes too.

Question 8: What habitat and tree species did sloths prefer in and around Cloudbridge NR?

- Cecropia and Joco. Open places and close to pasture land in forest.
- Both species of guarumo (cecropia). They prefer more open spaces not on the mountains.
- Cecropia trees, but also other trees. Mostly young leaves. Secondary forest with open places, not in dense forest.
- Secondary forest. Different trees but especially cecropia trees.
- They used to be in open places, and they ate guarumo (cecropia).

Question 9: What where the major threats to sloths in and around Cloudbridge NR?

- No other threats then mentioned before. 3x
- Mostly coyotes and also puma (leonsillo de Breñon). Now there are still a lot of pumas.
- Doesn't know exactly. Difficult for a predator to catch because it is high in the tree. Maybe it moved to another place.

Question 10: Do you have any other comments regarding this interview or my research?

- He really likes to help with the research.
- Really interested in nature and why the animals disappeared. Preferred the protection of the forest.
- It is a good idea to bring some of the animals to this area.
- Really interesting research.
- I would like to see sloths again around here.

Appendix 11 Aerial picture Cloudbridge NR

Cloudbridge NR is indicated as a red area.

(Google, 2013)

Appendix 12 Tree species found in Cloudbridge NR

1. *'Ira'*
2. *Aioueae costaricensis*
3. *Alnus acuminata*
4. *Alnus sp.*
5. *Ardisia sp.*
6. *Biala hippocastanum*
7. *Bocconia frutescens*
8. *Brosimum costaricense*
9. *Brosimum sp.*
10. *Cecropia polyphlebia*
11. *Cedrela tonduzii*
12. *Cedro dulce*
13. *Cestrum racemosum*
14. *Chione sylvicota*
15. *Cichona pubescens*
16. *Cinnamomum triplinerve*
17. *Citharexylum donnell-smithii*
18. *Clusia sp.*
19. *Cyathea sp.*
20. *Dendropanax arborens*
21. *Elaeagia auriculata*
22. *Erythrina costaricensus*
23. *Erythrina sp.*
24. *Ficus tuerckheimii*
25. *Ginchona pubescens*
26. *Gliricidia sepium*
27. *Gonzalagunia rosea*
28. *Guarea glabra*
29. *Heliocarpus americanus*
30. *Hyeronima alchornioides*
31. *Inga oerstediana*
32. *Inga sp.*
33. *Macrohasseltia macroterantha*
34. *Meliosma vernicosa*
35. *Miconia sp.*
36. *Moilinedia sp.*
37. *Mortoniodendrum anisophylum*
38. *Myrcianthes fragrans*
39. *Myrsine coriacea*
40. *Myrsine sp.*
41. *Nectandra sp.*
42. *Oreopanax sp.*
43. *Oreopanax standleyi*
44. *Oreopanax xalapensis*
45. *Panopsis suaveolens*
46. *Perrottetia longistylis*
47. *Persea americana*
48. *Piipisdoclamys sp.*
49. *Piper nigrum*
50. *Posoquena latifolia*
51. *Posoquena sp.*
52. *Prunus annulans*
53. *Pseudolmedia sp*
54. *Psychiotra sylvivaga*
55. *Quercus bumelioides*
56. *Quercus costaricensis*
57. *Quercus sp.*
58. *Quiebra hacha*
59. *Randia sp.*
60. *Rondeletia amoena*
61. *Rubiaceae*
62. *Sabia melliosma*
63. *Salanum sp.*
64. *Sapium sp.*
65. *Saurauia montana*
66. *Saurauia pittierii*
67. *Saurauia rubiformis*
68. *Saurauia sp.*
69. *Solanum sp.*
70. *Sphaeropteris brunei*
71. *Symphonia globulifera*
72. *Ulmus mexicana*

Appendix 13 Results of the inventory

Secondary forest

Name species	DBH (cm)	Height (m)	Basal area (cm2)	Crown development (1-4)	Liana development (1-4)	Transect nr.
'Ira'	14	7	153,94	2	1	3
Cestrum racemosum	15	6	176,71	2	3	3
Cichona pubescens	26	11	530,93	3	1	6
Citharexylum donnell-smithii	18	6	254,47	3	3	4
Citharexylum donnell-smithii	46	6	1661,90	3	4	4
Citharexylum donnell-smithii	23,3	10	426,38	2	1	5
Citharexylum donnel-smithii	39,7	9	1237,86	2	1	6
Citharexylum donnel-smithii	10,4	6	84,95	2	1	6
Citharexylum donnel-smithii	12	5	113,10	3	3	6
Erythrina sp.	12,5	6	122,72	3	3	3
Gliricidia sepium	16	11	201,06	2	3	4
Gliricidia sepium	14,1	8	156,15	3	3	5
Heliocarpus americanus	28	9	615,75	3	3	3
Heliocarpus americanus	15	10	176,71	2	1	3
Heliocarpus americanus	21,2	11	352,99	2	2	4
Heliocarpus americanus	22	10	380,13	2	1	5
Heliocarpus americanus	20,4	13	326,85	2	1	5
Heliocarpus americanus	12,3	11	118,82	2	1	5
Heliocarpus americanus	14,2	11	158,37	2	1	5
Heliocarpus Americanus	11,4	9	102,07	2	2	5
Heliocarpus americanus	17,5	11	240,53	2	1	5
Heliocarpus americanus	21	12	346,36	2	1	5
Heliocarpus americanus	26,5	11	551,55	2	1	6

Heliocarpus americanus	27	11	572,56	2	1	6
Heliocarpus americanus	44	13	1520,53	2	1	6
Heliocarpus americanus	34	12	907,92	2	1	6
Heliocarpus americanus	24	13	452,39	3	1	6
Inga sp.	43	15	1452,20	4	1	4
Inga sp.	14,7	13	169,72	2	1	6
Inga sp.	36,7	14	1057,84	3	1	6
Myrcianthes fragrans	17	12	226,98	2	1	4
Myrcianthes fragrans	13	12	132,73	2	1	4
Myrcianthes fragrans	21	12	346,36	2	1	4
Myrcianthes fragrans	26	12	530,93	2	1	4
Myrcianthes fragrans	28	12	615,75	2	1	4
Myrcianthes fragrans	15	12	176,71	2	1	4
Myrcianthes fragrans	15	8	176,71	2	1	4
Myrsine sp.	21,4	12	359,68	3	1	3
Myrsine sp.	12	13	113,10	2	1	4
Myrsine sp.	15,5	13	188,69	2	1	4
Myrsine sp.	12	9	113,10	2	1	4
Myrsine sp.	18,5	9	268,80	3	2	4
Oreopanax sp.	10,6	10	88,25	3	1	4
Oreopanax sp.	28,9	11	655,97	2	2	4
Oreopanax xalapensis	28,3	11	629,02	2	1	5
Oreopanax xalapensis	16,5	12	213,82	2	1	5
Oreopanax xalapensis	23,3	10	426,38	2	1	5
Oreopanax xalapensis	13,5	11	143,14	3	1	5
Oreopanax xalapensis	55	14	2375,83	3	1	5
Oreopanax xalapensis	11,9	7	111,22	3	2	5
Oreopanax xalapensis	43,6	14	1493,01	2	1	6
Oreopanax xalapensis	59	12	2733,97	2	1	6
Oreopanax xalapensis	21	13	346,36	3	2	6
Oreopanax xalapensis	26,1	11	535,02	2	1	6
Oreopanax xalapensis	22	10	380,13	2	1	6
Perrottetia longistylis	14,4	10	162,86	2	1	3
Perrottetia longistylis	20,4	12	326,85	3	1	5
Perrottetia longistylis	12	9	113,10	2	2	5
Perrottetia longistylis	12,2	11	116,90	2	2	5
Perrottetia longistylis	11,1	8	96,77	2	1	5
Perrottetia longistylis	14	9	153,94	3	1	5
Perrottetia longistylis	13	13	132,73	2	2	6
Perrottetia longistylis	14	13	153,94	2	2	6
Perrottetia longistylis	62	10	3019,07	2	3	6
Perrottetia longistylis	18,5	12	268,80	2	1	6
Perrottetia longistylis	17	12	226,98	2	1	6

Quiebra hacha	14,5	9	165,13	3	2	5
Quiebra hacha	25,4	7	506,71	3	3	5
Rubiaceae	10	6	78,54	2	2	3
Rubiaceae	40,3	12	1275,56	2	1	5
Rubiaceae	22,2	13	387,08	3	1	5
Rubiaceae	21,1	10	349,67	2	3	5
Rubiaceae	23	14	415,48	3	1	5
Rubiaceae	25,7	13	518,75	3	1	5
Rubiaceae	22,6	14	401,15	3	1	5
Rubiaceae	24,9	14	486,95	2	1	5
Rubiaceae	13,9	11	151,75	2	1	5
Rubiaceae	25,5	13	510,71	3	1	5
Rubiaceae	20,4	14	326,85	2	1	5
Rubiaceae	19,3	14	292,55	3	1	5
Rubiaceae	23,6	12	437,44	2	1	5
Rubiaceae	22,8	13	408,28	3	1	5
Rubiaceae	27,5	12	593,96	3	1	5
Rubiaceae	21,9	11	376,68	3	1	5
Rubiaceae	17	12	226,98	2	1	5
Salanum sp.	23,4	7	430,05	2	3	6
Salanum sp.	23	6	415,48	3	2	6
Saurauia	26,4	8	547,39	3	2	3
Saurauia montana	29	10	660,52	2	1	6
Saurauia montana	24,9	11	486,95	2	2	6
Saurauia montana	51,5	14	2083,07	3	2	6
Saurauia montana	25	12	490,87	2	2	6
Saurauia montana	10	8	78,54	2	1	6
Saurauia montana	16	11	201,06	2	2	6
Saurauia montana	10	8	78,54	2	1	6
Saurauia montana	34	11	907,92	2	2	6
Saurauia montana	13	6	132,73	2	3	6
Saurauia montana	12	6	113,10	2	4	6
Saurauia rubiformis	12	7	113,10	2	3	5
Secropia polyphlebia	35,7	13	1000,98	3	1	5
Secropia polyphlebia	16,8	12	221,67	2	2	5
Secropia polyphlebia	55,8	14	2445,45	2	1	5
Secropia polyphlebia	18,4	10	265,90	2	2	5
Solanum sp.	11,6	6	105,68	1	1	6
Solanum sp.	24	5	452,39	3	3	6
Sphaeropteris brunei	26,5	8	551,55	3	1	3
Ulmus mexicana	18	11	254,47	1	1	4
Unknown	24,9	13	486,95	3	1	3
Unknown	14	7	153,94	3	3	3
Unknown	23,5	11	433,74	3	1	3
Unknown	70,3	8	3881,51	2	3	3
Unknown	19	10	283,53	2	1	3

Unknown	24	8	452,39	2	1	4
Unknown	10,5	7	86,59	2	1	4
Unknown	13	8	132,73	2	3	4
Unknown	15	8	176,71	2	3	4
Unknown	22	11	380,13	2	1	4
Unknown	15	12	176,71	3	1	4
Unknown	14,5	9	165,13	2	1	4
Unknown	14,5	4	165,13	2	1	5
Unknown	35,1	14	967,62	3	1	5
Unknown	10	8	78,54	2	1	5
Unknown	18	8	254,47	2	2	5
Unknown	15	14	176,71	2	3	6
Unknown	31,5	14	779,31	2	2	6
Unknown	32,4	16	824,48	2	1	6
Unknown	32,5	8	829,58	1	3	6
Unknown	24	7	452,39	2	2	6
Unknown	13	10	132,73	2	3	6
Unknown 1	75,6	14	4488,83	3	1	5
Unknown 1	50	13	1963,50	2	2	5
Unknown 1	19,5	14	298,65	1	1	5
Unknown 1	19	14	283,53	3	1	5
Unknown 1	31,5	14	779,31	1	1	5
Unknown 1	124,4	14	12154,32	3	2	5
Unknown 1	21,3	13	356,33	3	1	5
Unknown 1	49,3	14	1908,90	3	1	5
Unknown 1	80	14	5026,55	3	1	5
Unknown 10	13,4	11	141,03	2	1	5
Unknown 10	103,4	13	8397,13	3	1	5
Unknown 11	14,6	12	167,42	2	1	6
Unknown 11	31,2	13	764,54	2	1	6
Unknown 11	62,1	13	3028,82	3	2	6
Unknown 11	86	11	5808,80	3	2	6
Unknown 12	34	10	907,92	2	2	6
Unknown 12	16	12	201,06	2	1	6
Unknown 12	24	6	452,39	2	2	6
Unknown 13	32,5	13	829,58	3	1	6
Unknown 4	36,2	9	1029,22	3	2	3
Unknown 5	26,3	6	543,25	3	4	3
Unknown 8	29	13	660,52	3	1	4
Average	25,64	10,66		2,33	1,54	

Per hectare	
Total stem numbers	471,88
Basal area (m2)	35,75
Volume (m3)	299,29

Primary forest

Name species	DBH (cm)	Height (m)	Basal area (m2)	Crown development (1-4)	Liana development (1-4)	Transect nr.
Alnas acuminata	28,3	13	629,02	3	1	2
Cecropia polyphlebia	20	12	314,16	3	1	2
Heliocarpus americanus	35,3	11	978,68	3	1	2
Heliocarpus americanus	20,5	10	330,06	2	1	2
Heliocarpus americanus	24,1	11	456,17	3	1	2
Heliocarpus americanus	15,4	10	186,27	1	1	2
Heliocarpus americanus	25	12	490,87	3	1	2
Myrcianthes fragrans	17,4	12	237,79	2	1	1
Myrsine sp.	11,5	4	103,87	3	1	1
Oreopanax standleyi	17,1	7	229,66	3	1	1
Oreopanax standleyi	13,7	10	147,41	2	1	1
Oreopanax xalapensis	19,1	10	286,52	3	1	1
Oreopanax xalapensis	14,3	6	160,61	2	1	1
Oreopanax xalapensis	14,9	9	174,37	2	2	1
Oreopanax xalapensis	15,8	10	196,07	2	1	1
Oreopanax xalapensis	14	7	153,94	3	1	1
Oreopanax xalapensis	19	7	283,53	3	1	1
Oreopanax xalapensis	30	6	706,86	3	3	2
Quercus bumeliodes	43	22	1452,20	3	3	2
Quercus bumeliodes	52	24	2123,72	3	2	2
Quercus bumeliodes	60	25	2827,43	4	2	2
Quercus bumeliodes	33	11	855,30	3	2	2
Quercus bumelioides	23	12	415,48	2	1	1
Quercus bumelioides	45,8	12	1647,48	2	1	1
Quercus bumelioides	16,5	11	213,82	2	1	1
Quercus bumelioides	32,4	9	824,48	2	1	1
Quercus bumelioides	14	8	153,94	2	1	1
Quercus bumelioides	13	9	132,73	2	1	1
Quercus bumelioides	37,3	12	1092,72	2	1	1
Quercus bumelioides	22,6	16	401,15	2	1	1
Quercus bumelioides	19,3	16	292,55	2	1	1
Quercus bumelioides	28,7	15	646,92	3	1	1
Quercus bumelioides	24,5	14	471,44	2	2	1
Quercus bumelioides	14,7	13	169,72	1	1	1
Quercus bumelioides	17,1	11	229,66	2	1	1
Quercus bumelioides	11,9	12	111,22	2	1	1
Quercus bumelioides	18,4	14	265,90	2	1	1
Quercus bumelioides	15,3	11	183,85	2	1	1
Quercus bumelioides	12	7	113,10	2	1	1
Quercus bumelioides	10,8	6	91,61	2	1	1
Quercus bumelioides	29,7	16	692,79	2	1	1

Quercus bumelioides	23,8	15	444,88	2	1	1
Quercus bumelioides	15	9	176,71	2	1	1
Quercus bumelioides	26,5	14	551,55	3	2	1
Quercus bumelioides	15	12	176,71	3	1	1
Quercus bumelioides	26	9	530,93	3	1	1
Quercus bumelioides	26	9	530,93	3	1	1
Quercus bumelioides	21,8	11	373,25	2	1	1
Quercus bumelioides	17,4	15	237,79	2	1	1
Quercus bumelioides	18,7	12	274,65	2	1	1
Quercus bumelioides	17,9	30	251,65	2	1	1
Quercus bumelioides	16,8	30	221,67	2	1	1
Quercus bumelioides	46	35	1661,90	3	1	1
Quercus bumelioides	11,5	9	103,87	2	1	1
Quercus costaricensis	22	12	380,13	2	1	1
Quercus costaricensis	54	17	2290,22	4	1	2
Saurauia montana	18	7	254,47	2	1	2
Saurauia montana	14,1	8	156,15	2	2	2
Saurauia montana	20	10	314,16	2	2	2
Unknown	25	15	490,87	2	2	1
Unknown	11,7	8	107,51	2	2	2
Unknown	16,3	7	208,67	3	3	2
Unknown	37	12	1075,21	3	1	2
Unknown	45	30	1590,43	3	2	2
Unknown	15,5	6	188,69	2	1	2
Unknown	21	5	346,36	2	3	2
Unknown	65	30	3318,31	3	2	2
Unknown	30	25	706,86	2	3	2
Unknown	20,1	8	317,31	3	2	2
Unknown	19	7	283,53	3	3	2
Unknown 1	22	11	380,13	3	1	1
Unknown 1	21,1	11	349,67	2	1	1
Unknown 7	10,3	8	83,32	2	1	1
Unknown 7	24,5	7	471,44	2	1	1
Average	23,57	12,53		2,39	1,34	

Per hectare	
Total stem numbers	468,75
Basal area (m2)	25,20
Volume (m3)	303,20