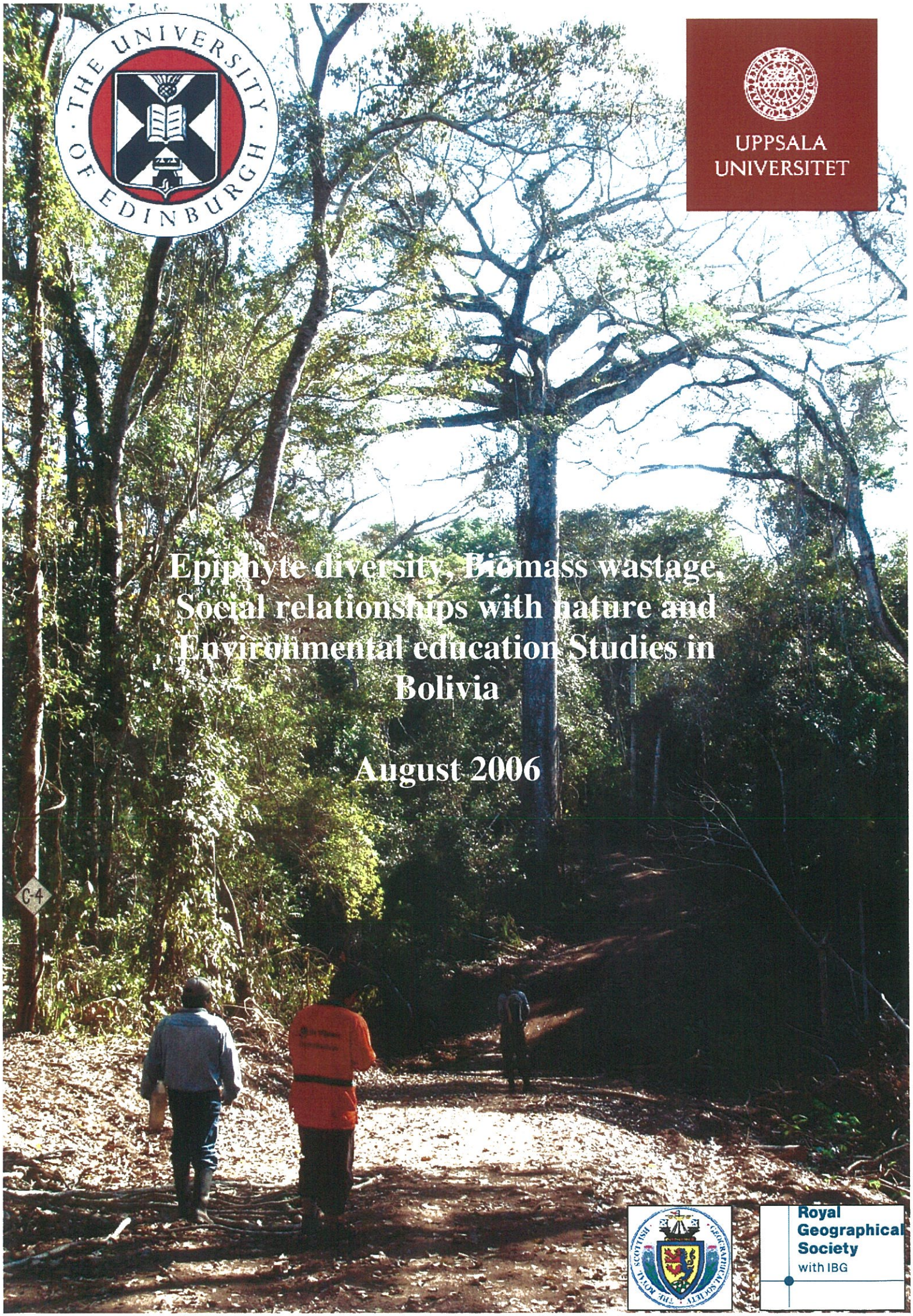
THE UNIVERSITY OF EDINBURGH
UPPSALA UNIVERSITET
Epiphyte diversity, Biomass wastage, Social relationships with nature and Environmental education Studies in Bolivia
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Contents

Project Bosque

Project Bosque was the continuation of a partnership between students from the University of Edinburgh and the Bolivian Forest Research Institute (IBIF). In 2006 Bosque expanded its focus and involved students from the University of Uppsala, Sweden, with collaboration and support from Friends of Nature, Bolivia (FAN) and PACT inc. Bosque seeks to investigate aspects of Bolivian life related to the development of sustainable forestry within the Bolivian lowlands.

With the assistance of the La Chonta logging company; the communities of Urubicha and Yaguarú; and the invaluable support of several local guides and translators, Bosque investigated industrial, educational, social, and ecological aspects pertaining to sustainability in Bolivian forestry.

The experience of the Bosque team, involving 16 students from 7 different countries covered the full range of project development, fundraising, adaptation, and data collection during an eleven month period. Extreme highs and lows were felt by all during the process, with particular frustration at a lack of funding and institutional support characterising the early months. Working as a cohesive team, despite a geographic divide, complicated a process that may have been expected to have been fraught even without the reliance on indirect methods of communication. Ultimately the team's dedication and willingness to adapt carried us through tough times, indicating the perseverance and good humour that was to characterise the Bosque experience.

Combining two groups with distinct individual characters was for me the greatest achievement of Bosque. Working in the field in often arduous conditions; trekking at high altitude; early morning physical training programmes; forsaking Copacabana beach for project report writing, were all elements of Project Bosque that would not have been achievable had the team not bonded and worked as an effective and supportive entity. Indeed the set backs we experienced through equipment failure; logistical support problems; communication difficulties and the effects of Bolivian political change, were tackled in a head on "can-do" approach. Having experienced the converse of this situation during phase one: with a team where teamwork was for others, the unity and capability of the Bosque team was especially appreciated.

As a project, Bosque originally aimed to transform the nature of student directed expeditions. Personally I wanted the focus of the project to be on hard science, producing journal quality work and building a project that may grow and involve numerous co-actors and partners in its subsequent phases. With hindsight many of these ambitions were probably beyond the reach of any student directed project, however what we have achieved is still significant.

The concept of student directed research with no academic related benefit is foreign to many students outside the UK. Facilitating awareness of the potential opportunities available to European students was always a Bosque priority and something I feel we have contributed towards.

Bolivia is a wonderful country, warm, welcoming and extremely adaptable. Bolivia itself can also be highly challenging, where events happen in "Bolivian time". Undertaking a research project in such an environment was always going to mean that success would be intimately linked to the ability of the team to adapt, innovate and "roll with it". Major political change in Bolivia during the project meant that long hours of preparation and planning pre-departure was obsolete. Adapting, rethinking and at times completely redeveloping the original plans ensured that every member of the team was challenged. If project Bosque had been based in Europe I seriously doubt that the outcome of this process would have been half as successful. The nature of Bolivia is such that it is highly possible to

arrive at a destination with no prior knowledge or notice and to develop a meaningful project from scratch. Many thanks must be given to the communities of Urubicha and Yaguarú, who not only accepted members of the Bosque team, but went out of their way to accommodate their aims and objectives. Education Bosque with its highly positive reception among the villages closely neighbouring large areas of important forest, demonstrates the attainment of many of the original Bosque targets.

Bosque may not have made the front cover of Nature or Science (scientific journals), however the team developed projects from which conclusions on industrial, ecological, educational and social aspects pertaining to current forest sustainability may be drawn. The project has introduced 16 students to a wonderful part of the world while educating them on the reality of promoting sustainability. This work has promoted an interest among not only the next generation, but also within the villages, in simple steps that may be taken to maintain the forest for future generations. Bosque also continues to play a major role in promoting effective approaches to developing conservation and biodiversity initiatives. A long term position in the promotion of developing "best-practice" within a national biodiversity initiative ensures that Bosque will continue to positively influence the drive towards sustainability.

Jacob O'Mahony

Project Leader "Bosque" 2004-2006

Vascular Epiphyte Diversity within the La Chonta Forestry Concession, Bolivia

August 2006

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Abstract

The diversity of the vascular epiphyte communities was assessed in natural forest and two different logged forest habitats within the La Chonta Forest Concessions, Guarayos Forest Reserve (15°45'S, 62°60'W), Bolivia. To achieve this both a ground based shrub layer survey and an aerial canopy based survey were employed. A ground based comparison of the family diversity between Control (Testigo) and Normal study sites showed a difference between each of the family communities, orchidaceae, bromiliaceae, piperaceae, and pteridophytes. The normal distribution approximation conferred a statistical difference may occur between the bromiliaceae ($|z_0|$ = -2.98), piperaceae ($|z_0|$ = -3.56), and pteridophytes ($|z_0|$ = -2.66) communities of each study site. No difference was found to exist between the proportion of orchidaceae in non-logged and logged communities. Within the shrub layer study it was found that there is a large variation in diversity across relatively small study areas in La Chonta. It was found in the canopy study that no statistical differences occurred between any of the vascular epiphyte families (not including pteridophytes, which were not present in the normal study sites). The diversity of vascular epiphytes was found to vary according to zone within the sites and between logged and non-logged conditions in the shrub layer, but that logging had little effect on the canopy epiphyte communities in La Chonta, Bolivia.

Introduction

"Biodiversity is the totality of hereditary variation in life forms, across all levels of biological organisation, from genes and chromosomes within individual species to the array of species themselves and finally at the highest level, the living communities of ecosystems such as forest and lakes" (Crawly, 1997). Plant biodiversity has for the most been accounted for, with only hundreds of species being discovered each year. At present there is approximately 250,000 vascular flowering plant species, of this 65% live in the tropics (Raven, 1988). Bolivia, like its fellow South American countries, shows exceptional biodiversity within its geographical borders.

The traditional reasons why efforts have been made to conserve biodiversity consist of ethical and moral obligations, aesthetic and recreational potential, ecological impacts and economic importance. The main difficulty with these theories is that they do not have high priority in political terms and scientific arguments supporting them are somewhat fragile (Crawly, 1997). When looking at a country like Bolivia with such an economically unstable past, interests of ethics and aesthetics are not ranked highly on the list of relevant issues when reaching financial security. The fact is, biodiversity is being lost world wide at a staggering rate (Crawly, 1997), it is vital to ensure that within a country such as Bolivia the endemic species are not lost. It is invaluable to show the Bolivian Government, who has the capability of sustaining the range of flora and fauna, the consequences of their political decisions and actions in terms of environmental implications.

Bolivia has been placed within a geographical area known as the neotropics, a "biodiversity hot spot", so termed for its extremely high percentage of flora diversity per metric unit (Crawly, 1997). Bolivia is the poorest and consequently the least researched country in South America. In spite of this, some studies have been completed and show that there are exceptionally high levels of endemic flora within some forested regions (Ibisch, 1999).

Within our research forest, the Guarayos National Reserve, three of the four most destructive events that take place within tropical ecosystems occur. These include; the increasing pressures of the human population and the need for additional land for cultivation; commercial agriculture; and commercial logging and forest road building. Our study will be addressing the effects of silvicultural practices on vascular epiphyte communities.

Silvicultural management is a titanic struggle, which aims to use natural resources in a sustainable way and at an acceptable level to all parties involved. In some regions of Bolivia, up to 60% of the forest has been destroyed through human related activities (Steininger, 2001). Therefore consequential management ideals have forced their way into governmental polices to ensure the sustainable use of Bolivia's forested regions. Thus far, legislation has been aimed at the forestry practices effect on a forest's future production abilities, focusing primarily on commercially viable species regeneration capabilities. Biodiversity has as yet featured heavily in the considerations of silvicultural impacts in Bolivian forestry management ideals. Our research was designed to give a further insight into the effects of such activities to NGOs working with the policy makers in Bolivia, in order to support the biodiversity within the areas that have been allocated for commercial logging.

The area of epiphyte research that was undertaken by four University of Edinburgh students was formally suggested by Instituto Boliviano de Investigación Forestal (IBIF), an NGO with whom the work was in conjunction with. IBIF's mission is to promote sustainable forestry management through long-term research in natural tropical forests. At present, work on epiphytes is not within the organisations capabilities or budget, especially with current funding cuts under the present government. Our expedition aim was to investigate the effects of the current silvicultural practices adopted by a Bolivian logging company on the diversity of the vascular epiphyte community.

Epiphytes, also known as aerophytes, are plants that grow on other plants, upon which they are dependent for mechanical support, but not for nutrients. Epiphytes make up about ten percent of all vascular plant species world-wide and they are almost exclusively found in tropical forests (Neider et al. 2001). For this reason, they constitute a large part of the global plant biodiversity and in tropical countries represent up to 25% of all vascular plant species (Neider et al. 2001). In the specific region of the forest in which our research was undertaken no previous studies had ever been carried out on the epiphyte community.

The aim of our study was to assess the diversity of the vascular epiphyte communities in both undisturbed and logged natural habitats within the reserve and to try and establish the impacts, if any, that logging has had on the epiphyte communities present. Through our study it is hoped that some much needed information was gained, which can be passed on to IBIF. With this new information IBIF may be in a better position to address the epiphyte community as a scientific entity in consideration for future management advice. The production of this report will provide a further insight into biodiversity research in relation to the impact of logging in Bolivia.

Site

For the purposes of the vascular epiphyte canopy study the climbing team focused specifically on one tree species, the commercially valuable *Ficus boliviana.* This canopy emergent tree commonly known as, Bibosi Colorado, reaches a maximum height of 35m, with a diameter above root buttress height of

220cm (Justiniano et al. 2004). The Bibosi´s dense umbrella canopy grows from its expansive wings radiating from the cylindrical stem. The smooth exterior bark has a grey or beige colouration, with the inner bark showing pink and with latex white sap oxidizing to a coffee white colour. The species is distributed throughout Bolivia in the provinces of Guarayos, Velesco and Miplo de Chaves (Santa Cruz, Beni and La Paz). This deciduous shade tolerant tree grows at a maximum pre-mountain altitude of 850m down to flat lowland areas at 250m, taking into account humid to semi-humid forest regions.

The 100,000ha Agroindustria Forestal La Chonta Ltda. forestry concession lies in the Guarayos Forest Reserve (15°45'S, 62°60'W) in the province of Guarayos, 30km east of the town of Ascención de Guarayos, Bolivia (Pariona, 2002). The site has an elevation of 250m and an average yearly regional rainfall of 1560mm, of which the majority falls between November to March (Gill, 1997). With this rainfall and the mean temperature of 25.3°C the site can be described as a humid tropical forest (Gill, 1997), with soils consisting of a mixture of oxisols, ultisols and inceptisols (Pariona, 2002). Approximately one hundred species of trees have been identified within the area, with 18 species currently considered by La Chonta as commercially valuable (Belfour, 2000). The site maintains the vast flora diversity that is seen in many other neotropical ecosystems, and like other ecosystems epiphytes feature heavily. Within the Guarayos epiphyte community the dominant family is the orchidaceae.

La Chonta Ltda. was certified by the Forest Stewardship Council (FSC) in 1998, which provided forestry regulations, including a time limit for subsequent logging entries of 30 year intervals (Gill, 1997). The average forest area harvested per annum is approximately 2730ha, with an average volume of $22m^3$/ha (Belfour, 2000). The main site disturbance is the removal of trees using chainsaw felling and the removal of logs by rubber-tyre skidders capable of clearing pathways and crushing all plants with a diameter of up 30cm (Pariona, 2002).

Within the La Chonta forestry concession there are a number of study areas which are maintained by the Instituto Boliviano de Investigación Forestal (IBIF). For the purposes of this study five study plots were sampled in total. Non-logged data was taken from study plots maintained by IBIF, referred to as Testigo Plots, of which there were three separate areas of an average 27 hectares. Testigo (Control) blocks are not harvested, but minimal liana cutting has occurred. This practise is thought to have had little impact on the test plots.

Two plots having undergone standard silvicultural treatment (Normal), also maintained by IBIF, which have been harvested, on average five years ago, according to the current logging practise in the La Chonta concession were investigated. An average of 62 trees were cut and removed per plot (approximately 27ha). This silvicultural management also consists of the planning of roads and a logging system based on a yearly census, which harvests trees above set diameter limits, cuts lianas on remaining commercial species and retains 20% of commercial species to act as seed trees for the future. Data was also collected from previously logged areas, not maintained as IBIF research plots, which are referred to as 'logged areas'. These areas have been previously logged according to the same FSC regulations, but remain close to a substantial logging road, which has been active as one of the main access roads in the last year. Work was undertaken in this study outside of IBIF Research Areas due to the lack of suitable trees in logged research plots.

Methodology

Ground Based Survey

Studies were carried out in non-logged (Control) and previously logged (Normal) test sites. Two out of the three study blocks were randomly selected for both Control and Normal. Within each of the four blocks twelve 50m by 20m transects were sampled counting numbers of shrub layer epiphytes in each. These transects were generated randomly using the random number generation key on a calculator.

Numbers were selected and the matching 50m squares were sampled from their 25m middle point running on a magnetic north-south or east-west bearing. Using a compass at the start of each transect, three 50m measuring tapes were laid out on a north or west bearing so as that the transect area was clearly marked for the sampling team. The edge effect from the plot paths was ignored as it was thought to be very minimal.

A maximum height limit, of 5m, was set for sampling epiphytes in the shrub layer and anything above this height was not included in the data collection. The shrub layer in this habitat may have reached above this limit, but this data collection was unobtainable. Therefore in this study the shrub layer is defined as being the layer of plants that fall within the height range of 0.5m to 5m (PRBO's Terrestrial Program protocols).

To standardise the identification of the shrub layer epiphytes, the plants were categorised at a family level consisting of orchidaceae, bromiliaceae, piperaceae and pteridophytes. A six member team, consisting of 4 students and 2 guides, sampled each transect. A 5 person line was formed with each individual covering approximately 4m of the 20m transect. Every shrub was identified and searched from 0.5m level to 5m. One team member was designated as scribe, whose role it was to record and group at the family level all epiphytes found. If an individual was unable to identify the epiphyte to a family, the group leader and guides were able to give clarification.

The collected data from both the Control and Normal test plots were pooled into the respective groups allowing statistical comparisons to be made between each plot and overall comparisons between logged and non-logged plots.

Figure 1. Author identifying Vascular Epiphytes in the shrub layer.

Bromiliaceae, of the Shrub Layer Survey

Ficus Boliviana Canopy Survey

To achieve the maximum potential for research in the canopy, the team used the Basic Canopy Access Proficiency (BCAP) techniques. The BCAP techniques use a two rope method of climbing with fixed anchors and a strict safety protocol using artificial grips to ascend and descend the ropes.

Included in BCAP`s safety protocol is the requirement for rigorous tree selection for safety purposes, thus reducing the random selectivity of tree species. For this reason only the species *Ficus boliviana* was used for sampling, as it provided the desirable characteristics for safe climbing including large healthy climbable branches and sound stable roots. This was amplified in the Normal plots where the best commercial trees were removed resulting in tree selection being further affected. As the

commercially viable trees are more often than not the healthier, the number of desirable trees for climbing was reduced and led to additional research being undertaken in Logged Areas, outside of research plots.

Once a tree was selected and safety checks met, the following sample procedures were performed to analyse epiphyte family richness.

The tree was subdivided into the following five vertical zones according to Johansson (1974). The five zones created a single transect from the base of the trunk to the tip of one major trunk.

- Zone 1. Basal part of trunk, to include the first third of the main trunk from ground to sample branch.
- Zone 2. The remaining two thirds of the trunk up to the ramification of the trunk zone excluding isolated branches originating on the trunk.
- Zone 3. Basal part of the large branch, up to the second third.
- Zone 4. Second third of branch length.
- Zone 5. Outer third of branch length.

The scheme is based on tree structure and conspicuous differences in epiphyte community composition, although each Johansson zone may not coincide with distinguishable epiphyte communities. The three principal communities of vascular epiphytes of the rain forest occur in zones 1-2, zone 3, and zones 4-5. These communities differ in species richness (low in 1-2, high in 3-5).

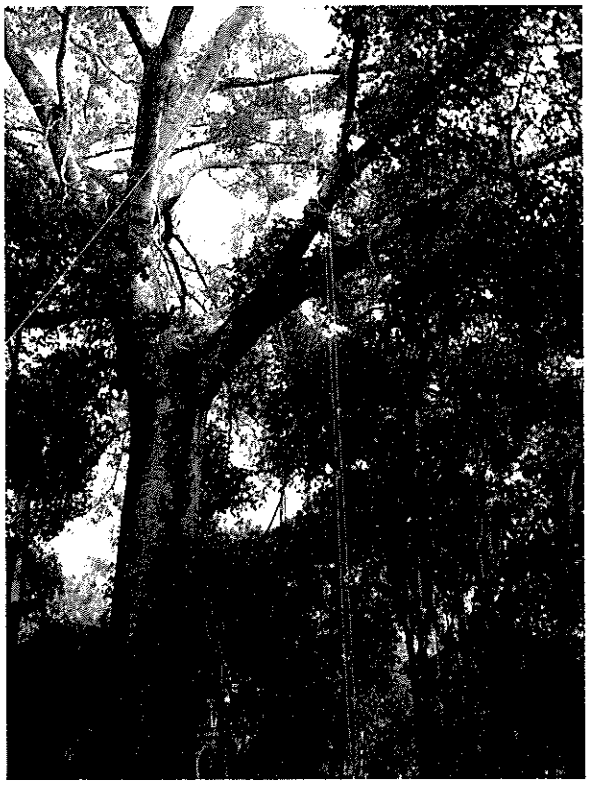


Figure 2. Epiphyte identification in the *Ficus Boliviana.*

For the purposes of this study one branch per tree accounted for a sample transect, which allowed the climber to gather a detailed profile of one tree limb at a time. A maximum of three transects were used on each sample tree. The number of epiphytes were counted and recorded by the climber for each of the following families orchidaceae, bromiliaceae, piperaceae and pteridophytes. If the climber was unable to identify to the family level, then aerial photographs were taken for ground based identification by other team members and local guides. The width and angle from the main stem, of the sample branch was visually estimated from the climbing site.

Data collected from ground based surveys and *Ficus Boliviana* samplings was analysed statistically as diversity proportions to represent family diversity within logged and non-logged sites. The proportion of each epiphytic family observed was calculated for each site and then represented graphically as a Box Plot. The Mann-Whitney-Wilcoxon Rank Sum statistical test or a Normal distribution approximation, for the larger sized samples over 20, was carried out, on each site, to test the null hypothesis; there is no difference between the diversity proportions for each epiphyte family in the different study sites. For ground survey data, Control and Normal test sites were compared and for the *Ficus Boliviana* survey, the Control site was compared to Normal and logged sites.

The angle at the point of branching at zone 3 was analysed graphically against the diversity proportion of each epiphyte family in zone 3. The proportion of each family in each sample zone on the *Ficus*

Boliviana according to Control, Normal and logged study sites has been represented graphically in histograms.

Methodology Adaptations

In the original methodology, the team planned to collect and photograph epiphytes and identify each one to a species level, whilst creating a herbarium catalogue. In the field, the limitations of climbing techniques and equipment breakages made gaining close proximity access to remove plants and attain usable samples and photographs to produce the herbarium catalogue unachievable. This meant we were not able to identify at a species level, due to this we moved the identification back to a family level which was achievable through the knowledge of vegetative architecture. Furthermore with the forest study area being in a severe drought period, epiphytes were not flowering as hoped, further adding to identification problems if the species level study was perused. Robert Vasquez, a local epiphyte expert in Bolivia, advised us in person, that species identification would only be possible if the plants were grown until their next flowering opportunity, a year or more after collection, which would have stretched the achievability beyond our capabilities in the available time-frame. Due to the nature of the location of the research, in a maintained research area, it was unacceptable to aim to collect many samples, as this would have led to disturbance of the research areas. The combined factors caused the team to change their aim, avoiding plant collections and identifying the vascular epiphyte communities to family level.

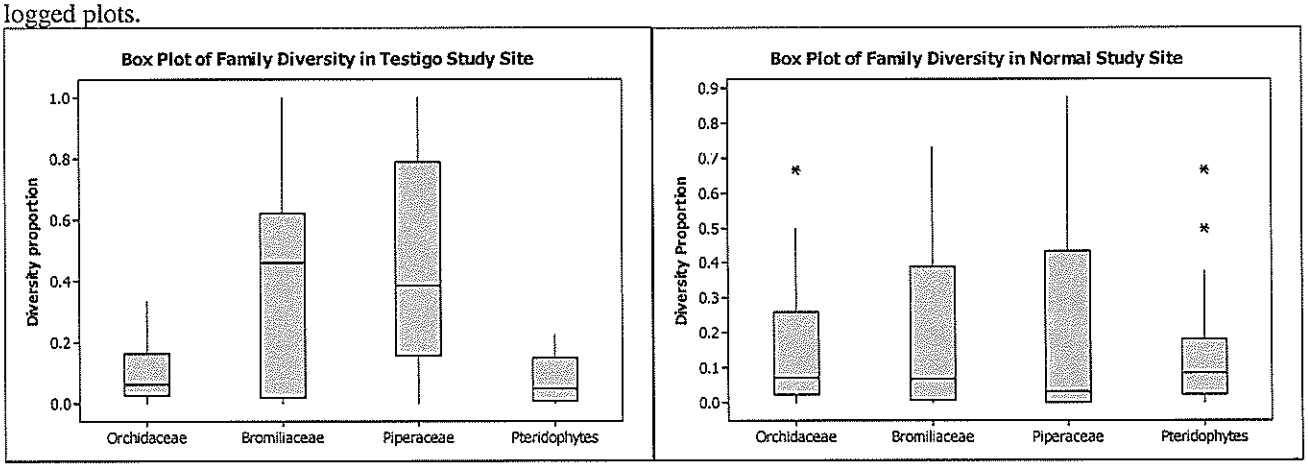
Results

Ground Based Survey

A comparison of the family diversity between Control (Testigo) and Normal (Normal) study sites represented in a Box Plot reveals an observed difference between each of the family communities in non-logged and logged areas. The Normal distribution approximation conferred a statistical difference may occur, at a 95% confidence interval, between the bromiliaceae ($|z_0| = -2.98$), piperaceae ($|z_0| = -3.56$), and pteridophytes ($|z_0| = -2.66$) communities of each study site. The Box Plot representations of bromiliaceae and piperaceae show a largely decreased median value in the logged site compared with the non-logged site and a decreased range only for the bromiliaceae family, Figures 1.1 and 1.2..

The orchidaceae and pteridophytes families show a very slight increase in median value and range between Control and Normal study sites, the difference being insignificant for only the orchidaceae ($|z_0| = 0.48$) and therefore the acceptance of the null hypothesis and the conclusion that with the data available, no difference between the proportion of orchidaceae in non-logged and logged communities exists. The presence of outliers in both the orchidaceae and pteridophytes families represents the location of large populations of one family in the community in particular areas of the study transects.

Figures 1.1 and 1.2. Box Plot representation of Vascular Epiphyte Family Diversity in the shrub layer of Logged and Non-logged plots.

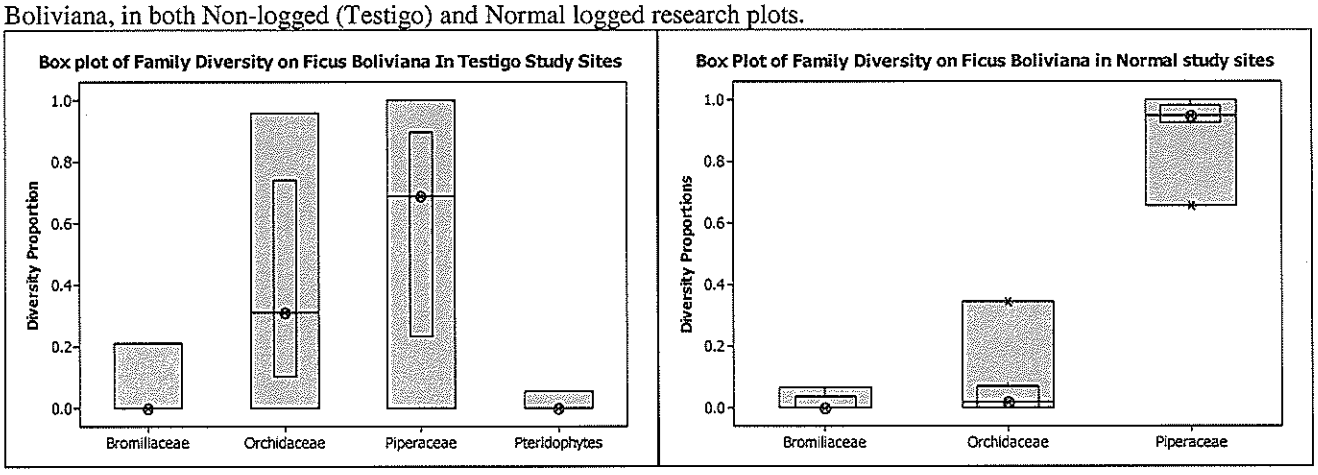


Across the Testigo study sites at some points the vascular epiphyte community existed solely of either bromiliaceae or piperaceae families, and yet in other areas of the two study sites (Testigo and Normal) zero epiphytes of each family were found. This represents the large variation in diversity across the relatively small study areas.

Ficus Boliviana Canopy Survey

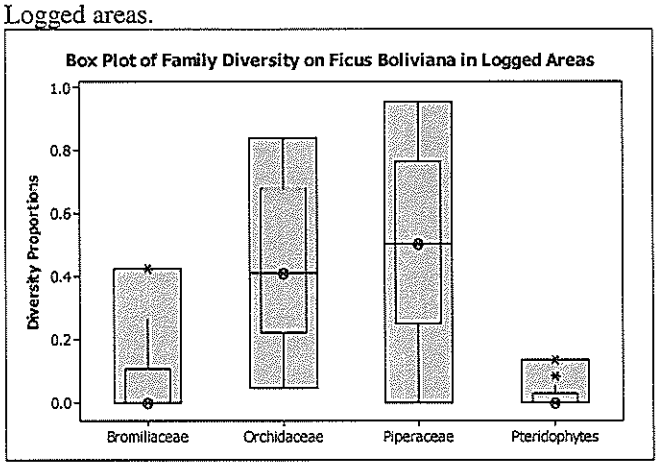
To test whether the two conditions, logged and non-logged, differ with respect to epiphyte diversity, the Mann-Whitney-Wilcoxon Rank Sum test was used between the Testigo site and the Normal study area. No statistical differences occurred between any of the vascular epiphyte families (not including pteridophytes, which were not present in the Normal study sites). Graphical evidence in the form of a box-plot, Figures 2.1. and 2.2., however, suggests a difference between the orchidaceae and piperaceae population diversities in non-logged (Testigo) and Normal sites. The sample sizes for the Testigo and Normal sites are drastically different, which is not represented in the graph.

Figures 2.1. and 2.2. Box Plot representations of the Vascular Epiphyte Family Diversity in the canopies of the Ficus Boliviana, in both Non-logged (Testigo) and Normal logged research plots.



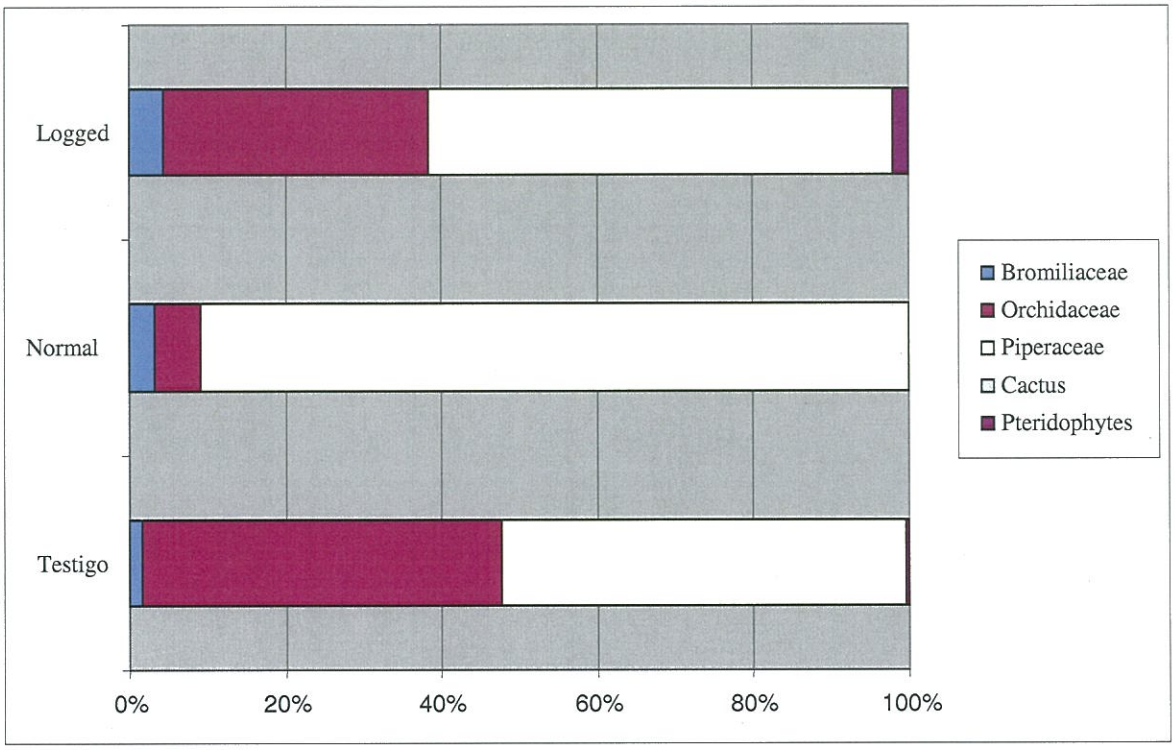
The Normal distribution approximation was used to compare the Testigo site with the Logged study area due to the larger sample size of the latter site. The results state that the null hypothesis must be accepted for bromiliaceae ($|z_0|$ = 1.49), orchidaceae ($|z_0|$ = 0.26) and piperaceae ($|z_0|$ = -0.66), to suggest there is no difference in the proportions of each family between the Control and Logged study areas. A difference was noted between the diversity of pteridophytes in the Testigo and Logged areas, however there were only 3 of 24 transects in which pteridophytes were found in the Testigo, allowing the numerous zero values to influence the overall statistical result.

Figure 2.3. Box Plot representation of the Vascular Epiphyte Family Diversity in the canopies of the Ficus Boliviana, in Logged areas.



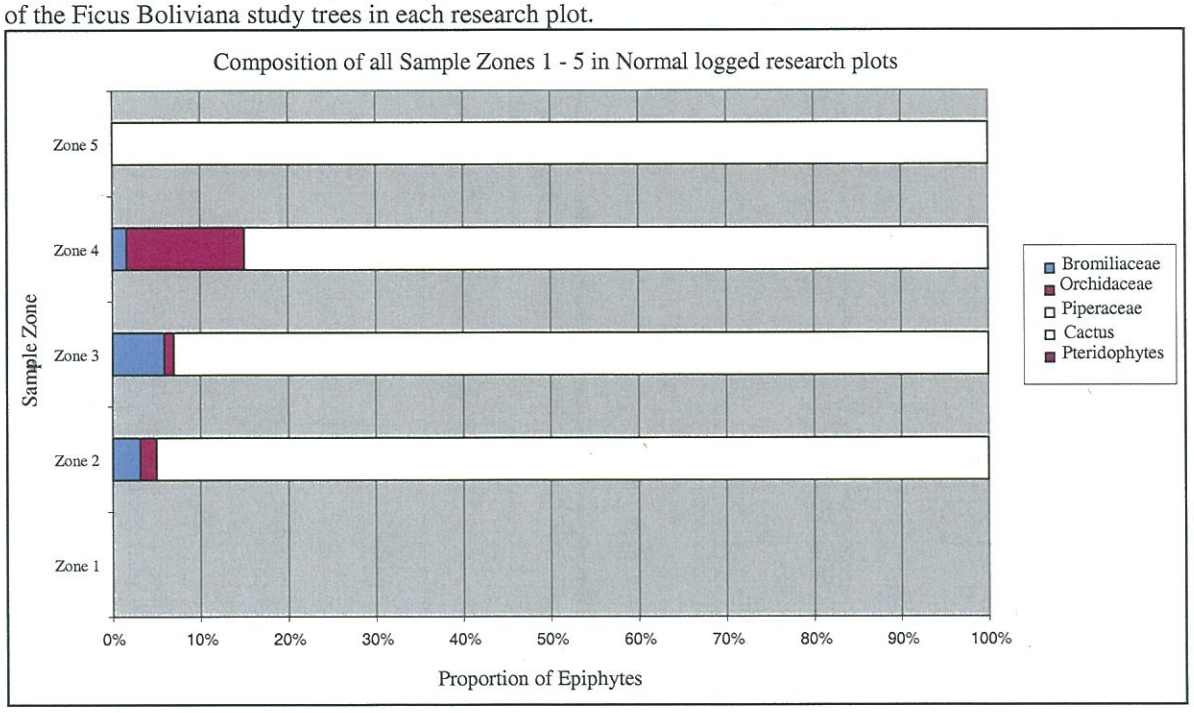
In the Normal plot, piperaceae (median = 0.9, $\mu = 0.92$) were the dominant vascular epiphyte family, whereas in the Logged and Testigo study sites, orchidaceae (L: $\mu = 0.41$, T: $\mu = 0.41$) and piperaceae (L: $\mu = 0.50$, T: $\mu = 0.56$) were almost equally as dominant. See Figure 2.4.

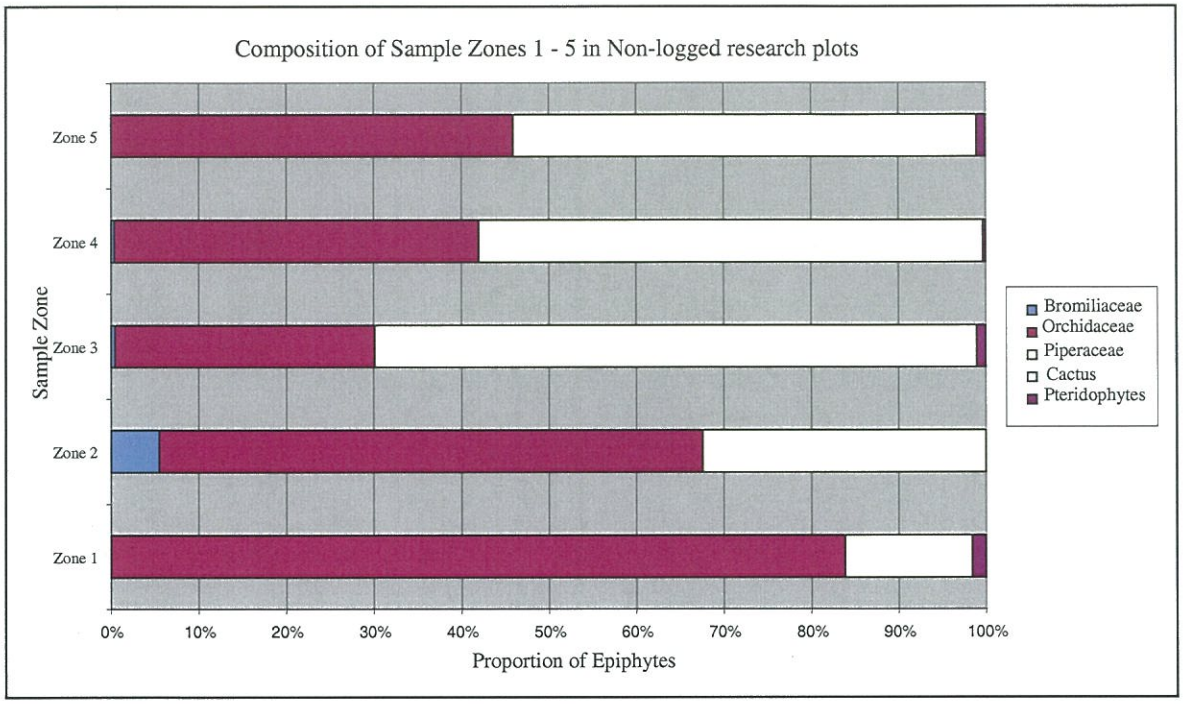
Figure 2.4. Graphical Representation of the Family Composition of the three research areas, Logged, Normal and Non-logged (Testigo).

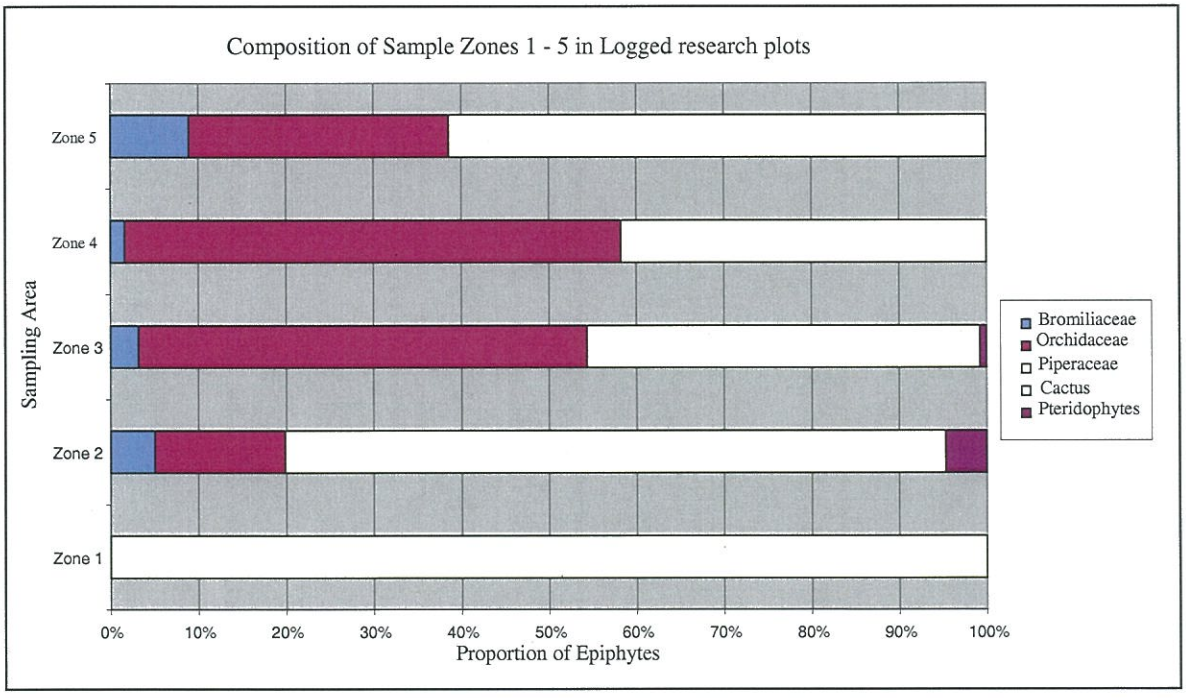


The diversity of vascular epiphytes varied according to Zone, within the three study sites. In the Control site orchidaceae contribute to 84% of Zone One. The proportion of orchidaceae decreases with an increase in the proportion of piperaceae across the Zones. Vascular epiphyte diversity is less diverse in Zone One of the Normal and Logged areas, which have none and 100% piperaceae respectively. Figures 2.5, 2.6 and 2.7.

Figures 2.5, 2.6 and 2.7. Graphical representation of the Family Diversity of Vascular Epiphytes in each Johansson Zone of the Ficus Boliviana study trees in each research plot.







The diversity of all Zones in the Normal plots is low, with piperaceae consisting of 85% or over in Zones 2 to 5. The Logged study area shows a greater diversity, with all four families present in Zones 2 and 3, and only lacking pteridophytes in Zones 4 and 5.

The diversity of the vascular epiphyte families varied according to the angle of the branch from the main stem. The branch angles between 15° and 65° were more common, (41% between 15° and 35°, 43% between 36° and 60° and only 16% between 61° and 90°).

Discussion

The epiphyte life span can be very different from one species to another, let alone one family to another. Some individual orchids can reach up to fifty years in age, where others may only last a year (Zotz et al, 1996). The nature of the vascular epiphytes is for communities to accumulate on a host tree according

to its age and size. The successional development and diversity is also partly decided by phorophyte representation (Freiberg and Freiberg, 2000). Studies in Bolivia by Ibisch (1996) have shown the earliest time an epiphyte community is likely to reach its climax is approximately 25 years. In general, epiphyte diversity and abundance are positively correlated to the successional stage of a forest (Gentry and Dodson, 1987).

Diversity is an indication of community composition rather than the straight out abundance or distribution. The comparison of diversity in a plant community is most applicable when being carried out on a species level. Although this study could not achieve this, interesting interpretations can be drawn on the family level diversity.

Ground Based Survey

The Mann-Whitney results showed a positive statistical result to bromiliaceae, piperaceae and Ferns having been affected by the change in habitat committed by logging. Numbers of orchidaceae however, seemed to be unaffected by the logging practices in the study area. This suggests that the impacts of logging on the dry, tropical shrub layer in the semi-deciduous woodland of our study site can be observed and quantified at the family level for vascular epiphytes.

Both bromiliaceae and piperaceae show, on average, a higher proportion of diversity in the Control (Testigo) plots compared with the Normal logged plots. The Control plots show a significantly higher number of established canopy trees than the Normal plots, due to the removal of on average 62 trees per plot (27 hectares) during logging. This change in canopy cover between plots will influence the amount of irradiation reaching the shrub layer and consequently resulting in a change in the habitat characteristics (Benzing, 2004). A change in canopy matrix will affect the air moisture levels within the shrub layer, therefore affecting a key factor determining an epiphytes ability to occupy such a habitat (Freiberg, 2004). Studies by Hall et al. (1998) showed that a total of 43 epiphyte species were present in a primary forest in contrast to after logging activities where this number was drastically reduced to 1 epiphyte species being present. The change in the bromiliaceae community could be directly contributed to the changes in microclimate as many bromeliads show specific demands to humidity (Griffiths et al, 1984).

"Orchids are the richest family in the neotropics, constituting in some regions up to 57% of epiphyte diversity." (Ibisich, 1996). Orchids are also an important part of the epiphyte community in the Guarayos forest reserve, with family levels accounting for a high proportion of epiphyte diversity. In ecological terms it is an important finding that in our study area normal logging practices are having a minimal effect on the orchidaceae component of the vascular epiphyte community diversity in the shrub layer.

For the four families researched the proportion of diversity range has remained at similar levels in both treatment plots; normal logging and the control. This may suggest that not all the shrub layer in the normal plots has been affected by the logging of selected trees. Thus, allowing the possibility for undisturbed plot levels of epiphyte diversity to remain within the normal logged plots.

The shrub layer epiphytes are normally dependant on large mature trees that have upon them an abundant epiphyte community, which feeds the shrub layer below with seeds and asexual plant material, whose role it is to colonise the sub strata. When trees are selected for logging, normally the healthier and more vigorous trees are felled, as they represent the best tree architecture for timber processing and production. Although there are regulations to protect and maintain the number of healthy specimens in the forest as "seed trees" for regeneration, it has been seen to not always be adhered to in La Chonta Forest Concession. Therefore the choice of canopy trees selected for logging must also have an effect on the successional development of the vascular epiphyte shrub layer community.

Ficus Boliviana Canopy Survey

The removal of substantial trees from the normal and logged study areas had an effect on the diversity of the vascular epiphyte community in the canopy of these plots. The main difference that occurred in the overall community is that there was a decrease in the orchidaceae community. Studies by Barthott et al. (2004) found that the decreases in Orchid contribution, to overall species diversity, are mainly due to the less diverse Phorophyte structure and less differentiated microclimate in the disturbed and secondary vegetation compared to the primary forest. This is possibly similar to the reason for the change in our ecosystems.

Where the Orchid diversity decreases occur, an increase in piperaceae diversity proportion has replaced what has been lost. The species of piperaceae found at our study site, *Pepermonia*, are well known for being one of the few genera of epiphytes that have no mycorriza root relationship with a fungus. This makes them totally reliable on themselves for nutrient and water supply. This phenomenon has made them better suited for varied conditions in which an epiphyte might find itself (Benzing, 2004). It has been proven that anthropogenic disturbances also force a shift in species composition in an epiphyte community to more drought tolerant species (Wolf, 2005). These two ideas lend reason for piperaceae dominances in the new disturbed conditions. These changes are highlighted in the differences in zone diversity. Zones 1 and 2 show the most swing, from a majority of orchidaceae in non-logged forests to a majority of piperaceae in both logged areas.

Improvements

To provide the study with a greater insight into the effects of logging practices on epiphyte communities, it may have increased the study's potential if it were carried out in a region of forest where there is a more diverse epiphyte community. An area with a larger abundance of species and number present may have provided data which may show more clearly the effects of logging on an epiphyte community than was observed in the study area within the La Chonta Forestry Concession. The large epiphyte diversity observed in La Chonta would require an increased study area to account for any differences which may be present. Inevitable improvements to the study include an extended time frame and a larger research area, which would have benefited the canopy study due to equipment failure, amongst other reasons.

One option for the canopy study team to have considered would have been to reduce the number of sample trees and focus more on a complete coverage of a smaller number of trees, spending a larger number of hours rigging and climbing to gain access to all possible viewing angles. This would have provided a more in depth study of a reduced number of trees but may not have provided sufficient data for statistical analysis between varying logging practices. This reduced tree study may have allowed the team to gain closer access to the epiphytes being observed and allowed for species specific identification. As the climbing teams` first unsupervised study in a relatively hostile environment, it would require a large number of climbing hours and further training to develop the climbing techniques to gain close proximity branch access and increased lateral climber mobility. A large number of hours, approximately 90% of the research time, were spent rigging the study trees and only the remaining time sampling. For the climbing team to gain field experience of canopy access techniques and to be able to sample effectively, it was important to spend as much time climbing as possible.

Increased test plot areas in both the control sites and the Normal logging sites would have led to more random tree selection for the canopy study. It would be more suitable to sample logged areas, only from trees in the Normal study plots, however, due to the lack of safe climbing trees in these plots, the study was expanded to cover non-maintained research areas in sites which have less accurate information as to when logging took place.

Conclusion

Forest disturbance has a negative effect on the re-colonising of epiphyte communities on new and remaining trees (Wolf, 2005). Our studies have shown that the logging practices that are carried out in the La Chonta forestry concession have a changing effect on the vascular epiphyte diversity at a family level. This information is currently joining a mainstream genre of taxonomic and ecological epiphyte studies. To draw more conclusive answers, with reasons for change, more biological and physiological questions must be integrated into the studies. This information will be more constructive for NGOs and governments who are looking to reduce the impacts of logging on its native epiphytic flora.

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Investigation into Biomass Wastage through selective logging practises within the La Chonta Forestry Concession in Bolivia

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Abstract

This investigation quantified the amount of Biomass destroyed by the selective logging practises of the La Chonta forestry concession in Bolivia. One hectare of non-logged forest was studied in order to quantify the average amount of above ground wet biomass (m^2) within the La Chonta region. The area of damage created by the felling of a tree crown and its subsequent removal was quantified for 25 trees that were logged in the last three months. On average, the felling and removal of a tree causes 502.07 m^2 of destruction which results in 1286.314 kg of destroyed above ground wet biomass. It was also found that, on average, the logging process breaks or damages 37 commercial stems per tree felled.

Introduction

The world's forests are disappearing and the wildlife that roams within is suffering. Forestry is an ancient industry which is undoubtedly a contributor to this worsening situation. Valuable tree species are removed from the forest with little regard for the repercussions this can bring to the balance in the ecosystem. Where the act of clear felling occurs, the forest is stripped entirely, leaving nothing to remain but bare earth and tree stumps as a morbid reminder of what lay before. However, in many South American countries, including Bolivia, forestry is a vital component of the economy. More than 50 % of Bolivia's total land area is covered by forest, half of which is classified as highly diverse primary forest (Kreuger 2004). The annual value of Bolivian forest products is estimated to be approximately $50,000,000, and the industry currently employs 23,000 people (Mengabay). Fortunately, logging need not be such a force for destruction and degradation and, if managed properly, can be a tool to maintain and benefit the forest.

The La Chonta concession in the department of Santa Cruz has, according to Svensson (2000), has a positive effect on biodiversity and is considered to be a sustainable and cost-effective use of land in rural Bolivia. This is opposed to alternative practices such as slash-and-burn agriculture and cattle ranching (Kreuger 2004). Importantly however, the concerned consumer must be sure that the timber products purchased are contributing not to the disappearance of the forest but to its health and proliferation. A certification system is necessary to ensure both process and performance standards are met and that it can be translated into a national and regional context (Tickwell 2000). An unbiased inspection strategy coupled with the tracking of all timber, in order to record a "chain of custody" is essential. A record is required from the site of the felled tree, to the saw-mill, factories, warehouses, shops and finally to the consumer, to instil full confidence in the consumer that good forestry procedure and practice are being supported.

In 1990, a network of timber traders, environmental bodies and social organisations met in California, USA to address this need for identifying well managed forests as acceptable sources of timber

products. This umbrella organisation developed the name of the `Forestry Stewardship Council` (FSC). The FSC aimed to set the standards for responsible forestry, award accreditation to independent certifiers and introduce a logo to all certified products (Tickwell 2000). The La Chonta concession was certified by the FSC in 1998, and with the development of an Environmental Management System (EMS) will seek the International Organisation for Standardisation (ISO) certification for this management plan. Elements of the ISO certification require a management plan where continual improvement and correction routines are enforced (Marcus 1998).

After the new forestry law 1700 was implemented in 1996, every forestry management plan had to include (via a series of plots) a system which aimed to monitor the effects of logging and other Silvicultural practices on the remaining forest (Law 1700, Art. 28, 1996). Therefore in 1997 La Chonta not only managed a series 'Parcelas' (areas of forest which undergo different Silvicultural practices) but also adopted a more sustainable range of management techniques known as reduced impact logging (RIL). Bolivian forest management plans are today based on the removal of isolated mature trees on a sustained yield basis, with the goal of improving the overall commercial value of the forest. Minimum diameter-at-breast-height (DBH) cutting limits guide felling operations, and approximately 20% of trees above the diameter limit are left as seed trees to provide for subsequent, natural regeneration. (Kreuger 2004) The forestry regulations aim to minimise stand damage which increases the value of future timber (Feldpausch et al 2005).

RIL practices comprise harvest planning, infrastructure development, and operational techniques which aim to reduce the damaging impacts of timber harvest while improving the production efficiency of logging operations (Boltz et al 2003). It has been shown that RIL causes much less ground disturbance than conventional logging (CL) (Feldpausch et al 2005). It has also been shown to reduce operational costs and generate higher financial returns than CL. (Boltz et al 2001). However, it has not been proven that RIL techniques alone are sufficient for sustainable timber harvesting, even though they are an improvement compared to CL (Boltz et al 2001).

Currently, 18 commercial species are harvested in the La Chonta concession, representing approximately 15 % of the total species present (Kreuger 2003). The trees are pre-selected to be harvested based on diameter limits that vary by species from 50 to 70 (DBH) (Fredericksen 2003). Harvested trees are removed from the forest using rubber tire skidders that clear a trail from the main road to the selected trees, damaging a large area of forest and reducing over-story cover.

Disturbance caused by felled trees and skid trails can have both positive and negative effects on forest regeneration dynamics. Some light seeded, shade intolerant species benefit from logging gaps and have a high initial regeneration growth rate after a disturbance. Other less competitive species show problems getting established in the new environment. Previous studies have shown a decrease in the regeneration of commercially valuable species in the areas disturbed by skidders. In order for logging to be sustainable, the regeneration of seedlings and samplings of commercial tree species following harvesting must be assured (Fredericksen, 1999). Due to the time scale of the project (2.5 months) it would be impossible to perform a full scale regeneration study, which would take one to four years. Instead, this study will concern itself with assessing "damage" to all tree species <20 DBH as these are most commonly affected by logging practises, then using this information draw conclusions about biodiversity, commercial species damaged and biomass lost.

The investigation is concerned with satisfying two principal aims;

Firstly, to estimate the total above ground wet biomass per hectare of the Testigo plot and the average area damaged when one tree is felled within the La Chonta concession. Then, using this information, determine the average total above ground wet biomass destroyed when one tree within this region is felled and removed.

Secondly, to determine the efficacy of the reduced impact logging methods employed in the La Chonta region, via calculating the number of commercial stems damaged or broken when a tree is logged and removed.

A further investigation as to whether assuming tree volume as cylindrical with a diameter of DBH is an accurate method of predicting above ground wet biomass in comparison to reliable allometric equations will also be performed.

Study site

The study took place in the La Chonta Forest Concession (Fig. 1) in the Guarayos Forest Reserve, which is located 250 km north of Santa Cruz, Bolivia (15°45'S, 62°60'W). The La Chonta concession manages 220,000 ha of lowland, semi deciduous humid tropical forest, which accounts for 31% of all Bolivia's forested regions (SmartWood, 2000). The area has an average yearly regional rainfall of 1500mm, the majority of which falls between November to March and has a mean temperature of 24.5°C (Fredericksen, 2003). Although the concession is situated in entirely virgin forest, logging activities have been used for several years but cease almost entirely during December and January, the peak of the rainy season (Kreuger, 2003). The forest consists of 13% dense forest, 50% intermediate, and 36% thin forest that have been burned (Svensson, 2000). It is understood that tree species composition, when classified by market value, consists of 2% very valuable, 4% valuable, 39% with low value and 55% without commercial value. Species harvested at the concession according to Svensson (2000) are: Ochoó (*Hura crepitans*), Bibosi (*Ficus* sp.), Yesquero (*Cariniana estrellensis*), Ocorocillo, Serebó (*Schizolobium amazonicum*) and Yerdolago (*Terminalia oblonga*).

The concession is divided into areas named `Bloque` 1, 2 & 3, and within each, four plots of differing Silvicultural treatments exist. The site of the plots was chosen taking into account areas with similar tree densities using the existing tree records, as well as similar vegetation type and topography. Then the four different treatments were randomly assigned to each plot, except for the control plots, which were assigned subjectively to maximize the undisturbed buffer area around them. Each plot is mapped and maintained by Instituto Boliviano de Investigación Forestal (IBIF) who have classified each plot by differing Silvicultural treatments that take place there (fig 1.).

Figure. 1.

Name of Subplot	Description	Detailed Silvicultural Practices
'Testigo' Minimal management (control)	Typically 1-2 commercial trees per ha only and only 1-4 lianas per tree.	Liana cutting on some commercial trees when the trees were recorded in areas of normal logging. Therefore it could not be avoided when the plots were set in this area. However it is understood to only give a negligible impact. Essentially considered undisturbed.
`Normal` Normal Management practicc.	Same as `Testigo`	Liana cutting on commercially viable trees. An average of 62 trees are harvested according to La Chonta logging procedures. Harvesting of trees above 50 cm diameter at DBH, however above 70 cm diameter at DBH for species Ochoo (*Hura crepitans),* Mogno (*Swietenia macrophylla)* and Bibosi (*Ficus glabrata).* A proportion of crop (20%) left to act as reproductive trees to avoid genetic degradation. Directed logging to prevent accidents, facilitating the removal of the logs and preventing damage to other trees. Road planning based on a yearly census. Low and Intensive logging procedures.

Fig. 1. Detailed Criteria of Plot characteristics. The above table shows the *Silvicultural* methods employed within the test plots that were studied. (IBIF 2003)

Methods

Estimates of biomass loss in skidder operations

Biomass

An above ground biomass inventory of pristine forest was undertaken. 100m x 12m transects were randomly selected in two different IBIF control research plots, with a total area of 54 hectares. A total of 9.5 transects were surveyed, corresponding to 1.14 hectares of forest. The survey followed the methodology outlined by the RAINFOR group (Philips and Baker 2002). All trees with a circumference of less than 60cm were measured at diameter at breast height (1.30m). If the tree did not reach 1.30m, it was measured at 0.80m in the same way, and a diameter to height regression was utilised to correct for this. Trees below 0.80m height were not measured. A scribe recorded all data, and also noted whether the tree was broken above 1.30m, broken below 1.30m, leaning, dead, or if it had multiple stems. The species of the tree was recorded for every fifth tree, and a height recording of every fifth tree was also made, using a clinometer or, when possible, a tape measure.

Species recording

For every fifth tree measured, the species was recorded, with the help of a guide. The species were then classified into families, and the total number of families in the 9.5 transect was calculated. Out of these, the 10% least common species/families were excluded, as we do not regard them as being representative for the area if they only occur once or twice in a total of 1.14 hectares.

A regression analyses on the allometric relationships between height and DBH was performed, using Minitab. To compensate for human error and unreasonably large or small height to DBH ratios, height data were excluded from the analyses on the following premises: first, all trees that had been noted as broken above 1.30m, broken below 1.30m, leaning or dead was removed, since these would be unlikely to represent normal height to DBH ratios. Then, all remaining extreme values of height to DBH ratios were looked at individually, and unreasonable values were discarded as errors being made either from measurement, scribe, or data input. From this regression line the heights of all trees of unknown heights were predicted, and the data could then be used to predict biomass.

Two methods of biomass prediction were performed. Firstly, the allometric equation obtained by Steininger (2000), and secondly, a simplified method which assumed trees as cylinders.

Method 1: The Steininger (2000) Allometric Equation

There are several equations published in Steininger's work, however, only one of these allometric equations is applicable for the species within the test plot. The equation models all hardwood trees <16m in height, and as only three of the individuals measured in the Testigo test plot did not fall into this category as they were 1m over the height restriction, this was the only equation used. The equation is as follows:

Wt.=[10^(0.860 log(100* DBH^2*H)+0.20) +10^(0.612log(H*DBH^2)+0.40)]/1000

The data, after being processed as described above, was inserted into the equation using the excel spreadsheet, and the Estimated Volume of the Total Above Ground Wet Mass of one hectare was calculated.

Method 2: The Cylindrical Method

An investigation to whether biomass could be estimated by assuming all trees as cylinders with diameter of DBH and of measured height was also performed. It was assumed that by simplifying the tree into a cylinder, the amount of biomass added is equal to that taken away by the branches (see fig 2.).

Therefore, using the predicted heights and the known DBHs, the total volume of the above ground biomass was calculated using the formula:

π (DBH/2)^2*H = Volume (cm^3)

Where H = Predicted height of the tree
DBH = Diameter at breast height (cm^3)

Figure. 2. Details the assumption that each model has equal Biomass

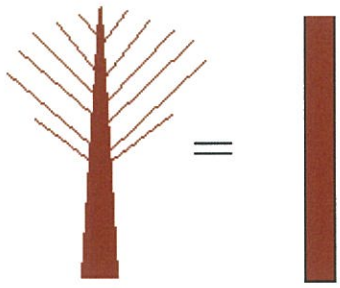

Fig. 2. The Cylindrical method is based on the assumption that the total wet biomass of a tree is equal to that contained in a cylinder of equal height and with a diameter equal to the trees DBH.

The sum of the all the volumes calculated was used to calculate the estimated total volume of above ground biomass per hectare. Then, using the top 90% of tree species recorded in the La Chonta area, a density table was produced displaying the average densities (obtained from Baker et. al. 2002) of the trees in the Lower Quartile, the two Middle Quartiles, and the Upper Quartile. The percentage abundance of the trees in each grouping was then calculated from our species count data. Using the Percentage Abundance (PA), Average Density (AD) and total Estimated Volume (EV), the Estimated Volume the Total Above Ground Wet Mass of one hectare was calculated.

Area plotting

In recently logged areas, two main skidder trails were randomly chosen, named C4 (Block 3), and C27 (Block 1). These trails stretch from the main road and 1-2 km into the forest, providing access to the trees selected for logging. The damage from logging was measured as follows: Around each individual tree, the damaged area was outlined and then split into geometrical shapes, triangles preferred as they proved to be easiest to handle. Spray-painted poles were placed at each corner of the shape. The distance between each pole was measured using a tape measure. Along this line two angle bearings were taken using a compass, one from each direction along the line. All data was recorded on waterproof notepads, including an outline of all shapes and points showing how the areas are interconnected. Any trails made by skidders to access the tree were included in measurements of damaged area. The main skidder trail area was also measured. The total damaged area was then calculated with the help of Excel.

The above ground biomass previously calculated was then applied to the damaged area, to provide an estimation of the biomass lost in skidder and felling operations.

1) The efficacy of reduced impact logging techniques in La Chonta

The number of broken and damaged stems around each felled tree was recorded. A stem was defined as broken when broken below where it branches, whereas a damaged stem was not broken below where it branches but visibly damaged. The stems were classified into four categories:

1) Damaged, commercial stem
2) Broken, commercial stem
3) Damaged, non-commercial stem
4) Broken, non-commercial stem

In addition, the diameter of broken or damaged trees was recorded at breast height for stems with a circumference greater than 60 cm. With this information the ratio of commercial to non-commercial species damaged in the Testigo and both the Carrils was determined. Using this information, it was possible to determine the average number of commercial stems per hectare, and therefore, the average number of commercial stems damaged when a tree is felled.

Results
Characterisation of Testigo Forest.

The Total Area Characterised (TOC) within the Testigo plot was 1.14 hectares. All 4375 trees of <20 DBH were measured within this area, 615 of which were of known height and species. Using the trees of known height a regression line was calculated (*Fig. 3.)* to predict the heights of the trees within the Testigo plot where this parameter wasn't measured. The equation shows a linear relationship with an equation of y = 0.7116 + 1.3687, the best R^2 value obtainable with the collected data was 0.727.

Method 1

The first method used to estimate Total Above Ground Wet tree Biomass was to use an allometric equation obtained from Steininger (2000):

Wt.=[10^(0.860 log(100* DBH^2*H)+0.20) +10^(0.612log(H*DBH^2)+0.40)]/1000

The equation is appropriate for all of the top 95% of species which were present within our Testigo transects. Using this equation, the biomass was calculated. The area of Testigo plots characterised was 11400 m^2, and total calculated biomass for trees <20 DBH within that area was calculated to be 29209.24 kg. Therefore, on average, using Method One there was found to be **2.562 kg.m^-1 of biomass within the Testigo plot.**

Figure 3.

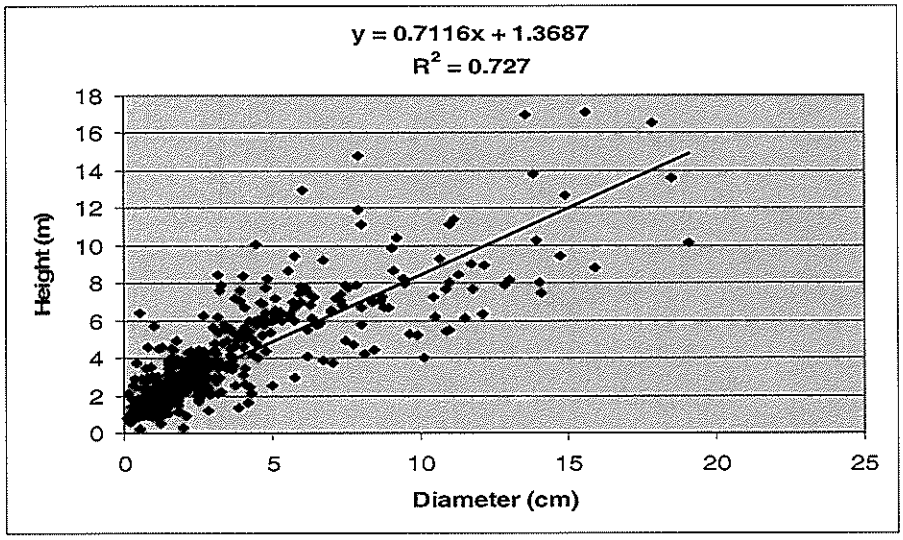

Fig. 3. shows the regression line calculated from trees of less than 20 DBH and of known height. The equation for the regression line is y = 0.7116 + 1.3687, with an R^2 value of 0.727. This equation will be used to predict the heights for which this parameter is unknown.

Method 2

Using the regression equation, the Total Volume (TV) of the above ground biomass was estimated; 73.50752m^3 was calculated within 1.14ha. Therefore, the Estimated Volume (EV) was found to be **64480280(cm^3ha^-1).**

Using the following table (fig 4.), the average densities were calculated:

Fig. 4. Calculation of Total Above Ground Biomass

Species Density Grouping	Percentage Abundance (%)	Avg. Density (g/cm^3)	Mass (g)
Low (min – IQ1)	0.14	0.510504	4608440
Medium (IQ1-IQ3)	0.768889	0.653469	32397810
High(IQ3-max)	0.091111	0.755192	4436655
Total Mass (g.ha^-1)			41442000.91

Fig. 4. Using the grouped average species densities, percentage abundance and the Estimated Volume, the Total Above Ground Wet Mass of one hectare was calculated. (Densities from Baker, 2004)

Therefore, on average, using method 2, there is **4.14429kg/m^2** of biomass within the Testigo plot.

Method One produces a result that is almost half that of Method Two, which shows that the two methods produce drastically different results. The biomass (kg.m^-1) result from Method One was used for the wastage equation as it has been reliably tested, whereas Method Two was simply an inaccurate attempt to simplify Method One.

Wastage Calculation

Using the Average Biomass m^-2 calculated by Method One, it became possible to calculate the amount of biomass damaged or destroyed within Carril 27 (C27) and Carril 4 (C4) (*fig. 5.*).

Fig. 5. Wasted Biomass Calculation

Carril Number	Total Area Damaged (m^2)	Total Estimated Above Ground Wet Tree Biomass (kg)	Number of Trees within the Carril.
27	4701.9793	12046.47	10
4	7849.874	20111.38	15

Fig. 5. shows the total area damaged by the trees in Carril 27 and Carril 24, The Total Estimated Above Ground Wet Biomass was calculated from these values by multiplying by the average biomass (kg/m^2) calculated from the Testigo plot using Method One.

The Total Estimated Above Ground Wet Biomass for Carril 27 (containing 10 trees) was calculated to be 12046.47 kg, and Carril 4 (containing 15 trees) to be 20111.38 kg. The total damaged area to both Carrils was 12551.85 m^2. Using these values, the Average Wastage per Tree Crown was calculated:

Average Area Damaged by the felling of a tree within C27 and C4 is **502.07 m^2**.
Average Above Ground Wet Biomass Wasted per tree was **1286.314 kg**.

Ratios of commercial to non-commercial stems:

Fig. 6. Ratio of Commercial to Non-Commercial Stems			
Area Characterised	**Total Stems**	**Total number of Stems per hectare**	**Ratio Commercial to Non-commercial stems per hectare**
Testigo	4735	4153.509	0.11345
C4	1957	2493.034	0.257712
C27	518	1101.664	0.12854
Fig 6. shows the total stem count in each area, then, using the total area damaged, the total number of stems per hectare was calculated. Using species count data from each area characterised, the ratio of commercial to non-commercial species was then calculated.			

There were 40% less stems counted per hectare in Carril 4 than the Testigo test-plot. The stem count in Carril 27 was even lower, containing 70% less stems in comparison to the Testigo test-plot. It was then assumed that there were discrepancies in the method of stem count collection for Carril 27 and Carril 4, and that the total number of stems per hectare was assumed to be the same as in Testigo (4153.509). The ratios of commercial to non-commercial species in each area characterised are similar, so they are all considered to be relevant.

Using the data recorded in *Figure 5* the average ratio of commercial to non-commercial stems was calculated and found to be 0.1666. Therefore, on average, 37 commercial species are broken or damaged per tree felled.

Discussion

Biomass

The R^2 value calculated from the regression of height to diameter ratio was 0.727. A value of + 0.95 allows one to conclude that there is a strong statistically significant positive correlation. The value obtained in the regression does not allow, with full confidence, the prediction of heights of the trees that were not measured as this value is too small to reach the 95% confidence threshold required. However, the value is sufficiently high to draw a strong, if not statistically significant, conclusion.

The regression line is more accurate at lower diameter and height values and less accurate and precise at larger diameter and height values. Small trees, up to four meters, were measured using a tape measure fixed on a long stick. Large tree heights were measured using a clinometer. Clinometers are difficult to use in a dense forest where ground vegetation covers the base of the tree and its canopy is covered by other trees. This may be one reason for the low accuracy on larger values of the regression line. If this was proved, R^2 should be taken as larger. However, there may be other reasons as well, for instance, as different trees grow larger, their different life strategies make them structurally different and so have different diameter-height correlations. Also, human error is a feature which should undoubtedly be mentioned. This is especially noteworthy when considering the use of the clinometers to measure heights of trees. The clinometer is not easiest of tools to use in a dense, highly stratified forest, to see both the top of a tree and the bottom of a tree clearly to take a reading is difficult. The accuracy of the instrument itself is of some concern, with +/- 1 degree leaving errors in heights of trees, which could alter the strength of the regression value, especially for heights above 16 m.

Two different equations were used to calculate the above ground wet standing biomass. One equation was formulated from simple cylindrical volume equations ($\pi r^2 h$) calculations with standard species specific densities. Allometric equations outlined by Steininger (2000) which account for family specificity, within differing height ranges, were also used. Steininger's equations are more complex and account for the form of a tree much better than very basic cylindrical equations, which produced a biomass (kg/m^2) almost double that of the more complex allometric equation. There are several

equations published by Steininger (2000), but do to the species composition of the La Chonta Logging Concession, only one of these was applicable to the population we studied. There is an equation available for trees with heights over 16 m for the family Moraceae, but the total proportion of this family as well as the small numbers of trees recorded over 16 m (only 0.008 % of the total) made it unnecessary to apply a separate equation for these. Therefore, it is not appropriate in this case to assume that trees can be modeled as a cylinder when calculating total above ground wet biomass.

The Testigo plot, which was our effective control, was more disturbed and affected than detailed by the IBIF documents. There were more disturbances in the form of widened paths, litter and other research infrastructure already set for other studies, for example, litter traps. This makes the exact extent to which they could affect our study unquantifiable. Edge effects of the paths are probably the greatest feature which needs to be outlined and which could have affected our results most dramatically. Whilst effort was made to ensure that every transect was at least ten meters from any path disturbance, the test plot paths do sometimes have to be redirected where large fallen trees have interrupted the paths, forcing new paths inside the test block area. This may have affected light access within the transects, and affected the species stratification in this area unfairly. To diminish the effect of paths in species quantity and composition, transects should be ten meters apart from the paths not only in parallel to the paths but also perpendicularly.

Also, only trees with a DBH of less than 20 cm were measured. The reasoning behind this was that we only needed to record biomass which could be destroyed indirectly by logging practices. This value was calculated from an initial survey of a single skid trail and felled tree area. It was found that the skidder would or could not skid over a tree which was greater than 20 cm DBH. However, the trees damaged when the crown falls were commonly greater than 20 cm DBH, were not measured. The inclusion of such trees would greatly increase the Total Above Ground Wet Biomass destroyed by the felling of a single tree. Although logging and skidding did not affect a certain quantity of trees within the areas defined as damaged, which may largely compensate the defect of exclusion of larger trees.

Selective logging in La Chonta fells one species at the time. The species chosen is sometimes dependant on the demand from the customer, although they have to conform to published guidelines. Our area plot measurements for the destroyed areas were done when a few of the intended species had been logged, but not all. Trees near the carrils were marked to be felled in the future. This will cause additional damage to the area and makes it difficult to conclude how much damage is caused by each tree species. Each subsequent tree will most likely cause less damage to the area than the previous one, since the same skid trails and carrils can be used again, damaging less pristine forest. It is therefore impossible to conclude, without further investigation, any relationship between the indirect damage caused by the carril length and the number of trees felled.

Ratio of commercial to non-commercial species

It can often be difficult to identify both commercial and non-commercial stems in the logged areas. Some areas were so severely damaged that they were inaccessible to people and fallen tree crowns could completely obscure large areas where stems could be present. This would certainly account for the large discrepancies in species density where 40% less stems counted per hectare in Carril 4 than the Testigo test-plot. The stem count in Carril 27 was even lower, containing 70% less stems in comparison to the Testigo test-plot. In further studies it would be helpful to include correction factors, whereby areas obscured by large felled trees could be included in identification by simply predicting the number of commercial and non-commercial species from known species-density data.

Another possible source of error in the damaged stem count could be that the count was done by a different group of people, probably with different criteria, and the count was done before the damaged areas had been defined. This may lead to discrepancies between number of trees found in a determined area within the Testigo plot, and the number of trees counted in an area that was determined "after" the

tree count in the logged area. The best way to find out the number of trees damaged by logging and skidder operations would be the set out small plots around the tree to be logged and the count of stems in these plots before and after logging and skidder operations.

Unfortunately, the carrils had been logged at different stages, leaving different amounts of time between the logging and data collection. Carril 27 was not logged for three months whereas Carril 4 had been logged only three weeks previously. Therefore the extent of forest regeneration in each of these areas could have differed. However, on these time scales, it is unlikely that there was much difference between species composition and extent of growth to have affected the results significantly (Chapman & Chapman 1997). It is more likely that the extent of the gap in the canopy area, the disturbance to the soil and thus the seed bank, would have a far greater influence on the stratification and growth in these areas. Therefore, counting commercial and non-commercial species in the two differing areas is not effected by the differing usage durations of the two areas and is not a significant problem.

Improvements and further research

If our study was to be repeated there are a number of improvements that could be carried out, in particular to the methodology of the investigation, in order to increase the reliability and significance of the results. Our fieldwork was restricted by time and resource limitations, and perhaps our lack of experience of working in the forest and our basic knowledge of local species. An example of this is that we measured the diameters of 4375 trees in the control plot, but only recorded the height and species of every fifth tree due to time restraints and restricted availability of experienced local guides. This meant that we were only able to use the data for 615 trees in the height to diameter regression analysis. The regression may have been more significant if we had a greater sample size, and this could have been achieved by more efficient methodology. If, instead, we had measured the diameter of every second tree in the forest, and recorded the heights of every second measured tree, we would only have needed to spend time measuring the diameters of half as many trees, but would have gathered more than twice as much usable data for the regression analysis.

Human error may account for some of the ambiguous results. Efficiency and accuracy of the data collection sometimes seemed to correspond to the working conditions in the field. In less favourable conditions, for example in high temperatures or on days when there was a particularly high abundance of flying insects, it was physically (and mentally) harder to take measurements so the data collected may have been less reliable than in preferable conditions. Communication limitations between Spanish speaking guides and English speaking students may have resulted in some of the measurements dictated to the scribes being recorded incorrectly, though this is unlikely to be a significant factor.

The reliability of our data collection would have been greatly improved if we had used more advanced equipment to aid our measurements. It has already been discussed that the reliability of the height measurements using the clinometers was uncertain. Much greater accuracy of measurements could have been achieved by using laser technology, although this was beyond the budget of the study. Devices using lasers give highly precise readings, are much faster and easier to use than clinometers and have the added advantage that they can store electronic data gathered in the field to be uploaded later onto a computer for instant analysis (LaserTech.com). The disturbed areas may have been more accurately measured using aerial laser technology or advanced Global Positioning Systems devices.

For analysis of the control biomass data, we did not include any figures for broken or leaning trees, since it was not possible to apply the standard diameter to height ratios to them. In any forest a high proportion of trees might not conform to the 'standard' architecture, and yet they still make up a significant proportion of the total biomass, so exclusion of these individuals quite likely led to an unrealistic quantification of biomass in the control plots. A more direct way of calculating the amount of destruction caused by harvesting a tree, as opposed to calculating areas and making comparisons to

the control biomass, could have been to quantify the number of stems and to identify all the commercial species in the surrounding area immediately before and after the tree was felled.

It would be interesting to extend the time span of our investigation over a number of years to investigate the regeneration and succession dynamics of the disturbed areas around each of the felled trees we studied. We classified stems affected by the felling as damaged or broken but we do not know how well either group would recover given time, and whether there would in fact be any differences in their regeneration. Annual surveys and inventories of the study sites would allow us to document the recovery of the forest after logging.

Appendix 1. Reason for changes to Wastage Project

The initial aim of Project Wastage was to quantify wastage in two stages, direct and indirect. Direct wastage was defined as the biomass discarded from an individual tree in its passage from felling to saw mill, and indirect wastage was defined as any collateral damage and living biomass disturbance that occurred in the process of felling and extracting a tree.

The direct wastage required us to work alongside the logging crew to be able to follow the wasted sections of wood from the forest via the loading area to the saw mill using the `chain of custody` system to monitor the overall wastage as the tree under went all processing steps. Our objectives for direct wastage were to characterize species specific wastage throughout the cutting, processing and production phases. The methodology included taking mass and volume measurements of wasted sections that were left behind in the forest after cutting, taking mass and volume measurements of wasted sections in the loading area after the logging had finished for the day but before the timber were transported to the saw mill, and recording volume of wasted sections in the La Chonta saw mill. Unfortunately, during our two months of field work, logging did not take place in the area. The only logging that occurred was for wood required for infrastructure for the roads and bridges within the concession and therefore undergoes an entirely different protocol and system of extraction and processing which is unfortunately not applicable for our project. These circumstances forced us to change and adapt the project to a large extent, focusing on the indirect wastage rather than the direct. Therefore, the areas surveyed in the indirect wastage projects are extended beyond what was initially intended, providing more accurate data. In addition, a complimentary study to the effect of logging on the canopy using hemispherical photography was made, where a skid trail was surveyed for leaf area index, to be compared to the total area destroyed by the skidders. A feasibility study on weighing was also conducted, where an entire tree crown was cut into manageable pieces, weighed and measured. The methodology was then assessed in terms of accuracy by comparing the results with existing density data, and in terms of logistics.

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Analysis of the Leaf Area Index within three plots of the La Chonta Forest Concession using Hemispherical Photography

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Key words; Hemispherical; Leaf Area Index; La Chonta, Lowland Forest, Canopy

Abstract

This investigation compares, using hemispherical photography, images to calculate the difference between canopy openness of control sites, logged areas and carril trails in the La Chonta concession in Bolivia. Although this technique has some problems it is generally regarded as the standard method for measuring canopy openness. In total 3.81 hectares were photographed in these areas and analysed digitally. There was a significant difference between the canopy openness of the control and logged sites ($t = 3.22$, $p = 0.001$), where the logged areas had far greater canopy openness and also between the control site and the Skid trail ($t = 19.74$, $p < 0.001$) where the Skid trail was far greater canopy openness. Therefore regeneration dynamics are accelerated in these areas altering species composition with time.

Introduction

Acronyms: LAI - Leaf Area Index

Hemispherical canopy photography is a technique used to measure sub-canopy light conditions; it involves the analysis of photographs taken from a specific measurement point using a 180° "fisheye" lens, then, through photograph analysis, infer properties of the canopy. The method has advanced rapidly since its conception by Anderson (1964) to where it stands today, a rapid computer program analysis of large numbers of digital hemispherical photographs. Studies, such as Barrie *et al.* (1990), Rich *et al.* (1993), and Easter and Spies (1994), suggest that computerised analysis of hemispherical photography is a reliable and accurate method, and Jennings (1999) states that it has become the standard method for researchers to measure canopy openness.

This study aims to characterise the forest canopy using the Leaf Area Index (LAI) which Riaño (2004) states can be calculated from Passive Optical Remote Sensing which, in this case, is hemispherical photography. LAI is the total canopy area expressed per unit ground area (Van Gardingen et al. 1999) and it is an important parameter of the forest canopy as it dictates its interception of radiation. LAI is important in many ecological processes such as transpiration, evapotranspiration and photosynthesis (Pierce & Running 1988), and has also been used to predict future vegetation growth (Coops et al, 2004). Both logging and skidder trail production will decrease the LAI due to canopy damage and therefore increase the amount of radiation reaching the forest floor. This will consequently increase the growth rate of that area (Dupuy et al 1999).

However, hemispherical photography, as with other remote sensing techniques, is associated with several problems and assumptions as detailed by Roxbourgh and Kelly (1995). Principally, it is assumed in the computer analysis that leaves will completely block the passage of light towards the forest floor and that transmission of light through leaves and reflection of light by leaves are completely ignored. Under computerised analysis, canopy areas are assigned to either black (blocked

light) or white (open sky). This brings about errors where reflected or transmitted light from leaves is recorded as open sky, therefore decreasing LAI. Computer analysis programmes also assume that the canopy area above the camera lens is one layer, and consequently leaf proximity to the sensory device is not taken into account which will also affect LAI. Roxbourgh and Kelly (1995) go on to conclude that, if the previous problems do not cause unacceptable errors, hemispherical photography can be a useful tool for measuring percentage canopy openness, gap formation and closure, and other physical properties of plant canopies. This study is concerned with testing two null hypotheses;

i) There is no variation in LAI between Normal and Testigo plots
ii) There is no variation in LAI between Skidder and Testigo plots

The first null hypothesis will be tested by performing a direct comparison of LAI between Testigo (Minimal Management) and Normal (Standard Management) test plots in the La Chonta Forest Concession in order to assess the effect of the two silviculture treatments on the canopy within those areas.

The second null hypothesis will be tested by performing a direct comparison of LAI between Testigo test plots and a skidder trail, named Carril 27, to characterise the extend of canopy damage caused by skid trail production on the canopy of the La Chonta Forest Concession.

Study Areas and Methods

Study Area

The study took place in the FSC certified La Chonta Forest Concession in the Guaryaros Forest Reserve, which is located 250 km north of Santa Cruz, Bolivia (15°45'S, 62°60'W). The La Chonta concession includes 100,000 of lowland, humid tropical forest which has an average yearly regional rainfall of 1560mm the majority of which falls between November to March and a mean temperature of 25.3°C (Gill, 1997). The forest consists of 13% dense forest, 50% intermediate, and 36% thin forest that has been burned (Svensson, 2000). Three plots named Bloque 1,2 & 3 were used which are mapped and maintained by Instituto Boliviano de Investigación Forestal (IBIF). In each of the plots there where further subplots were different silvicultural treatments had taken place. The study was carried out in undisturbed plots with minimal management and plots of standard silvicultural management. The undisturbed areas, named `Testigo`, have the sole management practise of restricted liana cutting which gives negligible impact. The standard silvicultural managed areas named `Nomale` have an average of 62 trees extracted per plot and are removed in accordance with La Chonta Concession logging plans. Liana cutting occurs on commercial trees above a set diameter limit in preparation for harvesting . Exactly 20% of commercial species are retained to act as seed trees. The subplots are areas of 450m by 600m which are divided into 50 m^2 by footpaths running on an East-West Y axis and North-South X axis. A second study was performed on a Skid trail leading to 12 trees logged in Febuary 2006 called "Carril 27". It was formed by a skidder vehicle which destroys all trees <20 DBH.

Digital Photography

A Nikon Coolpix 5400 digital camera with an FC E9 0.2x fisheye conversion lens was used via a Nikon UR-E10 adapter to capture the images giving an almost 180 degree view. The camera was set at the widest angle with a focal length of 35mm, mounted on a tripod with the top of the fish eye lens 1000 mm from the ground, levelled with a bubble spirit level and orientated to true North using a compass. The automatic setting was used to select suitable aperture and shutter speeds and the non-flash function was selected for each individual image. Photographs were taken between 6.30 and 8.30 am and again between 3.30 and 5.30 pm or at anytime during overcast days. This avoided taking images in direct sunlight where subsequent lens flare can interfere with analysis, and also prevented the capture of bright reflections on leaves in relatively open canopy which can often be mistaken for areas

of sky during analysis. Images were of 5.1 mega pixel quality under the fine setting and used JPEG compression so each image was 1 MB.

Images were taken at 10 m intervals along a 50m transect. When a spot was unsuitable (due to interferences resulting from immediate shrub layers e.g. liconias and lianas directly covering lens or occupying its designated position) these were removed or the camera was replaced perpendicularly at a maximum of 1m from the transect at the photographer's disgression. Transects were generated randomly using a random number generator which translated into X and Y axis within the blocks. The start of transect was then taken 25m North of the coordinate (halfway up the x axis of the 50 m^2 area) on an Easterly bearing. 120 images were taken in the control (Testigo) and logged (Normal) areas which cover 1.2 hectares each. For analysis of canopy damage caused by the skid trail, a transect down the centre of the track 'Carril 27' was used for photography at 10m intervals for 1080m.

Image Analysis

There are several computer programs available for analysis of hemispherical photography. All images were uploaded onto the Gap Light Analyser, GLA_v2 software program. Faulty images where large obstructions, such as people, were captured were not analysed. Images that had evidence of bright reflections off leaves and lens flare were also discarded. Images were converted to binary format (black and white pixels) where the threshold was determined by the user to compensate for different light conditions. However according to Englund et al (1999), this could introduce errors in analysis as the user's judgement is imprecise. Canopy openness is the proportion of the sky hemisphere not obscured by vegetation when viewed from a single point. Canopy openness is used to calculate the effective Leaf Area Index (Jennings *et al*, 1999).

Results

The descriptive statistics *(fig. 1)* show that the mean LAI for the Testigo plots is the highest, the Normal plot is the median and the LAI for Skid plot is the lowest. Each of the plots display a similar Standard Deviation, however the Normal plot shows the most deviation from the mean. The standard errors of the means are also similar in each plot. The maximum LAI reading was obtained in the Testigo plot, and the minimum obtained in the Skid Plot. Comparison of the Inter Quartile Ranges show that the Skid plot showed the most range within its sample set.

Fig.1. Descriptive LIA statistics from Normal, Testigo and Skidder plots

Plot	Number of photos	Mean LAI	Standard Deviation	Standard Error	Minimum	Maximum	1st Quartile	3rd Quartile	Interquartile Range
Testigo	141	1.9235	0.2227	0.0188	1.4700	2.5800	1.7700	2.0600	0.290
Normal	134	1.8331	0.2436	0.0210	1.2800	2.4900	1.6675	1.9725	0.305
Skid	107	1.3509	0.2308	0.0223	0.8100	1.7500	1.2100	1.5300	0.320

Fig. 1. This table shows the descriptive statistics of the Leaf Area Indexes calculated through the analysis of the hemispherical photographs obtained within the Testigo, Normal and Skid plots.

The boxplot in *Fig. 2a* shows visually that the testigo plot contains less spread about the mean than the Normal plot, and that they are distributed normally with similar variances. *Fig 2b.* shows that the LAI of the Skid plot is considerably lower than that of the testigo plot, and that the Skid and Testigo plots are distributed normally with similar variances.

Fig 2a. Boxplot comparison of Normal and Testigo LIA´s

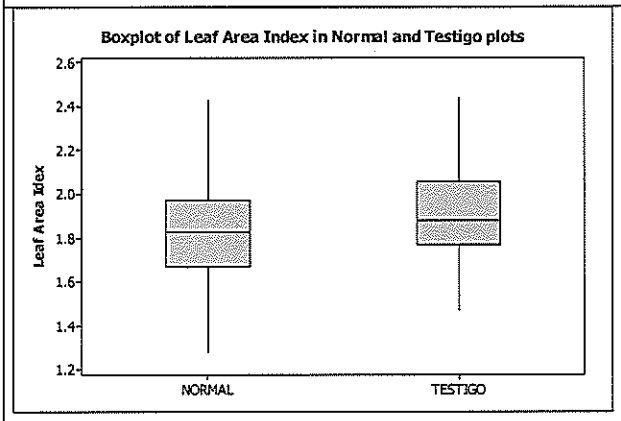

Fig 2b. Boxplot comparison of Testigo and Skidder LAI´s

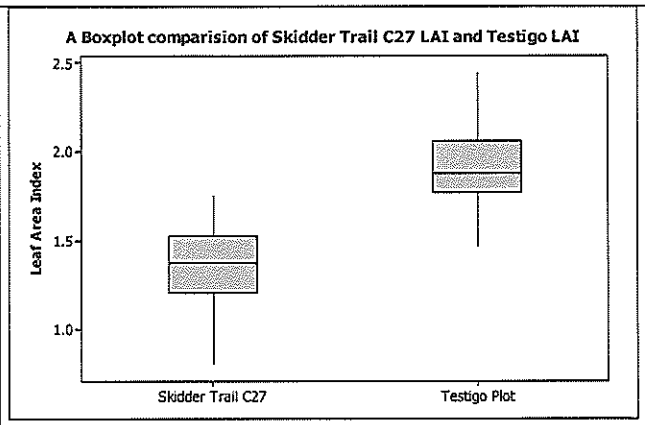

Fig. 2a. displays box plot summaries of the data calculated in fig 1. for the Normal and Testigo LAI´s. and Figure 2b. displays a boxplot comparison of Testigo and Skid LAI´s.

The Unpaired Two sample T-test (*fig. 3*) performed between the Normal and Testigo plots produced a T-Value that was statistically significant at the 99% level at 273 degrees of freedom. There was also a highly significant relationship found at the 99% level in the Unpaired Two sample T-test performed on the Skid and Testigo plots at 246 degrees of freedom.

Fig. 3. T-test results for plot comparisons

Unpaired T-Test performed between plots	**Degrees of freedom**	**T-Value**	**P value**
i) Normal vs. Testigo	273	3.22	0.001
ii) Skidder vs. Testigo	246	19.74	< 0.001

Fig. 3 shows the results obtained when an unpaired Two sample T-test was performed on the LAI data at a 99% level. The Null hypotheses were;

i) There is no variation in LAI between Normal and Testigo plots
ii) There is no variation in LAI between Skidder and Testigo plots

Discussion

Conclusions

The differences between the mean (see *fig. 1*) LAI´s and the distributions of LAI´s (*fig 2a* and *fig 2b*) of Testigo, Normal and Skid plots primitively indicates that logging in the Normal plot reduces canopy LAI slightly, and that Skid trail production drastically reduces canopy LAI in comparison with unlogged Testigo plots. The relatively small size of the standard deviations (≈0.23) and the distributions observed in *fig. 2a* and *fig. 2b* within each plot means that it is possible to conclude that the LAI´s varies only slightly within the plots and that leaf area is very consistent. The Testigo plots showed the least amount of variation within its samples. This was expected as the Testigo plots contain uniform pristine forest. The variation within the Normal plot was slightly higher due to selective logging within the plot causing a larger amount of LAI variation, due to canopy damage, than within the Testigo plot. The highest amount of variation was observed within the skid plot, due to the frequent changes in skid trail width. This results in the LAI of the canopy varying slightly more than that of both the Testigo and Normal Plots.

Both of the unpaired two sample T-tests performed produced statistically significant data. The first test, between the LAI of the Testigo and the Normal plots, produced a P value of 0.001. This allows us to reject the first null hypothesis that there is no difference in LAI between the Testigo and Normal plots. A hemispherical study carried out in the same area by Goddings (2005) not enough photos were taken

to establish a statistically different relationship (their sample size was 35). Using a sample size of 134 photos made it possible to determine that there was a difference between the two plots. However, the mean LAI of the Normal plot was only 4.3% lower than that of a Testigo unlogged plot. Therefore, in conclusion; the selective silvicultural treatment performed within a Normal test plot does cause canopy damage, but only to a small extent.

The second unpaired two sample T-test was performed on the Testigo and Skid plot Data, it produced a P value of <0.001, which is highly statistically significant, thus allowing us to reject the second null hypothesis that there is no difference between the LAI of a skid trail and a Testigo plot. In this case skid trail production reduced the mean LAI by 26.31% in comparison to the testigo plot. Therefore, it appears skid trail production causes a large amount of canopy damage resulting in a massive reduction of LAI. However, due to the differences in sampling methods between the Testigo and Skid trail plots, the LAI's are not directly comparable. The sampling method for the skid trail was to follow the length of the trail without deviating from the centre, thus making the sampling non-random, however this was the only possible method to adopt as complete random sampling in be unfeasible along a Skid trail due to the nature of its production. Therefore, in conclusion; Skid trail production does produce canopy damage and decrease LAI but the study has been unable to produce a valid statistical method or test to show this.

Limitations

Time was a limiting factor within this study. Due to the length of the window available to take photos in the mornings (06.30-08.00) and evenings (15.30-17.30) and the volume of photographs required to produce statistically acceptable data (>100), it was unfeasible to attempt to obtain data for the further two silvicultural treatments in the area. If a further study were to take place hemispherical analysis of Medio and Intensive silvicultural treatments and subsequent comparison with Testigo and Normal, would shed more light on the different treatments and the extent of canopy damage they cause.

The method for Skid trail analysis was also a limiting factor on the experiment. If a method could be found whereby the Skid trail areas could be sampled in a similar way to the Testigo and Normal plots, then a statistically significant conclusion could be obtained.

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Weighing as a method for quantifying logging wastage

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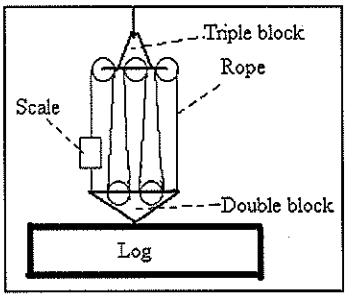
Abstract

A feasibility study on the logistics and accuracy of weighing the wasted mass of a felled tree, as an alternative method for biomass measurements, as opposed to the volume measurements widely used in forestry today, was conducted. The project objectives were to design and evaluate a method of weighing wastage in the field and to weigh the crown of a logged tree. The preparations and designs of the equipment were made in The Angstrom Laboratory, Uppsala, Sweden and the study was conducted on a *Verdolago* (*Terminalia amazonica*) crown that was logged three months before the study.

Methodology

The scale used consists of a 50 kg hanging scale from the Swedish company Vetek AB (product number KF 30L 50kg/20g), combined with a pulley system with blocks from Ronstan (product numbers RF20111, RF20212, RF20302) and a 3 mm rope with pre-stretched fibres. The blocks are ball-bearing blocks to ensure low friction. The rope thickness is also as small as possible to keep friction low. To weigh a log we put together the pulley system with the scale between the rope end and the lower block so that the weight is evenly distributed on 4 or 6 ropes, and the scale measures the force on one of those (fig. 1).



The log and pulley system is then lifted off the ground using a winch on a frame. The frame consists of 2 mm thick and 30 mm wide steel L-bars welded together into two big A-shapes that are then leaned against each other and secured by a bolt in the top and two side bars. The frame is 1.85 m tall when assembled.

Figure 1. Drawing of 6 gear pulley system

To ensure the accuracy of the scale and pulley systems, tests were made with known weights before travelling to Bolivia. The data from the tests have been statistically analysed using a regression and the resulting formulas for each regression have been applied to the measured values of the respective pulley configuration. To find the volume of the logs, three circumference measurements and a length measurement were made on each log. The circumferences were taken in the middle and on both ends. The total volume of the crown was calculated using two methods; in the cylinder method the mean of the three circumferences was used with the length to make a cylinder of each log and in the double frustum method every log was split into two frustums and the volume calculated for each.

Results

The linear regressions of the accuracy tests gave us the following formulas; for 4 gear pulley system: (actual weight) = (measured weight) / 0.9935 + 1.7397 with $R^2 = 0.9856$ and for 6 gear pulley system:

(actual weight) = (measured weight) / 0.9501 + 2.2433 with $R^2 = 0.9978$. In total 400 trials were made on 8 different weights. Other regressions were tried but linear turned out to be the most suitable, as expected.

The total weight of the crown with bramble was 1726.60 kg, and without bramble it was 1624.22 kg. The volume of all the measurable parts of the crown was calculated to be 2.118 m^3 using the cylinder method and 2.121 m^3 using the double frustum method. The calculated density of the crown was 767 kg/m^3 which is almost equal to the Verdolago wood density at 12% humidity content that is listed as 760 kg/m^3 (references 1 and 2). In terms of the project timing, it took four people less than one day to complete the entire crown and there were no problems with the equipment.

Discussion

Concerning logistics it is very feasible to use weighing as a method of quantifying wastage. The equipment is heavier and more expensive than ordinary tape measures but also more accurate and faster. The time it took was not unreasonable, especially as this was our first try and the working speed is likely to increase considerably with experience. Volume measurements were also done in tandem, which slowed us down and can be cut out as soon as the method of weighing is considered a reliable tool. One thing that should be kept in mind is that this is a very small tree crown for Bolivian standards. The process of weighing a Bibosi (*Ficus Boliviana*) crown, three or four times the size would be a different project, but weighing would still be expected to be faster than volume measurements.

The scale construction chosen could be replaced by a larger hanging scale without the pulley system to make the process easier and the results more accurate. However, the system used provides a high accuracy when used for weights close to the maximum capacity of the configurations (200 kg for the 4 gear pulley system and 300 kg for the 6 gear system). This is because of the friction force being almost constant and thereby being of less significance when weighing heavier loads. A good way of making the system better would be to add a 2 gear pulley system that would increase accuracy considerably between 50 kg and 100 kg.

When the crown was cut up it was done so without much planning. If the cutting of the crown was planned so that the pieces were close to one of the maximum capacities of the different configurations (50, 200 or 30 kg) the results would be more accurate. The density that we have calculated is slightly lower than expected. The moisture content in the crown is very hard to estimate, but three months is probably not enough to lower the moisture content to 12 %, but because of the crown being exposed to direct sunlight and the period being very dry and warm it is not entirely impossible. Other reasons for the low density could be the bark, which has a lower density, not being included in the listed values and the volume measurements not being exact.

There are a couple of weak points in this project. The volume measurements we have done are not accurate enough to make the comparison between volume and weight exact. It would also have been preferable to make thorough measurements of density on samples from the crown or do moisture content measurements to be able to get the exact density and therefore have an expected density to compare with. Unfortunately this project was planned and performed in a short period of time and therefore we were unable to do the accurate volume measurements and density measurements that would have made this study better.

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People's Relationship with Nature

A case study of two villages in North Eastern Bolivia with a focus on environmental awareness

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Abstract

The social study took place in two villages in the North Eastern part of Bolivia. The people's relationship with nature was studied through the methods of observation and semi-structured interviews. It was found that the informants were very knowledgeable when it came to their surrounding nature but that they showed much less knowledge on global environmental problems and environmentally friendly waste disposal. They hardly reuse and do not know the concept of recycling. Also, people in the research area were not aware that their forest is very unique due to its high biodiversity. Nature is viewed as a resource and therefore important to preserve. The villagers very much respect nature and condemn the procedure of forest fires which constitute a big problem in the area. Deforestation is as well increased through exaggerative logging but somewhat kept under control through the establishment of forest management plans. In general, there is a great need for environmental education and rapid behavioral changes in order to set the basis for environmental sustainable actions.

Introduction

Bolivia still has a wide range of intact natural resources and is on the verge of fully commercializing these. It is highly important that this process takes place as environmentally sustainable as possible. Of course, a country that is so far behind on the economical "development scale" does not prioritize sustainability. As any other country in the world, Bolivia also faces new external influences caused by globalization. The incorporation of these influences into the people's lives constitutes a challenge especially if the influences threaten the close relationship between the people and nature. These circumstances sparked the idea to study how close exactly this relationship is, how the people manage the changes that are happening in their lives and with what strategies they try to turn the challenge into something positive. Likewise, we also wanted to study the people's agency when it comes to environmental problems, their view of the environmental situation especially their concerns and how high their level of environmental education respectively awareness is.

As the international community is or will be a part of Bolivia's development financing different non-governmental organizations it is very important that the people engaged in NGO work get to know and understand the people they are creating projects and workshops for. To first understand the local level - the way the people think, their lives, problems, what is important to them – and then devise information strategies according to these findings will generate the biggest success. New regulations, enforced by the national government or project workshops developed by people from Westernized countries that do not have the Bolivian population as a starting point will create workshop situations where the people invited will not understand the message or will not be motivated enough to even come to the workshops.

In order to make future environmental projects most effective and in turn raise the locals' environmental awareness we wanted to carry out a social study whose findings enable projects to focus on topics that are most important to the Bolivian people. The study was concentrated on two villages in the Guarayos region close to the city of Santa Cruz where we spent two weeks in each village observing and interviewing people on their relationship with nature.

First of all, the reader will be introduced to the aims and purpose of the study in point three. In order to be able to contextualize the results the study site and its social background will be presented in point four. The methods employed can be found in point five which is divided into parts called informants selection, interviews, and problems with methods. After that we will present our results. This part will start with a brief introduction into the environmental problems that exist in the area. These were either named by the informants or also observed during the study time. The results were classified either as being part of the theme "Environmental Awareness" or "Perception of Nature". Point seven contains the discussion of our findings where it will be distinguished between aspects that describe the people's close relationship with nature and new external influences that represent a challenge for our informants. It will also contain a description of how the people try to incorporate both into their lives. Lastly the conclusion follows in point eight.

Aims and Purpose of Study

The main aim of the study was to investigate the people's relationship with nature. In order to achieve this, the main topic was divided into two different subcategories as following:

- **Environmental awareness:** How much do they care about nature? How aware are they of environmental problems in their vicinity and around the world? Do they recycle or reuse and if yes, what? What is their knowledge about nature? What is taught in school about nature? What knowledge about nature passes between generations?

- **Perception of nature:** Does their view of nature include a will of protecting it and do they consider it being important? If so, why do they want to protect nature? In what way is their view of nature different to the Western view of nature? Does their perception of nature contain nature as being something holy or mystical?

Site and its Social Context

The social study took place in the Guarayos Region relatively close (five hours by bus) to the city of Santa Cruz in the Santa Cruz de la Sierra department which lies in the North Eastern part of Bolivia. Santa Cruz is Bolivia's wealthiest city and the department is the economical heart of the country. During our research period, elections on autonomy were held in every department of Bolivia. Naturally, the Santa Cruz department was in favor of autonomy but up until our departure the President had still not accepted the outcome of the election.

Center of the Guarayos region is the town of Ascensión de Guarayos and scattered around it are nine villages of different sizes. We determined two of these villages as research areas; Yaguarú and Urubicha which are both situated about 40 km outside of Ascensión de Guarayos. Apart from the population size and amount of schools (Yaguarú: 1000 people, 3 schools; Urubicha: 6000 people, 6 schools) the two villages were very much alike in appearance, economical standards, composition of population, environmental problems, level of environmental awareness, existence of environmental education, and perceptions of nature. Our findings did not differ according to village. The following information will therefore be valid for both villages.

The villages' official languages consisted of the local language Guarayu and Spanish with Guarayu being spoken for the most part and Spanish being reserved for official usage. Every village is close to either a lake or a river, has a small hospital, at least one public phone as the only connection out of the village, several small shops, and a plaza where all social life takes place. It is common that every family has their own piece of land used for agriculture. They call it their *chako*. Together with hunting in the forest, the *chako* enables the people to live a greatly self-subsistent lifestyle. The high amount of young children that we observed in the villages was very surprising for European eyes. The villages apparently have a high birth rate despite the people's knowledge about and capability to buy contraceptives.

As our project was a part of a combined student expedition by the name of "Project Bosque" this Social study was carried out parallel to the Education study. This project aimed at raising environmental awareness amongst young school children through drama workshops. The reception in the villages was very good. Every person that we met was friendly and helpful. If one for example looks at the introduction of the environment awareness drama workshops that we carried out together with the Education project it becomes clear how welcoming and eager the directors and teachers of the schools were to work with us. We had offered the workshops as an extracurricular activity after school, but in the end we were given school time in order to secure high attendance. As the villages are not frequented by many foreigners and drama teachers are not common, the directors seemed happy to take our offer. Turning to the villages' environmental surrounding they are set in a humid neotropical forest. This kind of forest is characterized by high biodiversity and is considered intact. However logging concessions are highly active in the area.

Methods

Informant selection

When it came to selecting the informants for our study, our aim was to achieve a well represented view of the village population on the study subject. The selection of the informants did not only happen in one way, we used a mix of several ways to gather our informants.

The most frequent method that was used involved deciding on a range of informants that had to have certain kind of characteristics, such as age, sex, special occupation or social position in the village. It was important to us that our group of informants came as close as possible to representing the village composition of inhabitants. Because of the language barrier and lack of knowledge of the locals it turned out to be successful to ask our guide to find persons that fit our description as she was a local and already had many social contacts in the villages. We also chose informants without the help of our guide because of our close relation to them thus being easy accessible and as well singled out persons because of their profession or special knowledge.

Interviews

Before every interview questions were prepared to achieve a semi-structured interview. This model offered the opportunity to direct the interview into a certain topical direction. In the course of the study process, standard questions were also established.

It was always important that the informant considered the interview to be similar to a conversation rather than a rigid questioning session and that the questions were adjusted to the person's social context. This made it possible for the informant to contribute with personal stories or honest opinions and without being afraid of saying provocative statements. In every interview the person was asked to state their name (unless they wanted to be anonymous), age, profession and number of kids in order to personalize the received information and to be able to set the answers in the informants' social context. We debriefed the new information after every interview and decided what impact it would have on future interviews regarding questions and choice of informants for example. In order to make the interview situation as comfortable as possible for the informant, the interview took place either in the

informant's home or working place. The length of the interviews ranged between 45 minutes to 1, 5 hours. They mostly consisted of the informant, one main interviewer and two scribes. Depending on how fluent the informant was in Spanish, our guide/translator was present to translate from Spanish to the local language Guarayu and vice versa.

The translator was a local lady who as well functioned as guide in the villages. Her mother tongue was Guarayu but she was also fluent in Spanish. She was analphabetic, mother of six children and worked for IBIF (Instituto Boliviano del Investigación Forestal) which is a Bolivian institution monitoring activities in the country's forests. She was recommended by a European researcher working for IBIF as a good social communicator that had many contacts with the presidents of the villages as well as with many other key figures. With her help the project could set foot in the research area more easily and establish relationships with the population. Although she worked for IBIF she was independent whilst working with the project, meaning that people were able to speak freely in front of her. She was foremost a translator and guide. The fact that she had relations with a forest institution did not affect the project's work. Besides working for IBIF she was a spokeswoman for the local women's organisation, which made her a well-known and respected person in the area.

We spent about two weeks in each of the villages. The fact that the team was part of the villages' social life, even though for a short period of time, contributed positively to the project's work. Originally we had planned to organize Participatory Rural Appraisals. These had to be cancelled due to the participants that had agreed to come but unfortunately did not in the end.

Problems with Methods

Whenever one is forced to use a translator, the fact that the information received is not first-hand can create trouble. One never knows if the interview is translated correctly in both ways.
On the other hand, cultural misunderstandings can cause miscommunication as well. As previously mentioned, group discussions were not possible and one of the presidents of the villages advised us to only carry out one-to-one interviews in the informants' homes. He assured us that this method would be more effective. It is of course possible that the team, being white, female Westerners, had an effect on each interviewee and on his or her answers. Clearly, it is hard to know if this did have an effect. When the person interviewed was familiar with the translator, it seemed as if the person was more comfortable. On the other hand this brought with it that the translator and informant were engaged in personal conversation before and during the interview. Related to the effect the interviewer may have is the possibility that the informants wanted to seem more aware or concerned about nature than they actually were in order to make a better impression. Obviously, the time spent in the research area was short, but it gave an overview on the subject of study. Nevertheless, more time would have been preferable. On the same account, it happened to be that the village festival and one of Bolivia's national holidays took place during our study in the second village, which reduced the working time.

Statement of Ethics

The project hereby formulates a statement of ethics concerning the social science research relations with the respective Bolivian host communities – Urubicha and Yaguarú.

- The project fully acknowledged its responsibility towards the host communities where social research was conducted and did everything in its power to protect the locals' rights, interests and sensitivities.

- The project communicated its aims of investigation to the involved communities and introduced itself as part of a student led expedition from Europe.

- The project obtained in advance the informed consent of persons who were interviewed. Before every interview the project made clear that the informants' participation would not benefit

them directly and that their information provided would not be used for commercialized intentions but would be contextualized in a university paper.

- The project fully respected the informants' right to remain anonymous or their wish to receive recognition.

- The personal digital assistant, our data gathering device, was fully explained to the informants so that the capacities of such a device were understood. The informants were asked for their consent before every interview and were free to reject it if they did not wish to be recorded.

- The project respected its obligation to reflect on foreseeable repercussions for the general population arising from research and publication.

- The project views secret research with detachment and will only produce reports open to the general public.

- The project also acknowledged the social and cultural pluralism between the host community and members of the team and adapted behavior and research actions to local standards in order to be as least intrusive as possible.

Results

In this section the results will be presented. These are divided according to our aims into two sections; Environmental Awareness and Perception of Nature. The first section includes results on the informants' level of environmental awareness, their knowledge of nature, to what extent they care about nature, how much environmental education is communicated through school and between generations, and if they have some sort of system of recycling or reusing. The second section talks amongst other aspects about the informants' attitude towards conservation, how their view of nature differs from the Westernized one, and their perception of nature from a religious and cultural point of view. Before presenting our results we find it necessary to introduce the reader to the local environmental problems as these are important for further understanding of our results.

Environmental problems in the research area:

Environmental problems are part of nature and the social context in which the informants live. Despite not being our main research topic we found out about the local environmental problems during the course of our research. It needs to be said that because this is not an ecological study but a social study, we used a different approach to environmental problems. Our approach focused on observations and what *our informants* considered to be the main environmental problems. In order to contextualize the following results we will shortly state these problems.

- Heavy deforestation is taking place without enough reforestation. This includes too much and too irresponsible burning of the forest and exaggerative logging activities. As a consequence to the logging activities the animals' natural habitat is endangered.
- People have observed a decrease in rain and fish. Until recently, fish were regularly caught with the help of poison.
- The national waste pick up service system does not reach rural areas. This causes a waste disposal that is not environmentally friendly and is irresponsible meaning that the locals burn their everyday household waste including plastics, which in turn releases poisonous gases. A lot of waste is also left on the ground, which contaminates it.

Environmental Awareness

The people living in the research area are dependent on the surrounding nature. They live close to nature and have a wide knowledge of it. They know about the different kinds of species in their natural environment, they know how to hunt and fish, how to grow crops in their piece of land called *chako*, how to use plants for herbal medicines and how to take care of their animals. Despite this, our impression was that people's environmental awareness is limited. They do not know about the high biodiversity that surrounds them and that this high biodiversity is very special. It is unknown to them that their kind of pristine and intact forest does not exist in many other places in the world. People were very surprised when learning about the European forest not being the same kind of forest as theirs. The same lack of knowledge can be applied to global environmental problems like global heating or change of climate. They take notice to the changes these problems cause but do not know the reasons for these changes. On the same account, the hazards of global deforestation and global waste are unknown to them as well. The above concerns uneducated persons but higher educated persons did express knowledge about these problems that cause an imbalance in nature. Due to this, they lack awareness of the concepts of reusing or recycling.

On the other hand, it is well known that waste, especially plastic waste, contaminates the ground and water. People are aware that this is a problem which causes illnesses for humans and animals alike. The presence of carelessly disposed waste is very obvious in the form of land patches around the villages covered with it. Furthermore, some people expressed knowledge about sun exposure on plastics causing poisonous gases. Nevertheless, they burn their daily household waste and it stays unresolved whether this is because of lack of knowledge of the bad gases created when burning, or because of lack of alternatives concerning waste disposal. People are aware of a bad mentality regarding waste disposal in public places where no bin is in sight. This mentality contains the lack of thought of what happens to the waste after it has been thrown on the ground.

Turning to the problems of deforestation in the area, people know that high deforestation is taking place and notice its negative effects in their everyday life. They connect deforestation with the fewer amounts of fish in the lakes and animals in the forest as well as the decreasing amount of rainfall. They draw the conclusion that it is the decreasing amount of trees that causes less rainfall as trees attract rain, forces animals to leave their original habitat and increases sun exposure on ground vegetation.

One of their biggest problems regarding deforestation is the exaggerative and irresponsible burning of huge patches of land for agriculture. Everybody is aware of this activity although it is forbidden. They are also aware of more sustainable ways of burning, in the way of first cutting down the trees, then only burning the branches and using the rest of the trunk for various purposes. This is what former generations used to do. Many people nowadays believe that they took better care of their surrounding nature and had a non-exaggerative usage of nature's resources. Some informants complained about the lack of protection against people from other villages that sometimes come to use their forest and harm it through burning and hunting.

High deforestation also comes from exaggerative logging activities. These are performed by big logging concessions that exploit the forest for commercial reasons. These companies play a big part in the villagers' lives as they often have some kind of relation to them either through work or selling land rights. Since the reforms established in the late 1990's, every native has the right to a piece of land. Lately, many of them have taken advantage of this right and created what is called a *planemanejo*, where owners of land patches join together and form a collective ownership. By doing this, they become attractive to big logging concessions and can sell their land rights to them. This enables them to use their forest on an economically higher scale. For the big companies, this is a beneficial transaction because the locals are forced to sell their land rights at a lower price than their actual value. When complaining about the logging companies' high activity in the forest, people in a sense blame *the machines* for destroying nature.

Turning to water related problems, deforestation has had effects on the lakes and its marine life. The people sense a possible connection between the decreasing amount of trees and the fewer amounts of fish in the lakes due to imbalance in the rainfall average. Informants have also expressed dislike towards the procedure of fishing with poison that used to take place until recently in the lakes around the villages. They were aware that the poison killed a severe amount of marine life apart from the fish.

The results discussed so far are, in our opinion, connected to the fact that the environmental education in these villages is very low. Their school system is set up in a way that makes it impossible to teach any environmental education. First of all, the four hours of school every day are already occupied by the core subjects like Maths, Spanish, Religion and Natural Science, which means that there is no time for sufficient depth into environmental issues. Natural Science does contain some teaching about the environment, such as plants, animals, and life cycles; but does not teach enough about environmental problems on a global and local scale. In the Western world, environmental awareness is communicated through media such as TV, radio, newspapers, literature, civil society, and especially school. The fact is that in these villages, very few families own a TV. Radio in general is a weak information source as it mostly deals with local news. Newspapers only exist in more urban areas, literature is hardly available, and civil society is not very strong. Considering these facts, it seems plausible that school education could be the main information channel for creating environmental awareness. Yet, this is not the case, as there is no national curriculum for environmental education, except some small programs that are not obligatory.

Perception of nature

The Bolivians view nature as a resource, first and foremost a working place to be made use of. They find nature beautiful and are proud of it, but it is primarily a family security factor. Contrary to the general European view of nature, they hardly see it as a recreational space. Both adults and children expressed *working* as the main activity taking place in nature. This includes hunting animals, felling trees, growing crops, and collecting medicinal plants.

When asked why they thought nature should be preserved, informants always answered that nature is an important resource and that future generations should be able to secure their livelihood by using nature's resources. Many informants said that they communicate this idea to younger generations, urging them to preserve nature. Even though they do enjoy being in nature, they believe the forest should especially be preserved in order to supply them with vegetables and meat, to provide them with wood and natural materials. Recently, it has become more important to meet the growing interest in selling wood. This view of nature implies that it is not its uniqueness or biodiversity that makes them want to secure the forest's further existence. Nature does not have a value in itself but only through its resources.

There is a perception amongst higher educated Bolivians that, because Bolivia still has many intact forests as well as other natural resources and does not yet suffer from many severe environmental problems, it should make more use of its resources. They also believe that this is the reason why a high percentage of Bolivians still are very poor. On the same account, people from the villages do not want to stop cutting huge amounts of trees because, as they can observe with the big logging concessions, exploiting nature in an overly exaggerated way generates better living conditions. This is the dilemma they face. On the one hand people want to preserve nature for future generations, but on the other hand they feel a strong will to improve their living conditions and the only way visible to them is by exploiting nature's resources.

Revealing the meaning of the word *nature* shows the importance of the forest's resources. When using this word, the locals in actual fact mean *forest.* Another surprising finding is that although they are dependent upon and intimately related to nature, as well as expressing a will to preserve it, some of their daily activities include environmentally unfriendly habits. As a Westerner, one tends to believe that people living so close to nature and being dependent on it would treat nature well. Contrary to this

original notion we actually found people not reflecting on their actions, such as that of throwing plastic waste on the ground. The shameful feeling of throwing waste on the ground, created by the norm of acting environmentally friendly developed in Westernized society, does not exist.

Another part of their view of nature is connected to their superstitious beliefs. Although to a lesser extent than in the past, people still believe that the environment is a dangerous place. This is because they believe in devils that haunt the forest or mermaids and big sea animals living in the lakes that want to harm humans. There are a lot of myths told about these creatures with the intention to warn the listeners, for example, to not walk by themselves in the forest. Myths about nature are also used to communicate societal morals. Nevertheless, these myths are not as common as they used to be. Although misinformed at the beginning of the study, we did find the belief in *patchamama*, or Mother Earth, to be existent in the study area. This belief entails the procedure of showing gratitude towards nature's gifts in the form of symbolically giving something back. It is supposed to be more common in the highlands around La Paz, but informants in our research area also expressed such beliefs.

Discussion

An interesting picture of people's relationship to nature appears from our findings. Here we mean to analyze this picture more in depth and discuss its implications. The discussion is divided into two parts whereby the first part relates to the people's close relationship with nature. Here we want to discuss how people interact with nature in their everyday life. In the second part of the discussion we want to draw attention to new external influences that the people recently have had to face and the influences' implications on nature. At the end of this part we will claim that the people have not yet found the best way to cope with these new external influences and that it will be of utmost importance to increase environmental education and bring about fast behavioural changes.

Nature as an integral part of everyday life

Lack of awareness concerning the uniqueness of the forest

It was surprising to us that most of our informants were not aware of their forest's high biodiversity and uniqueness. Seemingly, they cannot place themselves in a global perspective and realize that they are living in an ecological hotspot. When it comes to their standard of living, people do know about their economical position compared to other countries. On the other hand, up until now communication on their richness, in terms of nature, has not taken place. Future environmental projects whose objective is to raise the local environmental awareness must keep this in mind as the most important aspect. It is crucial for the future conservation process to make the local population aware that their forest is very unique. Connected to this is the fact that they show a low awareness of global environmental problems and the rest of the world's environment. This probably has to do with their lack of education in this field.

When discussing the environmental situation in this research area, one must remember that the people have not yet experienced the feeling of endangerment of nature. Therefore, conservation is not as important to them as it is in the Westernized world. On the other hand, they do express willingness to conserve nature for future generations through preventing forest fires and controlling logging activities with the creation of *planemanejos*. Despite this, it is clear that a wide spread feeling of concern does not exist. Likewise, it is obvious that the economical dependency on the forest makes them willing to preserve it. Again, leaders of future environmental projects in the area should focus on the importance of keeping the forest for future use if they want their projects to grip.

Nature as a resource

During the interviews, hardly any references were made to nature as a recreational space or having a value of its own. The view of nature as a resource that we encountered instead was unexpected. This shows that our Western view of nature is different to theirs as we are not as dependent on it. It is interesting to consider which of these perceptions is more favourable to conservation. Nature is valuable for both perceptions but is the will for conservation stronger nature is viewed as a resource or as an ecologically important recreational space? Would the people still be as willing to preserve for future generations if the forest was not their primary economical resource? Nevertheless, for a long period of time the forest will still have this role in their lives. It is not possible to ask them to not take advantage of the natural resources they own. We noticed that the Bolivians had a strong will to develop. This explains why they can be less careful with handling their main resource - nature. It is every country's right to develop and it is in a way hypocritical of the Western world to point its finger on an underprivileged country like Bolivia implying that it should not use its forest. In the best-case scenario, Bolivia would be able to use its resources in an environmentally friendly way.

Environmental awareness through education

The level of environmental awareness is to a great deal dependent on the amount of environmental education in schools. The low level of environmental awareness, especially on a global scale and concerning waste disposal, are connected to the fact that a high percentage of the population, especially women, are illiterate. Even recent generations, women were not sent to school for more than just a few years as their parents considered it to be more important for their daughters to take care of a family. On top of this, there are many villagers who cannot speak Spanish. This explains the high position in society of people who are more educated, fluent in Spanish, and help the village population with issues such as translation or writing of important letters in Spanish and mediation.

The high percentage of uneducated people is a result of the short time of schooling every day. Four hours of school is very little, especially when one considers that the teachers have meetings during school hours whilst their pupils were running around the school area, as happened a couple of times during our workshops. This further reduces the already small amount of time offered for schooling. Likewise, as there are not enough resources for the village schools, there are of course no resources available for higher education facilities in the vicinity. It is very hard for parents in the research area to enable their kids a chance for higher education.

The lack of environmental education in schools and the generally low level of environmental awareness mean that another generation of Bolivians in this area will be brought up without sufficient environmental awareness. This will be a threat and further endangerment of the rich nature of the Guarayos region. On the other hand, the improvement of Spanish education in schools empowers the new generation with at least a stronger chance to have an equal say in the discussion of environmental issues in their country.

Religion and Nature

People in the research area respect nature. They are still afraid of it and show their gratitude towards it when taking something from nature. This respect is a reason to handle it with care. Yet, as economic activity in the forest is increasing, it will probably seem less and less dangerous to people. This in turn could mean that respect for nature might loose a great deal of importance.

Generally, religion in this area is something personal. Although we were able to observe many Catholic symbols in the homes of our informants, they hardly ever commented on their Catholic belief or asked about our convictions. Therefore, it was not easy to talk or ask our informants about their belief in *patchamama*. The one informant, who did say she believed in *patchamama*, was a little hesitant in the beginning to describe her gratitude ritual to Mother Earth to us. Although at first she had decided to not let us know, she did in the end. We can only speculate as to why she was hesitant.

Perhaps the influence of Catholicism in the area is underestimated, or she thought she would appear less modern in front of us, but most probably this ritual is very sacred and important to her and she wanted to keep the information private. At any rate, she insured us that the belief in *patchamama* was quite common in the research area.

New challenges due to external influences

Forest Management Plans

People often spoke about the fairly new institution of the forest management plans (*planemanejos*). These forest management plans put a strain on the exaggerative usage of the forest. These specify what forest parts are to be spared for a few years, which species to be cut in another section, and the amount of trees to be cut in general. Although the plans are a good step into the right direction of sustainable forestry, they do not state for how long the trees can grow or how much reforestation has to take place.

Unfortunately, the management of the *planemanejos* is not in the best interest of the people that sell their land rights. They are aware that they are loosing out on the deal but it is highly probable that more people will engage in the set up of *planemanejos*. If this comes into action, the people will gradually loose control over their forest. In sum, the logging companies have a lot of power over the people, and the people's attitude towards them is two-fold. They are both dependent on them for economical reasons but also blame them for destroying their environment through exaggerative logging activities. La Chonta is the big logging concession in the research area. The company has realized for future work in the area it has to be more concerned about people's attitude towards it. During fieldwork in one of the villages, a feasibility study took place where people working for La Chonta travelled around the villages to gather information on people's opinions. This was done to improve the company's reputation.

As for land rights, there have been ongoing discussions on reforms that would nationalize land currently privately owned by companies. The outcomes of these are not clear yet. In any case, this shows that the forest is a battlefield.

Deforestation as a Challenge

One effect of deforestation, especially forest fires, is that animals are driven away, which forces people to travel further into the forest to hunt. This effect is very obvious to the people as it affects their daily life. In the worst case scenario this might mean that people will have to find another way of acquiring meat. Then they would no longer be self-subsistent. Due to this possibility, it is not surprising that the informants were most passionate about the issue of forest fires. It is common to them, as people burn patches of land for agricultural purposes. They are aware that it is forbidden and that it is dangerous for the environment and villages as it can get out of control quickly. Already, young children in school are taught not to burn the forest. Some informants reported that sometimes people burn forest patches just for fun and in order to annoy others. All these things are visible to the people in opposition to problems like contamination of the ground or poisonous gases. This shows that when an environmental problem is actually affecting people's daily life and that negative effects of it are seen with their own eyes, it troubles them to that extent that they become very passionate. In a sense, this creates a stronger awareness about the particular environmental problem. Here we want to stress the importance of environmental education as this can be the best way to raise awareness of environmental problems that are not visible to human eyes.

Briefly, in order to explain less environmentally friendly deforestation through forest fires, it needs to be said that these are more time effective. We did not find an answer to the question as to why they burn the forest in a less environmentally friendly way. One can only presume that the demand among the villagers for bigger land patches for agriculture has increased and/or that they do not own the proper equipment to cut down a big number of trees to then only burn the branches and use the trunks.

In any case should deforestation continue in the way it is currently, it will eventually cause an even greater imbalance in the environment.

Water situation

Turning to the area's water situation, it is unclear what further effect the poisonous fishing will have. Only a few informants told us about this activity. Because of its seriousness it can be suspected that other people in the village that we talked to left out this information on purpose. Concerning the situation of people's drinking water, it was interesting in retrospect that very few persons brought up this subject or commented on it when talking about environmental problems. Possible reasons for this could be that the informants may not have thought that their water situation belonged to the discussion of environmental problems, or possibly that because the water has never been potable and still is not, this has made them adjust to that extent that they do not consider it problematic.

Although one would expect that not being able to drink ground water without boiling it or making *chicha* (tea) out of it beforehand would constitute an irritation, people generally did not complain about it. Only one higher educated man, the director of the school in Yaguarú, was highly concerned about the water situation stating that potable water projects were very important and necessary in the area. As we do not know the reason for the ground water's contamination, we cannot draw any further conclusions about this topic.

Environmentally friendly waste disposal?

With regard to alternative waste disposal it was surprising, considering their economical situation, that our informants do not reuse much. It is common that glass bottles must be given back to the shop owner as he receives an amount of money for the refilling of the bottles. Otherwise, plastic bags, for example, are given away for free by shops with every purchase. These black plastic bags can be seen in every corner of the village or in every ditch where the waste is to be burned. If perhaps people had to pay something for these plastic bags they would possibly not throw them away as easily but reuse them for the next shopping. On the other hand, it was not surprising to learn that our informants do not recycle, apart from the fact that current national logistics show even the concept for a recycling system does not exist, let alone the system itself! It is true, Bolivia does not produce nearly as much plastic packaging waste as the Western world, but their amount of waste also will not decrease in the years to come. Thus, if things were to continue the way they are now, environmentally friendly concepts will become more and more important. Again, we want to stress here that these environmental concepts can only be taught.

Concerning all the plastic bags, plastic packaging, and general waste lying around the villages, there is an overall consent amongst the people that it is disgusting and bad. They expect every family to clean the ground around their house every day but nobody seems to claim responsibility for the litter in public places. Many informants stated that it was the village president's responsibility to organize proper litter disposal. As mentioned above, the contamination of the ground through the litter lying around is not "in their face", not obvious to the people. It is not affecting them as much as they have not had plastics for a long time in opposition to, for example, forest fires. Forest fires are very visible, and their short and long term affects and have been existent in their culture for many years. Therefore, the people have a wide knowledge on this topic and are very aware of this environmental problem. Once again, in order to raise the people's environmental awareness concerning the contamination of the ground, it is necessary to provide the people with information on the subject, starting early in school to cultivate a mentality that condemns environmentally unfriendly waste disposal.

During our interviews we asked what our informants thought about the waste lying around the village. This was a sensitive question as we knew that our informants were probably involved in the way the village looked. We also felt a little awkward asking the question, because we were afraid it would seem as if Westerners were pointing the finger at something they thought to be very negative and

backward. Interestingly enough, the people were never ashamed but angry with other people that did not clean the ground around their house.

In the course of our research and the following discussions in the team, two specific questions began to take form; what is better – taking waste out of people's sight so that they do not see their waste? Or would this in turn make the people produce even more? Or is it better to not have a waste pick-up system and have the people dispose their waste locally? This question then leads to the next; what is worse for the environment - huge mines or mountains full of waste or many patches of land covered with waste? Have waste all in one spot or scattered?

We also started questioning ourselves and our study. Were we being hypocritical? Was it fair to be somewhat 'patronizing' if our home countries do not dispose their waste environmentally friendly either? For a Westerner, all the waste lying around, burning plastics, throwing litter on the ground without thinking twice may seem shocking as these activities are strongly condemned in the Western social context, but if one gave it more thought the waste situation in the study area was not as shocking as these activities lead one to think. The study area does not proportionally produce as much plastic waste as other Westernized countries and, in general, Bolivia's ecological footprint is positive. One just had to accept that the people think differently because of the lack of education on this subject and have no other alternatives and resources to take care of their waste in the best manner.

Here is exactly where we see Bolivia's chance to start correctly and to do it right from the beginning. This is their chance to take a different path than the Western world concerning waste disposal, meaning starting on a local level. Again, this should be the focus and starting point of future environmental projects.

As we have introduced above, the need for environmental education is huge and improvements in this field would change people's thinking when it comes to conservation, deforestation, and waste disposal. However, as much as environmental education is vital for the adaptation to new influences, we would also like to present the need for rapid behavioural changes. This would include changes in their daily treatment of the environment such as reusing plastic bags, reducing the amount of plastic packaging, stopping to throw waste on the ground, and reducing the activity of forest fires. Such behavioural changes could, for example, be achieved by information or slogans on sings, banners, and plastic bags. In the end, it is of course new environmental regulations by the national government and the introduction of a waste disposal system even in rural areas that will bring about the greatest change.

Conclusion

This study has shown that the environment is very important to the people in the research area and is a big part of their life. The people's knowledge about nature is considerably large. Despite this, they lack the awareness that the forest around them is very unique in a global perspective in terms of biodiversity. Nature's importance for the people is based on the fact that they use it everyday and therefore their main perspective on nature is formed by it being a resource. Furthermore, it is their dependency on nature that makes them willing to preserve it. Reasons such as nature's biodiversity or nature as a recreational space are not mentioned in this context. The lack of knowledge about environmental problems can be traced back to the fact that environmental education is hardly provided by the school system. Superstitious beliefs and the belief in Mother Earth are still present and show that people greatly respect nature.

However, the nature that the people are so heavily dependent upon is nowadays threatened by new external influences. These have had significant effects on people's lives. Since the logging activities have increased, the commercialization of land rights have as well. Deforestation is also taking place through forest fires for agricultural purposes. Despite being forbidden, forest fires continue to destroy

the forest although the people know about more environmentally friendly ways of clearing land for agriculture. The introduction of plastics has caused an overwhelming waste problem due to the fact that alternative waste disposal systems do not exist in rural areas. It seems as if the consequences of these new external influences are affecting the people in such a fast pace that they have not yet managed to develop a behaviour that is environmentally sustainable.

Acknowledgements
The team would like to thank the villages of Yaguarú and Urubicha that were so welcoming and helpful to us that we will always remember them with a smile. Without the people's willingness to cooperate with the study it would have not taken place. The team would like to thank Anais Phely for 'keeping our backs free' and working the PDA during the interviews, taking photos of the interview situation, but especially for her thoughts and ideas towards our research.

References

http://www.ibifbolivia.org.bo/

Appendix 1

Project Adaptation Justification

The project as it was proposed to the University of Edinburgh encountered several problems towards the end of the planning and had to be adapted to new conditions. These contained the postponement of the CAMBIO program for an unspecified amount of time due to Bolivian political changes. This meant that the output of possible work done in Amboro National Park would not have had a secured significance.

First of all, recording the baseline ecological data on above ground biomass increment in order to assess the feasibility of introducing a carbon credit project would have become invalid if the investment in carbon credit projects has not yet been decided upon by CAMBIO. Secondly, since the Deforestation Project saw itself mostly as a facilitating study dependent on collaboration with CAMBIO itself and the different NGO's taking part in it, the investigation from a gender perspective of the experiences of locals involved in community ecotourism projects and their attitudes towards the promotion of ecotourism as a change in land use also became impossible to research. This is since a further change in land-use by implementing ecotourism projects is not certain at the moment. Thirdly, the presence of NGO's would not have been as strong because CAMBIO had not yet started to implement its projects in La Yunga and Buena Vista which reduces the effect on the locals' attitude towards the interaction with the respective NGO's. A low NGO presence was not favorable to the research the Deforestation Team wanted to carry out.

Lastly, the Deforestation Project was a part of a larger joint student expedition and due to financial constraints the different projects could not any longer be as logistically independent as originally planned. Thus, the study place was moved to the Guarayos region close to Santa Cruz in the Santa Cruz de la Sierra Department. Because of the lack of ecotourism projects in this area the subject of research had to be changed drastically. Apart from this, the Deforestation Project was supposed to work closely with the Education Project of the joint expedition. This project focused on performing drama workshops on the subject of environmental awareness with young school children. In order to have both projects complementing each other the social studies' research topic was transformed to a study of the local people's relationship with the environment with a focus on their environmental

awareness. The knowledge exchange between both projects was achieved by running them parallel to each other.

The place change of study coincided very well with the adaptation of the research subject because the Guarayos region has a large quantity of forest that is cut down every year to a large extent by certified logging concessions. This seemed to be a good basis for studying the people's close relationship to nature as almost all local families are in some way related to working in the forest or for a logging concession. In the future it seems likely that environmental awareness amongst locals is prone to be a very important issue for the area. The idea of the research was to be able to facilitate possible national institutions or NGO's with information on the current status on the locals' relation to their surrounding nature and environmental awareness.

It was favorable for us that one of the projects of the joint expedition had already established a close connection to the Bolivian institution called Instituto Boliviano del Investigación Forestal (IBIF). IBIF's mission is to promote sustainable forestry management through long term research in natural tropical forests. This enabled us to easily establish a relationship with IBIF and to use IBIF's connections to villages around the Guarayos region – two of them turning out to be our main study area.

Appendix 2

The following email was written by the district director of education in Urubicha, Guarayos region, Bolivia and is directed towards the Education Project. Professor Amenda would like to express his gratitude to the project and show how much the study meant to his village, Urubicha. He would also like to know if the project will return and continue with its research. Should this not be the case, he would like to send us details for one of his projects. Although the e-mail was intended for the Education Project, it does show a positive response towards the research stay of both projects in the village.

>From: "raimundo cuarembi amenda"
>To: n_bekier_djerf@hotmail.com
>Date: Thu, 31 Aug 2006 13:12:28 -0400
>Santa Cruz 31 de Agosto del 2006
>
>Señorita
>Nathalie Bekier Djerf.
>Presente
>Dsitinguida Amiga.
>
>Por intermedio de la presente me dirijo ante su persona ,con el objetivo,
>primerameente para saludarla y al mismo tiempo saludarlas tambien a sus
>compañeras del trabajo, A:Michelle,y A Anaiis.
>El motivo de esta nota es para consultarles los siguientes: queria saber si
>van a recrezr nuevamente a urubicha para contunuar sus trabajos de
>investigacion, que estaban realizando en mi pueblo, ya que los trabajos que
>estaban realizando ha sido muy importantes para nosotros.
>En ese sentido les consulto a Usted sobre su retorno y si no fuera a si,
>tendria que pasarles mi proyecto urgente que tengo para Usted, por
>intermedio del su correo.
>Nada mas les escribo a Usted. esperando su respuesta.
>Atte.
>Prof. Raimundo Cuarembi Amenda
> DIRECTOR DISTRITAL DE EDUCACION- URUBICHA.

Exploration and development of existing environmental education within schools in the Ascención de Guarayos region

August 2006

Anais Phely
Project Bosque

Introduction

Project Bosque Education focuses on what people and in particular children local to the Ascención de Guarayos area learn about their surrounding environment. The study involved working with local schoolchildren by conducting workshops to assess their current knowledge and help them build on it. The study focused on two towns, Yaguarú and Urubicha, both in the surrounding area of Ascención de Guarayos, situated in the North-East of Bolivia. The largest nearby city is Santa Cruz. The Guarayos area includes 9 villages, Urubicha being the largest of approximately 6000 people. Both villages have two official languages, Guarayu and Spanish. Most of the population speaks only Guarayu, although some people are bilingual.

The first village visited was Yaguarú, a smaller village of about 2000 people. The team worked within one of the three schools in the village, Nuestra Señora de la Paz II, which held about 700 children between the ages of 6 and 15. The second village, Urubicha, is the largest village of the surrounding area, of about 6000 people. We conducted our workshops in one of the seven schools in the village. Two workshops were conducted per day during school hours, each lasting one-hour. The school is split into a morning group and an afternoon one, so each group had one set of workshops. The study lasted about 10 days. Groups were made up of individual classes, consisting of about 25 children aged about 6 years old in Yaguarú and 8 years old in Urubicha.

Minimal information about the villages was available before arrival in Yaguarú. Research acquired by the Project Bosque Social Study significantly helped the Education study. The social study's interviews with local townspeople, including school directors and other villagers, occurred at the same time as workshops were being held in the schools. Through these interviews much was learned about local people's knowledge and ideas about their surrounding environment, which greatly assisted the following workshops.

The village surrounding is filled with plastic bags, packaging and other garbage. There seemed to be a conflict in opinion with regards to the issue of responsibility of the garbage. An interviewee explained how Ascención de Guarayos has a garbage picking system emplaced. Each block pays 5 bolivianos to have their garbage picked up by a company who digs a hole for litter. There is no such co-ordination in Urubicha, according to two interviewees. However, another interviewee explained that people feel responsible for the garbage around their houses but not in public areas (excluding plaza). Yaguarú and Urubicha populations live with their own wastage unlike Britain, which provides services to hide a vast quantity of garbage and, therefore, encourages population ignorance on their environmental impact. The Guarayu villages' inhabitants survive off their forest, lake and farm animals. These factors provide an excellent ground for possible change of attitude regarding environmental issues.

Objectives

The main aim of Bosque Education was to raise awareness of local environmental issues. The project carried a philosophy of adapting to groups' learning needs, offering a range of methods and activities

to suit the groups' interests (for example games or mime). The main source of information before workshops started was an informal interview with an employee of IBIF. He stated that the general Guarayu population does not care about the environment because they do not know that the surrounded forest is unique and an important centre of biodiversity. He did not feel that there was enough information communicated from parents to children. The aims of the first part of this project was, therefore, to explore the different animals who lived in the forest, to learn about different food chain and to arrive at the conclusion that many food chains create biodiversity and makes their forest special.

- To understand the social and educational context of Ascención de Guarayos
- To research the popular knowledge and opinions on environmental issues
- To investigate the current nature of environmental education within local schools; the level of focus given to it and the content of what is taught
- To deliver drama workshops on environmental awareness in accordance with participants' learning needs
- To continuously amend, whilst in Bolivia, the workshop programme to fit the educational needs of target groups, in reaction to the response and feedback of children and teachers
- To run continuous series of workshops within the same groups
- To successfully create a relationship of trust and mutual respect between participants and facilitators, and between participants and subject of study
- To create an enjoyable and interesting workshop program

Methodology

Workshops were created by the team to be conducted to groups of children consisting of about 25 pupils, although the number varied depending on the day. The children were 6 years old in Yaguarú, and 8 years old in Urubicha. Children attend school either in the morning between 8am to 12pm or in the afternoon during 1:30pm to 5:30pm. We conducted two sets of workshops everyday, one to each set of students. The workshops lasted one hour, and were conducted over a time period of about ten days.

Workshops began with games, followed by discussion and exercises. All workshops finished by a song, saying goodbye in Spanish and Guarayu. Games at the beginning of the workshops were used to focus the group on a particular subject, and the group aimed to maintain this theme throughout the workshop and encourage participant interest in the subject. Traditional Western learning games were renamed to create an environmental affiliation while maintaining the same outcomes of focusing attention. For example, 'Stuck in the Mud' was renamed "The Spiders and the Bees', and 'House, Man, Storm' was renamed 'Monkey, Tree, Fire'. Some games also encouraged competition while at the same time ensuring the entire group was included. These games raised energy, excitement, and a sense of fun within the group.

The playful nature of games also broke the formal school environment and helped create a relationship different from that of teacher-pupil. It helped raise trust toward facilitators and broke children's inhibitions. However, this method requires facilitators to be constantly in control of the balance between participant's learning and their playing. A workshop based on games and miming could have become a playground and not learning in an enjoyable manner. Stopping the game at appropriate times and starting a question-answer activity on the same theme kept this balance.

Some games placed at the beginning of the workshop were aimed at raising confidence in one's own ability. For example, some were aimed at building confidence in miming. In a game aiming at miming animals, the whole group would mime one animal at the same time. This helped prevent participants

feeling self-conscious and helped break inhibitions. As they got better, their confidence in their ability rose and it was then possible to change to a more complex activity.

Some games were used to raise equality in status between participants and facilitators by using the Guarayu language. The game "Apple, Pear, Banana" became "Monkey, Snake, Fish" or "*Cai, Vibora* y *Pira*". Using the native language put facilitators in a learning position. Participants became more knowledgeable than facilitators and workshops were no longer one-way. It showed facilitators' interest and respect toward the culture of the participants.

The main body of the workshop was a mixture between discussions, miming and games on the same theme as the discussion. Questions were raised on a theme; a discussion ensued, and was then explored through mime or game. The didactic method of conversation was mostly used because of the group age range and also the language barrier. All workshops were dotted with questions to which the answers were already known by facilitators, as opposed to a more democratic approach in which the facilitator asks a question but do not expect a specific answer. The aims were to state the obvious in order to introduce or re-establish a new concept. Questions would start with a wide subject and narrow to more specific requirements. For example, 'what can we use water for' to 'what activity do we use the lake for'. The expected answers included washing clothes, washing one's self, cooking, drinking, and fishing. This particular question aimed at brainstorming activities that were later mimed. Language barrier was also a reason why questions were direct, avoiding any tangents in answers.

It was part of the team philosophy that facilitators should participate in each game if appropriate. It gave a sense of unison between facilitators and encouraged all participants to partake in the game. A person leading yet never participating would put participants in a position of being permanently observed. It creates an audience and participants become performers against their choice. Participants may feel self-conscious and not enjoy or partake in activities. However, a minimum amount of observation was necessary to ensure participants understood and enjoyed the game. Observation was also important to know when to stop the game to make it more complex or simpler and to assess the general group dynamic.

Workshops in Yaguarú focused on the different animals living in the forest and food chains. We explored the importance of bees and butterflies in the forest, what they eat, why it was important, and what eats them. The aim of this section was to understand why bees are important for biodiversity. The last workshop focused on the wastage of plastic bag and its potential effect on the forest and lake.

We used the same technique to explore bees and butterflies. The team created a small skit to explain that bees eat flower nectar and another skit to explain the transformation of butterflies. We decided to keep the content very simple so that participants would understand. Once this story was mimed, participants mimed the same story with facilitators. This play was introduced by a discussion to evaluate what participants knew about bees. Other discussions were carried out to evaluate if all participants understood the skit and to explain how the bee helped the flower.

The last workshop explored the problem of plastic bags. Participants were aware that plastic on the ground was not good, but they had never been introduced to the concept of re-using bags. We asked questions related to the forest and lake and how garbage affected them, specifically about the effects on animals and fishes. We introduced the idea that plastic can be confused for other animals or fish and be eaten by mistake and cause the death of the predator.

Workshops in Urubicha benefited from the information about the Guarayu lifestyle and local environmental problems learned in Yaguarú. Interviews showed that forest fire and clean water were some of the population concerns, and the team observed that litter was a problem. The environmental education in Urubicha focused on the reduction of plastic bag consumption and promoted reuse as an alternative. The workshops focused on the effects of pollution and fire on the river and the forest, as

well as how we can help reduce pollution. We focused specifically on plastic bags, as they are a very common item, and introduced the idea of reusing them. We also explored biodiversity and the differences between their surrounding forest and European ones.

Games in these workshops were aimed at teaching the children effects of pollution. For example, one game included miming activities held everyday at the river, including washing, and swimming. A discussion was then held about the effects of plastic bags in the water, in which children were aware that this was not good. We discussed examples using animals and fish mistaking plastic bags for other fish. We then repeated the miming activities at the river, and facilitators mimed pouring themselves a drink from this water. The children followed suit. The facilitators then mimed becoming very sick, and the children again followed. We also discussed the resources that the forest and water provides. It was followed that the forest and water were in danger. The group discussed fire and plastic bags and the idea of reusing them.

Results

We found the children, and the villages in general, gave us a warm welcome and generally enjoyed our presence. In both villages the mayor and school directors were very keen for us to work in their school. In one interview, Yaguarú director expressed his desire for more foreign projects to occur. Both schools let the project take a quarter of the time children spend at school. The workshops were very effective in generating children's interest and excitement in environmental issues, and on the whole they seemed to be very successful. We hope that the teachers may also have learned that these issues are important to discuss and learn about, and that they may carry on doing so with their children. One of the initial interviews conducted with a member of IBIF reported that there is not enough environmental knowledge passed from parent to child, so perhaps our discussions with children, teachers, and school directors may change this.

Ethical Discussion

Before beginning any workshops, meetings were held with the School Directors and senior members of the communities, such as they mayor. We were working with a translator who spoke Guarayu as well, so there was no confusion about our purpose and ideas. We obtained permission from these members before approaching the teachers, who were also enthusiastic. The children were encouraged to partake but we not forced, although all members of the class did willingly partake and were eager and excited to do so. All the children seemed to enjoy the activities. It was explained that a report would be written about our workshops, and that all participants would remain anonymous.

Discussion and Suggestions for Further Research

The workshops were in general a great success, especially considering the short time frame, lack of initial information, and need for translators. The children and the teachers both enjoyed them and learned about their surrounding environment and how to help it. In both villages the mayor and school directors were very keen for us to work in their school. In one interview, Yaguarú director expressed his desire for more foreign projects to occur. Both schools let the project take a quarter of the time children spend at school.

The workshops in Urubicha, on the whole, ran more smoothly than those in Yaguarú. This was due to the lack of basic knowledge at the outset of the project in Yaguarú, and also the younger age of the students. However, they were definitely still beneficial and successful. The information gained in Yaguarú led to smoother workshops in Urubicha, as we requested older children. They were much

quicker in understanding concepts and games. These issues were not so much problems as learning experiences for the facilitators on how to develop workshops for the benefit of the participants.

The language barrier was an obstacle, as most of the children spoke Guarayu; two translators were necessary for every transaction. This took time, and also meant the conversation was often more didactic than an exchange of information. We told participants what we wanted them to know rather than letting them discover. For example, the concept of re-using plastic bag was the conclusion we wanted the conversation to arrive at. The most effective method was to ask the children if throwing plastic was good or not, and how it could be prevented. Generally, the answer was to dig a hole and burn them. We would then introduce the idea of reducing consumption of plastic bags and re-using them was a better way of reducing garbage. A better method would have been to create a game that would explore the use of plastic bags and lead to the discovery that re-using plastic bag was the best method of reducing waste. However, this method relied on children's initiative and quick understanding and the age range did not permit to do so. It also relied on facilitator ability to improvise in the right language (Guarayu) during the game if it is not progressing as expected.

In the future, it is indispensable that anthropologic field research takes place before an alternative educational programme. One to two months adaptation and interviews in different villages would secure a well-researched workshop programme. This research would need to be focused on the relationship between the inhabitant and the natural environment and the already in-place educational programme. We hope these ideas will continue to be discussed and taught within schools and also within the community.

Financial Report

In total £31,872.80 was raised, with 60% of this from our funding bodies, 33% from personal contributions and the remainder was raised locally. The sum raised was sufficient to support the expedition in travelling to Bolivia and sustaining its members whilst conducting research. The funds were insufficient for the purchase of items of kit which had been proposed, but in this instance, personal items of kit were used in their place.

Project Bosque Money Funding	
	(£)
Personal Contribution	3000
	3750
	3750
Fundraising	
Fundraising - Poker (1)	305
Fundraising - Poker (2)	33
Fundraising - Glow Sticks (1)	708
Fundraising - Glow Sticks (2)	140
Fundraising - Glow Sticks (3)	180
Fundraising - Sweden Bake Sale	54
Funds	
Davis Fund	5000
Carnegie Fund	2000
Weir Fund - Epiphytes	2400
Weir Fund – Wastage	1000
James Rennie Bequest	2400
RSGS	200
RGS – Social	1000
RGS – Epiphytes	2000
Gilchrist Educational Trust	1500
Michelle Stipendia	269
Nathalie Stipendia	415
Jake Stipendia	210
Lina Stipendia	650
Peter Marsh Prize	250
Gordon Foundation	652
Bank Interest	6.84
Total	**31872.8**

Project Bosque 2006 Expenditure	
	(£)
Pre-Expedition	
Travel	9,692.50
Insurance and Visas	1,632.00
Training Courses	2,837.25
Expenses - Printing etc	233.75
Medical Kit	644.40
Fund Applications	499.67
Equipment	3,321.64
In Bolivia	
Accomodation	2,585.15
Transport	2,086.86
Food	2,643.64
Local Travel and Guides	3,147.49
Activities	213.20
Equipment	1336.21
Phone, Printing and Internet	791.93
Post-Expedition	
Post-Expedition	350.00
Total Sum Raised	**31,872.80**
Total Spent	**32,015.69**
Sum Remaining	-142.89

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Many thanks from the Project Bosque Team