CONSERVACIÓN EN ÁREAS INDÍGENAS MANEJADAS

Biodiversity & Sustainable Forestry (BIOFOR) IQC
Task Order No. 817

USAID Contract No. LAG-I-00-99-00014-00

Environmental Impact Assessment of community-based bamboo management in the Cofán Center of Dovuno, Sucumbíos, Ecuador

Submitted to:
Chemonics International Inc.
BIOFOR Consortium

Submitted by: Margaret Stern
June 2004

Environmental Impact Assessment

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in the Cofán Center of Dovuno, Sucumbíos, Ecuador

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Biodiversity Conservation in Indigenous Areas (CAIMAN)

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EXECUTIVE SUMMARY

About 1000 hectares of native bamboo-dominated forest occurs within the territory of the community of Dovuno, located on Aguarico River to the west of Lago Agrio. Though patches of bamboo are abundant in varying densities around Dovuno, this is a rare vegetation formation in the Ecuadorian Amazon. The Cofán people have historically used this natural resource for their housing and other subsistence needs but until now, have not recognized the potential commercial value of their bamboo. Presently, the residents of Dovuno make their living by subsistence agriculture and fishing activities, handicraft production for the tourist industry, unmechanized logging, and some men have worked as laborers for the oil industry.

Taxonomically, the Dovuno bamboo is in the genus *Guadua*, but without flowering material it is not possible to identify it to species. Without doubt, this bamboo is similar to the culturally and economically important *Guadua angustifolia* from coastal Ecuador and Colombia, but there are numerous potentially important differences that may or may not be due to the specific ecological conditions around Dovuno. The identification of this bamboo species is most important for adapting management procedures, determining appropriate uses for the raw material, and marketing bamboo products effectively.

Integrating conservation needs into development policies is an important challenge. The management and commercialization of *Guadua* from Dovuno is part of an integrated plan to manage the community's natural forest and river resources. The first phase of the bamboo project includes the following activities: territorial mapping and land use zoning, inventories of the bamboo-dominated forest, management plans for bamboo selection and harvest, technical assistance in bamboo management, market identification, and business plan development for competitive returns and the equitable distribution of bamboo-derived benefits. The project's second phase focuses on bamboo processing, transformation and commercialization of value-added bamboo products.

This environmental impact assessment considers the consequences of bamboo management, harvest and sale as distinct from other forestry activities[1]. The objective of the EIA is to minimize the probabilities for negative environmental, social and economic impacts, and to improve the design and implementation of the bamboo project. Numerous potential impacts are identified and for each potential impact, mitigation measures are suggested to reduce the likelihood or degree of their occurrence. The need for a good monitoring program to be developed early in the project is stressed. Potential impacts considered are:

- Effects on forest structure and ecosystem processes;
- Effects on bamboo production and growth;
- Effects on natural regeneration, including commercial tree species;
- Indirect effects during extraction and transport to market;
- Impacts on wildlife;
- Contamination due to chemical treatment of bamboo;
- Bamboo flowering and widespread death;
- Social impacts of bamboo management and harvest;
- Economic hurdles and market limitations;

Finally, the potential impacts of livelihood alternatives to those proposed in the project are considered. The potential for local bamboo to produce significant income for Dovuno forest dwelling residents has already proven an incentive to block the imminent threat of the oil industry to conserve this natural forest resource.

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[1] Environmental Impact Assessment of Awá forest management activity (Buschbacher et al. 2003).

RESUMEN EJECUTIVO

Aproximadamente mil hectáreas de bosque nativo dominado por bambú se encuentran dentro del territorio de la comunidad de Dovuno, ubicada sobre el río Aguarico al oeste de la ciudad de Lago Agrio. Las manchas de bambú son abundantes cerca de Dovuno, pero en la amazonía ecuatoriana en general, es un tipo de vegetación bastante raro. Históricamente, la gente de la cultura Cofán ha utilizado este recurso natural en la construcción de sus casas y en otras necesidades de subsistencia, pero hasta ahora no se ha reconocido el valor comercial potencial de los bosques de bambú. Actualmente, los residentes de Dovuno viven de la agricultura y pesca de subsistencia, la producción de artesanía para el turismo, la tala no-mecanizada y algunos hombres de la comunidad han trabajado de jornaleros en los campos petroleros.

En términos taxonómicos, el bambú que se encuentra en Dovuno es del género *Guadua*, pero sin tener muestras con flores no es posible identificarlo hasta especie. Sin duda, este bambú es parecido a *Guadua angustifolia*, la conocida caña guadua de suma importancia cultural y económica en la costa de Ecuador y Colombia, pero existen numerosas diferencias importantes que podrían ser consecuencias de las condiciones ecológicas específicas del área de Dovuno. La identificación de esta especie es importante para modificar los procedimientos de manejo, determinar los usos apropiados para la materia prima y comercializar efectivamente los productos de bambú.

La integración de la conservación de recursos naturales con las políticas de desarrollo rural es un reto importante. El manejo y la comercialización de *Guadua* proveniente de Dovuno forman parte de un plan integral para manejar los recursos del bosque y del río en el territorio Cofán. La primera fase del proyecto de bambú incluye las siguientes actividades: mapeo del territorio con zonificación del uso de la tierra, inventarios florísticos y estructurales del bosque dominado por bambú, planes de manejo para la selección y cosecha de bambú, asistencia técnica en el manejo de bambú, la identificación de mercados y el desarrollo del plan de negocio para generar ingresos competitivos y distribuir equitativamente los beneficios asociados con el bambú. La segunda fase del proyecto se enfocará en el procesamiento, transformación y comercialización de los productos de bambú con valor agregado.

Esta evaluación de impacto ambiental considera las consecuencias del manejo, cosecha y venta del bambú como caso específico y distinta a otras actividades forestales. Los objetivos de la EIA son minimizar las probabilidades que ocurrirían impactos ambientales, sociales y económicos negativos y mejorar el diseño e implementación del proyecto. Se identifican varios impactos potenciales y para cada uno se sugiere algunas medidas de mitigación para reducir la probabilidad o grado de su ocurrencia. Se enfatiza la necesidad de un buen programa de monitoreo para desarrollarse temprano en el periodo del proyecto. El informe considera los siguientes impactos potenciales:

- Efectos sobre la estructura del bosque y los procesos del ecosistema;
- Efectos sobre la producción y crecimiento del bambú;
- Efectos sobre la regeneración natural, incluyendo especies de árboles comerciales;
- Efectos indirectos durante la extracción y transporte del bambú al mercado;
- Los impactos sobre la fauna;
- Contaminación debido al tratamiento químico del bambú;
- Floración y muerte del bambú sobre áreas extensas,
- Impactos sociales del manejo y cosecha del bambú;

- Barreras económicas y limitaciones del mercado.

Para concluir, se consideran los impactos potenciales de las actividades productivas alternas a las que están propuestas en el proyecto. El potencial del bambú local para proveer ingresos significativos para la comunidad ya ha incentivado a los residentes de Dovuno a frenar la amenaza inminente de la industria petrolera con la intención de conservar este recurso natural del bosque.

I. INTRODUCTION

Project description

The community of Dovuno in the northern Ecuadorian Amazon encompasses an area of approximately 1000 hectares of native bamboo (*Guadua* aff. *angustifolia*; "caña guadua" Ecuadorian Spanish from the coast) that occurs in stands of varying density within the surrounding heterogeneous broad-leafed forest. Cofán community members have historically used this bamboo resource for housing (floors and walls), beams and building supports, scaffolding, ladders, aqueducts, hunting darts, and other subsistence uses.

Large extensions of naturally occurring *Guadua* bamboo forests, such as found in Dovuno, are not common in the Ecuadorian Amazon. Local residents have obviously been aware of this unusual vegetation type within their territory for as long as it has been there and present-day residents who were interviewed during the course of this assessment do not recall a time when there was no bamboo.

It is known that multi-hectare stands of canopy-forming bamboos are distinguishable from surrounding non-bamboo forest in satellite images due to two aspects of their growth and physiology: (1) woody bamboos have high silica content in stems and leaves and (2) their physical dominance and growth pattern that fills in gaps among trees in an otherwise corrugated forest canopy. This combination of factors results in a unique spectral signature in remotely sensed images. As a result, extremely large areas of bamboo-dominated forests are now recognized from the southwestern Amazon based on satellite imagery. It has been calculated that *Guadua*-dominated forests cover approx. 180,000 square kilometers at the binational border of Acre, Brazil and Madre de Dios and Ucayali, Peru (Judziewicz et al. 1999). In Ecuador, steep broad hillsides covered with Andean bamboo (*Chusquea* spp.) are distinguishable in satellite images and a *Guadua* thicket at about 1000 m elevation is discernable on the north slope of the Galeras Range (Napo Province) on the western edge of the Amazon. The bamboo-dominated forest around Dovuno is visible on satellite images that were used by the Jatun Sacha GIS team, and verified with GPS readings during a helicopter over flight, to delimit the area covered by this vegetation type.

Until recently, the residents of Dovuno had been unaware that the outside world may be interested in and willing to pay for culms and products made from their *Guadua* bamboo. Now they have been alerted to the fact that there are existing markets for this bamboo resource, as both a raw material for building, as well as value-added items that could be produced locally. The Cofán Federation (FEINCE) and numerous members of the community of Dovuno are, therefore, extremely interested in harvesting their natural bamboo-dominated forests for economic gain. The FEINCE has incorporated the bamboo project as part of their regional cultural agenda to implement activities that would improve the standard of living, strengthen the indigenous organization, and manage local natural resources. The FEINCE and the Jatun Sacha-CDC alliance recently signed an agreement indicating that Jatun Sacha would guide the community's guadua management and harvest activities in Dovuno.

The management and commercialization of guadua from Dovuno is part of an integrated plan to manage the community's natural forest and river resources. The management of naturally-growing bamboo requires training in appropriate methods of culm selection, propagation, and harvest in the forest, as well as task organization, culm processing and transport, business management, and especially, marketing of bamboo culms and other potential bamboo products.

Proposed project activities

The discovery of a large and significant patch of bamboo-dominated forest within the Dovuno community territory, led to the development of a project to manage, harvest, and sell bamboo culms (raw material) in the short-term and locally-produced bamboo products later. It is the general objective of the project to contribute to community development in Dovuno by generating alternative production activities, work opportunities, improved living conditions, and good management of natural resources (Jatun Sacha 2003a). Mechanisms will be devised so that the entire Dovuno community will derive some economic benefit from the bamboo project and not only the people who actively work on the project.

Specifically, the bamboo project aims to:

- Produce high quality bamboo culms following appropriate stand management and harvest techniques;
- Establish a bamboo center that will coordinate project activities and function as a community based small-business enterprise;
- Find value-added bamboo products that can be produced locally by the center and that will be competitive in specific markets;
- Build community capacity in the management and commercialization of their bamboo.

Two phases have been proposed for the Dovuno bamboo project and community members will participate in all aspects of the project; it is expected that ten people will be trained in bamboo management techniques during the project's first phase. The list of project activities follows, as presented by Jatun Sacha (2003a):

First phase

- Zoning of Cofán territory that constitutes the Dovuno community;
- Selection and identification of natural stands of bamboo;
- Inventories (floristic and structural) of bamboo-dominated forest;
- Development of management plans and bamboo harvest procedures;
- Technical assistance and training in bamboo stand management;
- Management and harvest techniques in a pilot study area;
- Market identification and development for bamboo raw material;
- Business plan development;
- Environmental impact assessment of bamboo management and harvest.

Second phase

- Design and construction of bamboo processing center;
- Equipment purchase and functioning of bamboo processing center;
- Training of the center's personnel in the production of bamboo strips, construction techniques, handicrafts and other potential uses of bamboo;
- Operation of the center that may produce bamboo strips, furniture, handicrafts and prefabricated structures such as houses, greenhouses, and latrines;
- Product commercialization;
- Development of a local small-business enterprise;
- Training and other technical assistance;
- Development and implementation of a monitoring program for the project.

The FEINCE will serve as a liaison between Jatun Sacha and the community. The Jatun Sacha and Ecuabambu consortium will provide technical assistance in the development and execution of a management plan for bamboo harvest as well as organizational support. Ecuabambu will research markets, establish links with other bamboo-focused institutions, and develop a business plan to find the most competitive outlets for bamboo products.

II. SCOPE OF WORK

The management of naturally-occurring bamboo forests in the Dovuno community territory will be part of the integrated planning of the community's natural resources.

Report objective
It is the specific purpose of this report to describe the environmental aspects of the project area and assess the potential environmental impacts that should be considered while planning and developing project activities so that their implementation will have the least negative impact on biological, social and economic factors that pertain to the community and their surroundings.

Regarding environmental assessments under the CAIMAN[2] umbrella, the USAID Environmental Threshold Decision document (LAC-IEE-02-44) states the following:

> *"A positive determination is issued to the capacity building and implementation of wildlife management plans and of forest management plans which have the potential to cause significant environmental impacts indirectly, especially when coupled with the competitive small grants"*
>
> *"As the USAID/Ecuador's Awá activity in northern Ecuador is currently conduction an environmental assessment (EA) for its forest management program, and the Awá activity will eventually be incorporated into the CAIMAN activity, this EA should provide sufficient guidance for other indigenous peoples' forest management activities in northern Ecuador."*

It was considered, therefore, that the EA prepared for the Awá forest management program (Buschbacher et al. 2003) would provide sufficient guidance for Cofán forest management activities. The management, harvest, and commercialization of a native bamboo species, however, was not specifically considered, hence the decision to carry out an EA that would focus specifically on the details pertinent to the rational harvest of this localized natural resource in a single indigenous community.

Methods

The following are the steps that were taken to elaborate an Environmental Impact Assessment (EIA) for the bamboo management activity in Dovuno:

1. Revision of documents to understand the environmental requirements of USAID, the environmental assessment of the Awá forest management program, the forest management activities of the Cofán, and the social, cultural, economic and ecological conditions in Dovuno. The GIS department of Jatun Sacha provided access to an annotated satellite image that had been prepared for this project.

2. Discussions with relevant people and institutions outside of the Dovuno community who have information on who will be affected by bamboo management. Consultations were carried out with bamboo experts from INBAR, Consejo Consultivo sobre Bambú (Ecuador National Bamboo Project), CORPEI, and with practicing *Guadua* silviculturalists and taxonomists.

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[2] Conservation in Managed Indigenous Areas (CAIMAN). Biodiversity and Sustainable Forestry (BIOFOR).

3. Identification of key elements in the bamboo management proposal (Jatun Sacha 2003a) which could cause negative impacts.

4. Site visit and activities in Dovuno (April 5-8, 2004)

- Transportation and route reconnaissance from Lago Agrio to Dovuno;
- Two long transects were walked with a Cofán guide in different parts of the community territory through natural bamboo-dominated forest, this included an area where bamboo grew in association with the palm, *Mauritia flexuosa*;
- Ten small plots were sampled in bamboo forest to quantify (a) the average number of culms/m^2, (b) the relative proportion of juvenile, mature and senescent culms, and (c) average culm diameters (Plate 1);
- The first stages of bamboo stand management by community members was observed, this consisted primarily of clearing understory debris and cutting and removing dry culms;
- Participation in two community meetings to get to know the opinion and feelings of the local people regarding the bamboo management project, their immediate problems with project, and their ideas about the distribution of future benefits from this initiative.

5. Prediction of potential environmental impacts and consequences (biological, social and economic) due to bamboo management following the site visit.

6. Identification of mitigation measures and recommendations that should be implemented to ensure that bamboo management and harvest results in minimal environmental impacts.

7. Report elaboration.

Plate 1. Clemente Quenamá, participant in the Dovuno bamboo project, measuring the diameter of a *Guadua* culm in a sample plot.

III. ENVIRONMENTAL DESCRIPTION OF PROJECT AREA

Location

Dovuno is a culturally Cofán community located within Cofán territory in the northern Ecuadorian Amazon This community is under the jurisdiction of the County of Nuevo Loja, in the Province of Sucumbíos. It is located on the south bank of the Aguarico River at an elevation between 250-300 m. The river is the principal access and transport route for daily activities. As well, a short secondary road between the river and the main road gives community members access to Lago Agrio, the capital of Sucumbíos Province and the regional commercial and oil exploration and production center. Dovuno is about 35 km west of Lago Agrio and about the same distance east of Lumbaqui (Jatun Sacha 2003b).

In early 2004, the Dovuno community was donated an outboard motor by regional authorities to facilitate their river transport needs. A newly built canoe, still unfinished, was being used for community needs, including transporting us from the road drop-off point to the community entrance some kilometers upriver. It took an hour and a half to make the trip from Lago Agrio to Dovuno by road (rented vehicle) and river (community canoe) at a time when the river was low and the beach wide; with more water the trip would be faster. The point is that transport from Dovuno to the commercial center of Lago Agrio is relatively short and easy by Amazonian standards.

Social and cultural aspects

The community of Dovuno is part of the Cofán Federation but interestingly, some community members are Quichua; numerous families are made up of intermarriages between members of the two distinct ethnicities. According to a FEINCE survey, there were 27 men and 26 women between the ages of 18 and 45 (both ethnicities) living in Dovuno in 2002. The Cofán are renowned for their conservation conscious attitudes. The presence of the Quichua culture in Dovuno affects many aspects of daily living as compared with other purely Cofán communities nearby, including leadership and the perception and use of natural resources. For example, the community of Dovuno has not yet established internal rules and regulations – as have been established in Dureno (Cofán) - regarding appropriate natural resource management, particularly with respect to timber harvest (Jatun Sacha 2003b).

In Dovuno, the basic services of electricity, drinking water, and sewers are poor or lacking. There is a community house, an elementary school, and a soccer field, as well as an abandoned health clinic. Local housing is a mixture of traditional Cofán construction that utilizes palms (roof thatch, floors), split bamboo (walls), round bamboo (ladders), and wood (beams and other supporting structures, walls), with the style of colonists who typically build with wood or cement and install corrugated zinc roofs (Plate 2).

Principal activities of local people are subsistence agriculture, hunting and fishing as well as handicraft production for the tourist industry.

Plate 2. House in Dovuno with outer walls made of split *Guadua* bamboo (traditional style) and a corrugated zinc roof (colonist style).

Cofán folklore has a story about the appearance of caña guadua, called "krgrg" in the local language. The story, as related by Emiliano Quieta (father) and translated to Spanish by Luís Hernando Quieta (son) of Dovuno, goes something like this:

> *A man was working his land planting banana, yuca, and corn, and where he planted, his crops produced seed. Another man was lying around being lazy. God told him that if he didn't plant anything then caña guadua with its nasty thorns would grow there instead. Later, God filled the land of the lazy man with caña guadua creating an impenetrable understory and leaving the land "useless."*

There are some anecdotes and scientific evidence that bamboo affects the quality of its soil:

- For some farmers in Acre, Brazil, the soils on which *Guadua* grows are considered particularly fertile and an optimum place to plant crops.
- In a Chinese forestry study, nitrogen fixing bacteria were found in the root zone of several bamboo species (Xiaoli & Xiaoping 2001).
- In Dovuno, I was told by one person that bamboo forest soils were good as demonstrated by the fact that banana plants grew well on them.

Bamboo basics

Bamboos are a subfamily of grasses (Poaceae: Bambusoideae). The best known species are woody and arborescent and due to their rapid growth, large biomass, and pattern of vegetative reproduction, these bamboos may have dramatic and far reaching consequences on the stability and productivity of forests in which they are common. Bamboos compete successfully with trees and may inhibit the establishment of tree seedlings or growth of tree saplings. The presence of bamboo in the forest will influence rates of nutrient cycling, forest dynamics, natural regeneration and carbon sequestration.

The same ecological and physiological traits that give bamboo a competitive advantage in the forest make these plants an ideal renewable resource for the development of local economies in Latin America (Londoño 2002). Bamboos have a wide distribution, are clonal, and grow very fast in the tropics. At appropriate sites and under managed conditions, a new plant may be ready for harvest in 4-5 years and numerous culms of a single plant may be harvested twice a year.

Bamboo morphology

Bamboos are made up of subterranean and aerial organs. Hefty ***rhizomes*** (underground stems) and hair-like ***roots*** are found below the soil surface to a depth of about 1m, depending on the species, soil quality, and the size of the plant. The type of rhizome and its pattern of growth make the bamboo either clumping or running; most tropical bamboos are the clumping type as are *Guadua* species. Bamboo ***culms*** (stems), ***culm leaves***, thorny ***branches***, and ***foliage leaves*** are all visible above ground. Destructive sampling of *Guadua angustifolia* on the Ecuadorian coast revealed the underground biomass (rhizomes and roots) comprised about one third of the total dry biomass of a mature plant (Stern 2002) and in Colombia, the contribution of rhizome and culm to total biomass in a mature plant was found to reach 90% (Riaño et al. 2001). Other technical features of the bamboo culm discussed herein include the ***node***, the ***internode***, and the ***culm wall***. The length, width and quality of these latter features are important to determine the physical properties (e.g., strength, flexibility, torsion) of the culm, particularly for construction purposes.

Bamboo growth and reproduction

Bamboos reproduce vegetatively for most of their lifetime. A network of rhizomes occupies underground space, each spreading horizontally away from the mother culm. New shoots develop from rhizome buds and curve upwards towards light as they develop into culms

(Plate 3). A single plant will produce new culms (or clones) regularly and each individual culm appears and dies naturally over a much shorter cycle than the lifetime of the entire plant. A single genetic individual, therefore, could be comprised of many, many culms and cover large areas. This is advantageous for sustainable harvest as numerous mature culms can potentially be harvested without killing the individual. New bamboo culms tend to increase in diameter as the whole plant ages but culms do not express secondary growth, so once above ground, a single culm's diameter does not increase over time.

At some point in time, a bamboo will flower. The timing mechanism (3-120 year cycles) and the behavioural trigger for bamboo flowering remain biological mysteries and numerouos genetic and ecological hypotheses exist in the literature (e.g., Janzen 1976, Keeley & Bond 1999). Some bamboo species flower only once in their lifetime and then die, others flower sporadically, and still others flower almost continually. Some bamboo flowering events are synchronized and massive, for example an entire watershed of a dominant or common bamboo species may flower and die at about the same time following decades of strictly vegetative reproduction. In other bamboo species, one might find a local population of bamboo plants in flower while other nearby populations remain sterile. This is a confusing scenario but bamboo flowering and potential dieback of a large bamboo population could have drastic implications to animals that feed on it or to an industry that relies on it.

Bamboo identification

Latin America has 39% of the species of woody bamboos known in the world; there are 42 species of bamboo reported from Ecuador (Judziewicz et al. 1999). There is no doubt that the dominant bamboo in the Dovuno forest is a species of *Guadua*. This genus is easily recognizable by its large size, the waxy white band at the culm node, paired branch thorns, and fine characteristics of the triangular culm leaf. There is also no doubt that this species of *Guadua* is closely related (or is) *G. angustifolia*, the ubiquitous and economically important timber bamboo of coastal Ecuador and Colombia (Rao & Ramanatha Rao 1998, Londoño 2002). Due to differences in a suite of vegetative characters such as the form of the culm sheath, the internode length (19-20 cm), and culm wall thickness (3 cm) (Plate 4), a definitive species identification cannot be made without flowering material. The observed differences could reflect a sister species, a good subspecies[3], or the specific ecological conditions of the Dovuno forest. It is therefore suggested that the species in question be referred to as *Guadua* aff. *angustifolia*, provenance from Dovuno, until more information is known.

Plate 3. A new shoot breaks through the leaf litter (left);
Plate 4. Cross section of a culm (right).

[3] Approved subspecies are: *Guadua angustifolia* subsp. *angustifolia* and *G. angustifolia* subsp. *chacoensis.*

Though *Guadua angustifolia* is predominantly a species of the western side of the Andes, it has been collected from natural forests in the Ecuadorian Amazon (see map of botanical collections, Appendix 1). More commonly, *G. angustifolia* is planted on farms and is frequently seen below 1000 m elevation along the highway from Quito to Lago Agrio. There are other species of *Guadua* that are typically Amazonian and new species have been recently described (Londoño and Clark 2002).

Predominant vegetation types

The Cofán territory covers nearly 200,000 hectares of humid tropical rain forest that still contains large areas of natural forest with little human intervention. Not surprisingly, most anthropogenic vegetation is evident along the banks of the Aguarico River and near the communities of Dureno and Dovuno. The vegetation within the Dovuno community territory can be classified as follows (Sierra 1999); vegetation description and characteristic plant species as per Jatun Sacha (2003b):

Natural vegetation

Lowland evergreen forest: Canopy emergent species reach 40-45m height (e.g., *Cedrelinga cateniformis, Cedrela odorata, Ocotea* sp. *Ficus* sp. *Ceiba saumauma*); Canopy species about 30m (e.g., *Minquartia guianensis, Virola sebifera, Clarisia biflora, Platymiscium stipulare, Guarea kunthiana, Sapium marmieri*); and subcanopy species. Palm species *include Iriartea deltoidea, Wettinia maynensis, Socratea exorrhiza* and *Mauritia flexuosa*.

LOWLAND EVERGREEN FOREST WITH BAMBOO: This vegetation type is unique to Dovuno and is primarily found in relatively flat areas with dark, well-drained alluvial soils that occur close to the population center. Even so, it appears that there have been little human-induced changes to the structure and composition of the bamboo-dominated forest probably because the sturdy pair of sharp branch spines makes off-trail passage difficult. This vegetation type is characterized by an association that is dominated by the woody bamboo *Guadua* aff. *angustifolia*, in some places reaching an estimated 80% level of dominance (Plate 5). Tree species commonly found mixed among the bamboo include *Cordia alliodora, Ocotea quijos, Ficus* sp. *Guarea silvatica, Guatteria* sp., *Inga* sp. and *Protium* sp. (Plate 6)

Plate 5. Understory of dense bamboo-dominated forest in Dovuno (left);
Plate 6. Vertical cross-section of bamboo dominated-forest (right).

Anthropogenic vegetation

Selectively logged evergreen forest: Forest that has undergone significant changes due to human presence, often the forest adjacent or near to population centers or rivers. Species composition is similar to lowland evergreen forest type but lacking the most valuable or useful timber species. In the Dovuno community territory, ongoing traditional non-technical logging has depleted some forest resources to a critical level. Today there are no longer timber species standing in areas near the community center, resulting in a forced reduction of logging activities (Jatun Sacha 2003b)..

Subsistence crops and associated vegetation: Areas where the forest has been replaced by subsistence crops, the most important being yuca (*Manihot esculenta*) and plantain banana (*Musa paradisiaca*); these are often cultivated in association with palms that bear edible fruit (e.g., *Mauritia flexuosa, Oenocarpus bataua*).

Secondary forest: Areas of human intervention where vegetation has been left to regenerate naturally. Sun-loving fast-growing species predominate in early successional phases (e.g., *Cecropia* spp., *Ochroma pyramidale, Castilla* spp. *Virola* spp. *Cordia alliodora, Jacaranda copaia, Vitex cymosa*)

Areas without vegetation: Areas with a minimum of vegetation due to disturbance or a natural condition. Soils are generally clayey, red and acidic and inappropriate for agriculture; limited plant species can populate them.

Present and potential land use

The Jatun Sacha Foundation recently carried out a feasibility study of sustainable forest management in Cofán territory, with emphasis on the Aguarico communities of Dovuno and Dureno (Jatun Sacha 2003b). The forested land of both of these communities is under human pressure due to expanding agriculture, logging and hunting. Dovuno forests were found to have 2.7 m^3/hectare of hardwoods and 9.6 m^3/hectare of softwood species, commercial wood volume values that are inferior to those from production forests of northwestern Ecuador. Even so, this study points out that the flat landscape around Dovuno, easy access to a navigable river, and the relatively short distance to a principal highway, make timber harvest with heavy equipment an attractive possibility for the future.

It is emphasized that the possibility to manage and exploit the large natural stand of *Guadua* bamboo is of particular interest as an alternative to traditional logging in Dovuno. Bamboo-dominated forests were estimated to cover 1195 hectares of Dovuno community territory; 545 hectares of that area is considered to have high potential for harvest (Table 1). Preliminary results from a single transect through the bamboo-dominated area yielded a volume of 4.9m^3/hectare of bamboo (Jatun Sacha 2003b). As *Guadua* bamboo culms are cylindrical and hollow, it is more common to cite bamboo volume in terms of average production of culms/hectare/year; in coastal Ecuador, the average production of *Guadua* was reported to be 1376 culms/ha/yr (Londoño 2002). Table 1 illustrates the results of zoning for production forests in Dovuno, considering both natural non-bamboo forest and natural bamboo-dominated forest.

Table 1. The area of natural non-bamboo, bamboo-dominated forest, and other vegetation types found in Dovuno territory and the respective harvest potential of each.

Harvest potential	**Natural forest** Area in hectares	**Guadua forest** Area in hectares	**Other vegetation types** Area in hectares
High	**2025**	**545**	--
Low	1476	201	--
Conservation value[1]	--	449	--
None	--	--	1188
Total area	3501	1195	1188

[1]This special zoning class refers to stands of *Guadua* that are associated with *Mauritia flexuosa* palms. These areas are considered a special vegetation association and will not be exploited, thus there is no harvest potential.
Source: Adapted from Jatun Sacha 2003b.

Flora and fauna

The forest inventory of Dovuno territory (bamboo and non-bamboo forests) included in the Jatun Sacha study (2003b) listed 145 tree species with dbh ≥ 10 cm, including palms. Eighteen of these tree species were considered to have commercial value but only four species have high commercial value (Table 2).

Table 2. Four tree species of high commercial value in Dovuno forests and their estimated volume (m^3) per hectare.

Scientific name	Common name	Volume (m^3/ha)
Cedrelinga cateniformis	Chuncho	4.1
Hyeronima alchorneoides	Mascarey	4.7
Parkia velutina	Guarango	8.7
Otoba parvifolia	Sangre de gallina	10.6

Source: Adapted from Jatun Sacha 2003b.

Tree species diversity in bamboo forest

Overall tree species diversity is expected to be lower in bamboo-dominated forests, especially in areas where bamboo stands are densely packed and highly dominant. At such sites, the relative abundance of individual trees is simply much lower than in adjacent non-bamboo forest. Some medium sized, relatively fast-growing tree species were cited previously as representative of the bamboo-tree association (Jatun Sacha 2003b) but there is no *a priori* reason to think that large slow-growing hardwoods might not be present as well in association with more dispersed bamboo forest.

A transect-based field comparison of tree species diversity in bamboo-dominated Amazonian forests vs. adjacent non-bamboo forests on the Amigos watershed in Madre de Dios, Peru, revealed similar tree species diversity values when bamboo was dispersed, but a drastic reduction of tree diversity in dense bamboo forests. In these dense bamboo forests, most of the few associated plant species were thorny themselves (Stern & Cornejo, unpubl.).

Effect of bamboo on forest structure

Bamboos that reach the forest canopy, as is the case with *Guadua* aff *angustifolia*, may pose a threat to the health and survivorship of associated tree species. It appears that Guadua's mighty branch spines can function as grappling hooks to sustain erect culms amidst surrounding vegetation and to help them climb into the forest canopy. The weight of water-filled culms, bamboo branches and foliage leaning over the apex of a subcanopy tree can snap tree branches and cause trunk damage (pers. obs.).

The intertwining nature of bamboo branches, spines, and foliage in the forest canopy also makes bamboo culm harvest extremely difficult under natural unmanaged conditions. A culm could be cut at its base but require many people to swing and pull on it to extricate the apical portion from the surrounding vegetation, while taking care not to break branches or fell neighboring trees (pers. obs.).

Fauna associated with Amazonian bamboo forests

Specialized fauna have been documented from bamboo-dominated forests of the southwestern Amazon that include birds that live in the understory (33 species; up to 5% of all Amazonian bird species may depend on bamboo), mammals that eat foliage or hide in the dense vegetation (most notably, the bamboo rat and the dusky titi monkey), and amphibians and insects that inhabit the aquatic environments of hollow culm internodes (Judziewicz et al. 1999). My questioning of numerous Dovuno residents – including those working in the forest with bamboo - about specialized animals that live in their bamboo forest was inconclusive.

IV. ANALYSIS OF POTENTIAL ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

The first phase of the bamboo project contemplates the following steps that could ‘cause significant environmental impacts indirectly’[4]: bamboo stand management, culm harvest, culm processing, culm transport, and product commercialization. Potential ecological impacts include effects on: the production and growth of clones of a harvested plant; ecosystem nutrient supplies, forest structure and dynamics; fauna; and contamination.

This section stresses the need for a good monitoring program and identifies potential environmental impacts that may occur in Dovuno due to the bamboo project and the biological, social and economic consequences of those impacts. For each potential impact, mitigation measures and recommendations are suggested to reduce the likelihood or degree of their occurrence.

Monitoring program

Any forestry activity will cause a series of effects on local forest composition and structure, soil quality, the transformation of organic material, and adjacent aquatic environments. It is essential, therefore, to design a biological mitigation and monitoring program during the first phase of the bamboo project. Attributes of sustainable harvest of bamboo should take into account its economic feasibility, social acceptability, and ecological consequences (Kusters et al. 2001).

The monitoring plan should consist of procedures that serve to evaluate the effectiveness of actions that mitigate the potential negative impacts of bamboo management, harvest, processing and transportation procedures. Government forestry regulations such as maintaining permanent protection areas on slopes, along river margins, and near lakes and other water sources must be respected.

Since this project is being implemented at the community level in an area that is of communal ownership, rather than private, community members should be involved in its design and function.

- Local participants should assist in the design of the monitoring plan to ensure its successful implementation.
- Participatory mapping of the management area should be based on walking long transects through the forest in a systematic way (rather than roaming around and observing). The map should indicate the availability of bamboo in terms of relative abundance and density, access routes, and an assessment of any extenuating environmental or land use circumstances.
- Indicators must be practical so that they are easily recognized and assessed (counted or put into categories) by local people participating in the project; local people should suggest indicators.
- A system of small plots within and outside of bamboo managed areas should be set up for periodic monitoring and analysis. This aspect of a biological monitoring program will serve to evaluate the effects of the different project activities such as the quality of bamboo cutting and management.
- The monitoring program should take into account that the consequences of improved production of almost any product include: the potential for increased direct and indirect use of natural resources, an increased release of contaminating

[4] USAID Environmental Threshold Decision (LAC-IEE-02-44)

materials into the environment, and in the case of community-based production, increased tension and controversy over production benefits.

Ideally, the monitoring program should be able to establish the critical harvesting level beyond which the reproduction of the bamboo population and the structure and functioning of the ecosystem will be disturbed. What impressions do local residents have about ecological sustainability of the bamboo forests and what level of harvest will be socially acceptable?

Other specific components of an effective monitoring program are suggested as part of the mitigating actions of the potential impacts listed below.

Effects on forest structure and ecosystem processes

Five hundred and forty-five hectares of bamboo forest were found to have high potential for production in the Jatun Sacha forest management feasibility study (Table 1). A pilot bamboo management area less than 20 hectares was selected for the first phase of the project. It is not known what criteria were used to determine the location and limits of the pilot study area. Forest clearing and the removal of senescent culms have already been carried out by Dovuno project participants as the first steps towards taming and managing the natural bamboo stands.

Culm density is variable within the bamboo-dominated forest of Dovuno and there appeared to be large forested areas where bamboo is absent. To get an idea of culm density in a natural stand, we sampled ten 5 x 5 m plots along one long transect through bamboo-dominated forest. Plots were placed in arbitrarily but only in areas where bamboo was present. Culm density ranged from 10 to 21 culms in 5m^2 and there were more than twice as many mature culms per plot than either juvenile of senescent culms (Table 3). Because bamboo is abundant but patchy in abundance and variable in density, it is unreliable to extrapolate this value of culm/m^2 over larger areas.

Table 3. The number of bamboo culms in each life stage and total number of culms sampled in ten 5 x 5 m plots. Juvenile culms were defined as the presence of culm leaves and no branching; mature culms were green in color (sometimes mottled with lichens) with branches; senescent culms were yellowish in color and drying.

	Culm life history stages			
Plot #	**Juvenile**	**Mature**	**Senescent**	**Total culms**
1	4	10	0	14
2	0	8	2	10
3	2	8	9	19
4	2	10	2	14
5	2	9	5	16
6	4	7	0	11
7	2	14	5	21
8	2	12	0	14
9	3	8	5	16
10	3	14	0	17

Suggestions for impact mitigation

- A map is needed that indicates where bamboo forests will be managed over the short and medium term. It is suggested that the Dovuno people who are working in the field on the bamboo project help produce the map, and they all definitely must be able to read the map.

- Well-defined and documented technical criteria, such as topography, drainage, relative abundance and culm density, should be used to determine where the remaining 525 hectares of culm production bamboo forest are located [545 ha minus the 20 ha pilot plot].
- Special ecological parameters, such associations with other species (e.g., *Mauritia flexuosa*) merit conservation considerations in land use zoning for bamboo production.
- Maintain a well-organized and detailed data log that indicates work progress, culm selection criteria, and different harvest treatments.
- New culms should be marked with indelible marker as they emerge to keep track of culm production per plant and growth rates (part of monitoring program). This is standard procedure in bamboo plantations and is not complicated.

Effects on bamboo production and growth

It is essential to follow management practices to protect the bamboo plant following culm harvest. Some of the most important practices include: culm selection for harvest; degree of culm harvest or thinning; height and location of cut on culm; and branch pruning.

Suggestions for impact mitigation

- Technical assistance provided by Ecuabambu silviculturalists will teach community participants the essential rules and practices for proper culm harvest. Harvest techniques used in *Guadua* plantation systems should be used with appropriate modification for this natural forest environment. For example, bamboo clumps may be more tightly packed in natural forests than in plantations, and this will make harvest of internal culms more difficult. Certainly, extrication of culms will be tedious and difficult during early stages of management as mature culms will be entangled amidst surrounding vegetation.
- Branch pruning regulates crown spread and may help reduce canopy entanglement.
- Only mature culms should be harvested (see Table 3 for a physical description of culm stages).
- Culm thinning generally controls clump size and influences production of new culms. The number of culms per plant to be harvested at any given time should be a conservative percentage, at least during the first phase of the project. Extraction rates cannot exceed growth rates!
- Culms of *Guadua angustifolia* are usually harvested above the third or fourth node at a distance less than 3 cm above the node (Plate 7). This will prevent rain water from filling a partial internode where it may penetrate and rot the basal portion of the culm and rhizome.

Plate 7. View of bamboo forest in Dovuno with cleared understory and dry culms cut and removed.

Effects on natural regeneration, including commercial tree species

It was observed that saplings and small trees were often cut by machete while clearing the forest around bamboo plants in the management plots. There appeared to be no thought about the tree being killed in an attempt to quickly and effectively clear the understory environment. If valuable tree species were left to grow among the bamboo, the Dovuno community will benefit from good quality timber after a few years and many animals (especially frugivores) in the forest will benefit from the presence of keystone species such as figs and other species that produce abundant or high lipid content fruit (e.g., pipers, melastomes, lauracs) consumed by birds, bats and small mammals.

Suggestions for impact mitigation

- The removal of all understory plants should be reconsidered in the management plan.
- While carrying out the bamboo inventory, census data should be taken of valuable timber species and keystone species as well. These data should be included in the monitoring program.
- Calculate the relative importance (abundance, distribution and dominance) of the different tree species that are present within the bamboo-dominated forest, particularly those of economic or ecological importance.
- The natural regeneration of valuable species should be left in place and monitored, though it is likely to be difficult to accurately identify seedlings of many tree species.

Indirect effects during extraction and transport to market

In Ecuador, bamboo culms have been transported by river, by trucks, in human-propelled tricycles and horse-drawn carts, on horses and mules, and over the shoulder (Morán 2001). Culms from Dovuno would most logically be manually hauled to the edge of the Aguarico River from where they would be floated - either in a boat or on floater logs - to a downstream beach on the north side of the river. The community will need to identify a site to collect and store bamboo culms to be loaded onto a truck for the next leg of their journey to Lago Agrio or Quito.

It is unlikely that culm extraction from the Dovuno forest will be mechanized given the cost and difficult access; human labor is readily available. Once the culms are at the riverbank, there could be an environmental impact associated with bamboo transport downstream to a roadside access point if floater logs are used. Because the Aguarico river is rocky, especially during the dry season, it would not be recommended to merely tie *Guadua* culms together and send them downstream as they would likely be bumped around and suffer damage.

Suggestions for impact mitigation

- Rely on human labor or mules to haul harvested culms to the bank of the river.
- On the river, culms could be transported by boat or on a raft of floater trees. Tree species likely to be used as floater logs will be lightweight, fast-growing pioneer species (Siebert 2001). These trees could be harvested from naturally disturbed floodplain of the Aguarico.

Impacts on wildlife

Associations of specialized fauna with bamboo are well documented, especially where large stands cover the landscape. When vast expanses of bamboo are eliminated, extinctions of rare species may occur, as likely happened to three North American bird species[5] with the

[5] Canebrake destruction may have contributed to the extinction of the Carolina parakeet, passenger pigeon, and Bachman's warbler.

demise of the canebrakes of the southeastern US. (Judziewicz et al. 1999). A recently published UN Environmental Program report[6] warned that the loss of natural bamboo stands may be catastrophic for rare animal species in many places around the world. The report pinpointed the Andes, Amazon and Atlantic forests as regions in the Americas where bamboo forests contribute to high levels of biodiversity and provide resources for highly specialized or rare animals yet are under considerable human pressure.

Although some Dovuno residents could not name any local fauna that are bamboo obligates or prefer a bamboo forest habitat, they are likely to exist. The increased human presence in the forest and the noise made during bamboo management and harvest are likely to affect birds and mammals that might normally be living in or passing through the environment. As well, hunting pressures my increase as a result of project workers spending more time in the bamboo forest.

Suggestions for impact mitigation

- Raise consciousness about bamboo associated fauna with Dovuno community members, particularly those people working on the project. Encourage discussion about this topic among bamboo workers. Ask people to write down names of birds or mammals that they think might be found more frequently in or restricted to bamboo forests and any insects or amphibians (or anything else) that they find in internodes when culms are cut.
- If the community agrees, monetary or work fines could be imposed for incidental hunting of birds and mammals in bamboo management areas. There would have to be an agreement as to who could be fined for hunting, the level of the fine, and the recipient of the fine.
- Making use of the bamboo forest does not necessarily mean that human actions will be destructive, rather, for conservation to succeed, it is important to work with the people of Dovuno who live in and rely on their forest.

Contamination due to chemical treatment of bamboo

Bamboo culms that are destined for construction or any other outdoor use should be chemically treated. During the second phase of the project, culm preservation techniques that could be applied in Dovuno would definitely be a logical and relatively easy way to add value to the bamboo product. A supply of high quality chemically treated culms would definitely open market possibilities as there is a demand for this product in Ecuador that is far from being satisfied by producers. As a reference, the *Bambua Company* (Marcelo Burneo) in Quito is presently selling selected and treated *Guadua angustifolia* from the coast at a price of $2/m, hence a 6m length of a single treated culm costs $12.

Chemical treatment provides bamboo culms with protection from insects (e.g., powder post beetle) and decay due to sun, rain and ageing. Unlike wood, bamboos must be treated from the inside out as the outer wall of bamboo internodes is highly resistant to penetration by any liquid; the inner side is somewhat more penetrable. Bamboo will best absorb liquid longitudinally through its cellular water vascular system when the culm is alive or recently harvested. There are various preservation methods used that employ chemical treatment through a passive soaking system, a vertical diffusion method or a boucherie sap displacement system. In all of these methods, the chemical of choice is a mixture of Borax and Boric Acid dissolved and diluted in water. These products have been widely used in agriculture for decades and are relatively cheap and easy to obtain.

[6] Forest loss catastrophic for wild bamboo. 11 May 2004. INBAR and UNEP-WCMC Report on Global Bamboo Biodiversity; http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=397&ArticleID=4512&l=en

Boric acid (borax and boron containing salts), originally registered as a pesticide in the US in 1948, is a low toxicity mineral with insecticidal, fungicidal and herbicidal properties. The *Safety Source for Pest Management* gives a *Beyond Pesticides Rating* of **Least Toxic**. (see Appendix 2 for detailed information from *Beyond Pesticides*).

Toxicity

> *"The EPA considers boric acid as a moderately acutely toxic due to acute effects including oral and dermal toxicity and eye and skin irritation. EPA has classified boric acid as a 'Group E' carcinogen, indicating that it shows 'evidence of noncarcinogenicity' for humans."*

Ecological effects

> *"Boric acid is practically nontoxic to birds, fish, aquatic invertebrates and relatively nontoxic to beneficial insects. However, its noncrop herbicidal use may harm endangered of threatened plants and pose a potential threat to aquatic vertebrates as a result of runoff into aquatic environments. EPA concludes that boric acid's limited outdoor use pattern, low toxicity and natural presence in terrestrial and aquatic environments reduces concerns about its impact on nontarget organisms."*

Suggestions for impact mitigation

- A mitigation measure for this potential negative environmental impact of boric acid is to avoid frequent or prolonged contact with skin and eyes and to safely dispose of the waste material following treatment of the bamboo culms.
- Measures should be taken to prevent direct runoff of diluted boric acid into streams and rivers. Once the chemical bath has been used, it is suggested to let the liquid filter through the ground in a place that is removed from water sources and the population center. This would reduce the negative environmental impacts on aquatic diversity, for example. Some recycling of the chemical treatment water may be possible but it is my experience that the water quickly becomes foul from immersion of organic material (the bamboo culms and any small critters that were living in the internodes).

Bamboo flowering and widespread death

Bamboos have a unique life history that often includes semelparous flowering (flowering once and dying). As flowering is such an infrequent event in *Guadua*, there is little reliable information about flowering patterns. In some smaller guaduas in Amazonian Peru, it appears that only the culms that flowered die, not the whole plant. Even regarding *Guadua angustifolia* there is amazingly little known about its flowering given its extraordinary cultural and economic importance in Colombia and coastal Ecuador. It is extremely rare to find a coastal Ecuadorian, even a senior citizen, who has witnessed caña guadua in flower.

It could be risky to develop an industry – and raise the hopes and expectations of community members – on a locally-abundant natural resource that may someday flower and die. The information known today about *Guadua angustifolia* is that flowering events are rare and that it is unlikely that there is full die back in the years following flowering (X. Londoño, pers. com).

Suggestions for impact mitigation

Not much can be done to influence the natural history and sexual reproduction of *Guadua angustifolia*. The bamboo project in Dovuno is part of a regional agenda to improve the standard of living of the Cofán by appropriate management of local natural resources. It would be best to consider bamboo management and harvest as part of a grander forest management scenario; another reason to promote natural regeneration of valuable timber species in areas of bamboo management.

Social impacts of bamboo management and harvest

The bamboo project is expected to provide standard of living improvements for the community of Dovuno over a sustainable period. Income improvements will result from the sale of bamboo culms that are harvested from community land. During the first phase of the project, local participants will receive daily wages that reflect the time spent in activities associated with bamboo management.

It is notable to point out that eight or ten participants had invested their time in bamboo-related activities during April-May 2004 without financial compensation. They were making an investment in their future with the expectation that the first sale of bamboo culms in May would pay the back daily wages owed to them. How will community members handle the influx of the estimated $4000 for back payment of daily wages that corresponds to clearing the initial 30 hectare pilot plot of bamboo forest?

Suggestions for impact mitigation

Not all members of the Dovuno community are likely to participate in the bamboo project. In order that social benefits are equitable, the distribution of the potential income generated by the project was discussed among Dovuno project workers and Emergildo Criollo, the President of the FEINCE. The preliminary agreement (4/04) was that income would be distributed in the following way:

- Workers wages for time in the field and for time spent teaching new project workers;
- Capital for the bamboo company;
- A percentage to the community of Dovuno;
- Ten to 15% to the FEINCE.

Training needs to mitigate potential negative social impacts

The bamboo project should provide the following training opportunities directly or indirectly:

- Land use planning (via zoning and mapping of bamboo-dominated forests in Dovuno community territory);
- Increase in agricultural productivity and diversity to improve Dovuno residents' daily diet and reduce their dependence on plantain bananas. Other appropriate food crops that could be planted on the good soils around the population center include palms, fruit trees and legumes.
- Basic accounting and money management, including a discussion of priorities for the use of income generated by the bamboo project that Dovuno residents are unaccustomed to having;
- Small business administration;
- Processing and transformation of bamboo culms;
- Marketing of bamboo culms and locally-produced bamboo products.

Economic hurdles and market limitations

An analysis of the economic feasibility of selling bamboo was carried out by Guarderas (2003; in Jatun Sacha 2003b). Local markets were found to be restricted to the building sector with the raw material being used for scaffolding, fences, house walls and TV antennas. Due to the relative abundance of wood in Lago Agrio, there is not much demand for bamboo for construction. In other regions of Ecuador, however, the demand for bamboo is greater and prices per culm are higher if the product is of good quality. As well, there is a large market for split bamboo culms destined for pre-fabricated housing for low-income families (e.g., Hogar de Cristo in Guayaquil). The Jatun Sacha report (2003b) described some marketing experiences of other Ecuadorian companies that sell bamboo and came to the conclusion that marketing *Guadua* is not easy at this time. A potential negative social impact of the bamboo project is the creation of false or exaggerated expectations in the Dovuno community with regards to markets for bamboo culms or other locally-produced bamboo products.

Suggestions for impact mitigation

- Identify adequate and appropriate markets for Dovuno bamboo and promote its status as a community-based product from managed Amazonian forests[7]. Ecuabambu, an Ecuadorian NGO specializing in *Guadua*, is well-situated to lead the project in the specific tasks of bamboo stand management and marketing.
- Evaluate and monitor the following components of economic feasibility: market access, trade structure, and competitive returns.
- Develop a strategy to reach niche markets with specialized and standardized bamboo products[8];
- Make realistic promises to the community about harvest volumes and prices to be paid for bamboo.
- Start small and let production increase slowly with emphasis on production reliability and quality, rather than quantity.
- Improve markets for bamboo products by promoting the production of and markets for environmentally certified products. To date, the people of Dovuno have not expressed interest sustainable forest management (SFM) (Jatun Sacha 2003b)[9].

Impacts of alternatives to those proposed in project

This project was developed under the pretense that managed harvesting of natural bamboo may be one potential means to collaborate with Dovuno residents in an activity that is compatible with forest conservation and local economic well-being.

What other livelihood activities would community members pursue if this project were not implemented?

- Farming and fishing activities;
- Handicraft production and other tourism related activities;
- Small-scale logging, an activity that has already virtually depleted valuable timber stock near the Dovuno population center and throughout much of the community territory (Jatun Sacha 2003b);
- Labor in nearby oil exploration and production facilities.

It is certain that these aforementioned activities will continue at subsistence and minimal commercial levels even as the bamboo project is implemented, but the potential income that could be generated by bamboo harvest is far greater than that currently obtained by small-scale logging and farming. The potential for bamboo harvest to produce a significant quantity of income for the community has already proven an incentive to conserve their natural forest resources. For example, the oil production Block 11 is within 800 m of the southern side of Cofán territory (Santa Fé). Because of the bamboo project and the expected income that it will generate for Dovuno residents, the community now wants to protect their bamboo-dominated forests and keep the oil company away from them.

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[7] The bamboo product might be called "caña guadua de Dovuno" or ". . . del oriente" to distinguish it from native *Guadua* from the coast that has been abundantly planted in the Ecuadorian Amazon.

[8] The importance of niche markets has been stressed by CORPEI (Jatun Sacha 2003b).

[9] If the community someday becomes interested in SFM, it must be determined if, in the case of the Dovuno project, *Guadua* aff. *angustifolia* is a timber species or a non-timber forest product that is extracted from the forest. The criteria and conditions are different for SFM regarding timber vs. non-timber forest products and bamboo could be considered in either category depending on the management and harvest regime.

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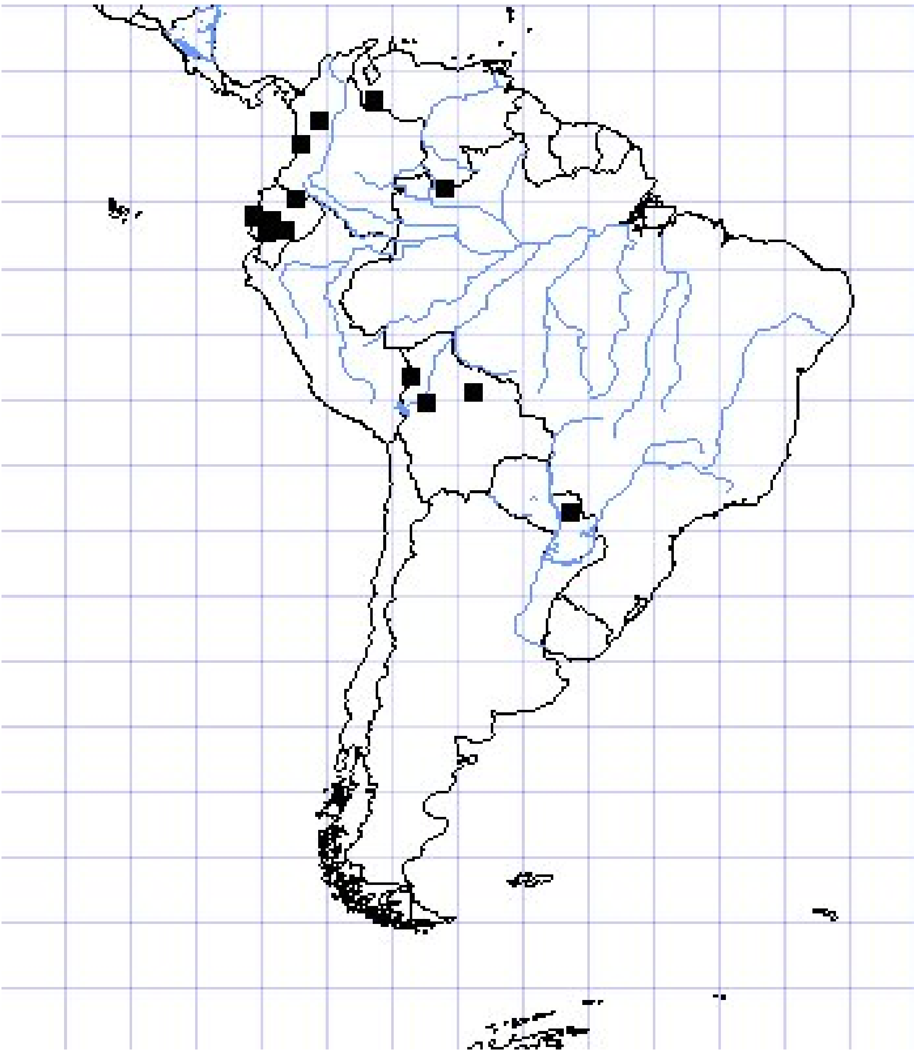
VI. APPENDICES

Appendix 1. Map of botanical collections of Guadua angustifolia



Provided by Missouri Botanical Garden

Appendix 2. Chemical watch factsheet: Boric Acid

chemicalWATCH Factsheet Boric Acid

701 E Street, S.E., Suite 200 • Washington DC 20003
202-543-5450 (v) • 202-543-4791 (f)
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Boric acid is a low-toxicity, non-volatile mineral with insecticidal, fungicidal, and herbicidal properties It has long been embraced as a safer alternative to highly volatile, synthetic chemical pesticides. Boric acid is especially effective when used as part of an ongoing integrated pest management (IPM) program that incorporates sanitation, cultural, mechanical, and biological practices.(3)

Boric acid and its sodium salts, all boron related compounds, generally refers to seven active ingredients, including boric acid, sodium tetraborate decahydrate (borax decahydrate), sodium tetraborate pentahydrate (borax pentahydrate), sodium tetraborate (anhydrous borax), disodium octaborate tetrahydrate, disodium octaborate (anhydrous), and sodium metaborate. No registered pesticide products contact boric oxide as an active ingredient.(6)

Boric acid was originally registered as a pesticide in the U.S. in 1948; there are currently 189 registered pesticide products on the market contain boric acid or one of its sodium salts as an active ingredient.(5) While exposure to boric acid has been linked to adverse health effects, experts agree that careful application offers a less hazardous, more effective alternative to many pesticides, without the indoor air problems commonly associated with pesticide sprays.

Use and Mode of Action
Boric acid and its salts, borates, have been used in medicine as a bactericide, a fungicide, and an antiseptic since the 1860s.(3) It is used as a wettable powder, liquid (applied as a spray or aerosol), emulsifiable concentrate, granule, powders, dusts, pellets, tablets, paste, bait or crystalline rod depending upon the circumstances and target pest.(6)

As an insecticide, boric acid acts as a “stomach poison” for ants, cockroaches, silverfish and termites, and is most commonly used in a bait formulation containing a feeding attractant or as a dry powder. The powder can be injected into cracks and crevices, where it forms a fine layer of dust. Insects travel through the powder, which adheres to their legs. When the insects groom themselves, they ingest the poison, which causes death due to starvation and dehydration 3-10 days later. Boric acid can also abrade the exoskeletons of insects.(5) As long as the material is not allowed to become wet, its continuous presence ensures that hatching insects, which sprays commonly spare, are exposed and die as well. Many insecticidal formulations contain a desiccant to protect the boric acid from airborne moisture. These formulations can be effective for more than a year.(3)

When used as an herbicide, boric acid desiccates and/or interrupts photosynthesis in plants, or suppresses algae in swimming pools and sewage systems. As a fungicide, boric acid can be used as a wood preservative that controls decay producing fungi in lumber and timber products.(5)

In agriculture, boric acid is used as an insecticide, herbicide and fungicide in food crops and orchards (6), and borates have also been utilized as a nutritional supplement for boron-loving crops, such as sugar beets and cabbage.(4)

Boric Acid Toxicity
Boric acid occurs naturally in water, fruits, vegetables and forage crops. It is an essential nutrient for plants and an essential element for many organisms.(5) The acute toxicity of boric acid in rats is less than that of table salt.(2) It is generally of moderate acute toxicity, and has been placed in Toxicity Category III by the EPA for most acute effects, including oral and dermal toxicity, and eye and skin irritation.(5) Sodium tetraborate (anhydrous borax) products are categorized as Toxicity Category I because of high acute toxicity for eye irritation effects.

There are few allergic responses from skin applications of boric acid. Absorption through skin is negligible unless the skin is broken or burned. Respiratory irritation can occur from chronic inhalation of airborne boric acid or borates. Workers show eye irritation, dryness of the mouth, nose, or throat, sore throat, and cough at mean exposures of 4.1 mg/m^3.(2) The oral LD_{50} in rats ranges between 3160 and 4080 mg/kg body weight depending on the species and sex, with males being more susceptible than females. (For comparison, an alternative termite treatment, chlorpyrifos (Dursban®), is about 20 times more acutely toxic at 163mg/kg).(2) Large chronic daily doses of boric acid (about 1g in 1kg food) shrink testicles in dogs and rats, and interfere with reproduction.(2) High doses are selectively toxic to the testes, causing histopathological changes and even sterility in both male rats and dogs. Workers exposed to large amounts of boric acid powders in manufacturing plants were also found to have reduced sperm count and motility.

Boric acid is not mutagenic. In chronic oncogenicity studies using mice, rats and beagle dogs, boric acid and borax were found not to be carcinogenic. The EPA has classified boric acid as a “Group E” carcinogen, indicating “evidence of noncarcinogenicity” for humans. Reproductive and developmental toxicity studies using rats, mice and rabbits found maternal liver and kidney effects and decreased weight gain, as well as decreased fetal body weights. Two studies found that no litters were produced at the highest dose levels. Prenatal mortality occurred at the highest dose levels in the rabbit study.(5)

Boric acid is toxic to all living cells, partially due to enzyme inhibition. Rats fed complex organic salts or boric acid had their serum cholesterol levels lowered due to liver enzyme inhibition. Boric acid was also found to antagonize riboflavin metabolism in chickens. The greatest danger of boric acid to humans results from chronic unprotected exposure to aerosols, or accidental acute ingestion of large amounts. It is extremely rare that an accidental poisoning of boric acid is lethal.

Ecological Effects

Boric acid is practically nontoxic to birds, fish, aquatic invertebrates, and relatively nontoxic to beneficial insects. However, its noncrop herbicidal use along rights of- way may harm endangered or threatened plants and pose a potential threat to aquatic invertebrates, as a result of runoff into aquatic environments.(5) EPA concludes that boric acid’s limited outdoor use patterns, low toxicity and natural presence in terrestrial and aquatic environments reduces concerns about its impact on nontarget organisms.(5)

Effectiveness

An EPA assessment of a boric acid pilot pest control program conducted at the U.S. Army’s Aberdeen Proving Ground in Maryland found that boric acid was both more economical and more effective than monthly spray treatments. (1) At least one study has shown that the combination of heat at 110 degree F for two hours with boric acid will increase the speed at which the German cockroach is killed. (1) A study comparing crack and crevice treatments in conjunction with a full IPM program for cockroaches in school cafeterias found that one crack and crevice application of boric acid reduced roach numbers from 40 per trap to less than three per trap within three months. The low average was maintained for two years by the single boric acid treatment. The same level of control with Dursban® required two full applications followed by a spot treatment. The need for multiple treatments combined with the higher unit cost of Dursban® made boric acid more cost effective.(1)

Regulatory Information

EPA is requiring three phytotoxicity studies to assess the risks of non-target plants and endangered plant species. These studies are not part of the target database and do not affect reregistration eligibility of boric acid and related active ingredients. EPA has requested product specific data including product chemistry, acute toxicity, and efficacy studies, revised Confidential Statements of Formula and revised product labeling for reregistration. EPA has reregistered all 43 boric acid products covered by the General Registration Standard. For these products, only current labeling and Confidential Statements of Formula must be submitted to ensure that they still meet the criteria set forth in that document.(5)

EPA has issued a general exemption for tolerance (acceptable residues) of boric acid in raw agricultural commodities, but is setting limits for the chemical in food and feed additives in the unlikely event that is use in food establishments results in food residues. Under its worker protection standard, EPA is requiring personal protective equipment (PPE) and a 12-hour reentry time for nonresidential uses of boric acid and its salts because it believes that use patterns present a potential for dermal and inhalation exposure among applicators and people reentering treated areas.(5)

Revised and Reprinted: Volume 21, Number 3, September 2001