FINAL TECHNICAL REPORT OF THE RESULTS OF CATIE'S SILVICULTURAL TREATMENT PROJECT IN BELIZE

by

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ACKNOWLEDGEMENTS

The initiative for the work carried out by CATIE in natural forest management and silviculture in Belize was entirely due to the late Ian D. Hutchinson. Ian always expressed high hopes for the work being undertaken with Belize and it is hoped that this report would meet with his satisfaction and faithfully describe what he initiated there. To him we all owe an enormous debt of gratitude.

Many thanks are also due to the following people, all of whom played an important role in the design and/or successful implementation of CATIE's technical assistance in natural forest management and silviculture to the Belize Forest Department and the Programme for Belize: from AID/Belize, Mr. Joseph McGann and Ms. Georgiana Vernon; from the Forest Department, Mr. Oswaldo Sabido, Mr. Earl Green, Mr. Angel Chun, Mr. Marcelo Windsor and Mr. Francisco Villafranco; from the Programme for Belize, Mrs. Joy Grant, Mr. Roger Wilson, Mr. Darrell Novelo and Mr. Marco Figueroa; from the Natural History Museum of London, Mr. John Howel, Chapal and Celia at Las Cuevas Station; from NARMAP, Mr. Pino Cawich; and finally, from CATIE, Mr. Hugo Brenes, Mr. Francisco Pacheco, Mr. Hans Tanner, Mr. Jaime Vindas, Mr. Victor Madrigal, and Mrs. Jeannette Sanchez. Thank you, all.

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(July 1996)

INTRODUCTION

In November of 1994, the RENARM/Production from Natural Forests regional project, implemented by the Centro Agronomico Tropical de Investigación y Enseñanza (CATIE) and funded by USAID/G-CAP, initiated a "buy-in" with AID/Belize to implement the Silvicultural Treatment Project (STP) and provide technical assistance to the Belizean Forest Department (FD) and the Programme for Belize (PfB). At the termination of the RENARM project in January of 1996, AID/Belize issued a separate contract so as to fund the STP for an additional five months and take it to the end of June, 1996.

The general objective of the STP was to demonstrate and teach a proven silvicultural technique known as "liberation"for improving the value of forests which have been overcut and degraded by previous harvesting practices. CATIE's technical cooperation basically involved the following activities:

1) establishment of a network of permanent sample plots (PSPs) by which the long-term effects of the liberation treatment can be quantified and monitored;

2) in-service training in the techniques for establishing, maintaining and evaluating the PSPs;

3) training in the installation and use of a computerized database system developed by CATIE known as SEMAFOR for entering, organizing, storing, manipulating and analysing the field data collected in the PSPs;

4) in-service training in the application of the silvicultural treatment known as "liberation" applied to selected future crop trees;

5) carrying out an operational scale application of the liberation treatment in order to report on costs and productivities of the operation;

6) giving two short courses in directional felling techniques.

This technical report contains two sections. The first section describes the results of the information collected to-date in the PSPs. It looks at the structure of the untreated forest in each of the five sites established and then compares this to the treated forest one year after application. Although only a very short period of time, one year, has elapsed since the establishment of the PSPs, analysis of the data using SEMAFOR already indicates interesting trends between treated and untreated forest, and among different components of the tree population. It should be stressed here that the purpose of this activity was not to demonstrate significant differences in the short time available, (the effects of silvicultural treatments on the structure and dynamics of a forest are generally not expected to be clearly evident until a period of at least five years has elapsed), but rather to set up the infrastructure and technical capability to monitor the PSPs over time. As will be evident from the results, the field methodology and database system provide a wealth of valuable, safely stored, well organized, information that is easily and quickly manipulated to provide insightful glimpses of how individual trees, groups of trees or the forest as a whole is developing.

The second section summarizes the results of the study undertaken to determine the costs and productivities of applying the silvicultural liberation treatment on an operational scale similar to what would be required for the treatment of a large unit of managed forest.

SECTION I - PERMANENT SAMPLE PLOTS

OBJECTIVES OF THE PERMANENT SAMPLE PLOTS

The main objective of establishing the PSPs was to demonstrate and quantify the beneficial effects of applying liberation treatment to degraded and overexploited forests in Belize.

In addition, the results of the technique will eventually be compared to two other silvicultural alternatives being promoted by others, intensive selective cutting and patch/strip cuts, also being studied by the FD and PfB. The latter of these two techniques is mostly for the purpose of encouraging mahogany regeneration.

A total of five different sites, were located with the intention of trying to cover some of the more common forest types requiring treatment, and in forests controlled by either the FD or PfB, where the long-term security of the plots could be assured. Paired PSPs were established at each of these sites so that comparisons between treated and untreated forest could be made within, as well as between, forest types.

Another purpose of establishing the plots was to provide in-service training to FD and PfB personnel so that they will be able to apply the field methodology in the establishment of new PSPs, as well as be able to utilize the database system developed for processing and analysing the data. These sites will continue to provide valuable information for many years to come, assuming that the necessary follow-up is undertaken.

CATIE's plots are not an experiment, per se, since the general outcome and benefits of the liberation treatment have already been proven and demonstrated by CATIE at Pilar de Cajon, in San Isidro del General, Costa Rica (Hutchinson and Wadsworth, in press). The plots in Belize will cuantify the extent of the effects of liberation thinning on the different forest types found and compare these to plots of similar forest where nothing was done.

LOCATION AND DESCRIPTION OF PSP SITES

Five sites were established throughout Belize, each with a set of paired plots, as outlined in Table 1. Appendix 1 contains diagrams of the individual plot locations at each of the sites, as well as the corresponding GPS readings of their positions.

Table 1. Permanent sample plot types, numbers and locations.

SITE NAME	PLOT NUMBERS		TOTAL NUMBER OF PLOTS
	CONTROLS	TREATED	
MILLIONARIO	2, 4, 6	1, 3, 5	6
SAN PASTOR	2, 4, 6	1, 3, 5	6
WEST BOTAS (IRISH CREEK)	2, 4	1, 3	4
DUCK RIDGE	2, 4	1, 3	4
COHUNE RIDGE	2, 4	1, 3	4
TOTALS:	12	12	24

The first two sites, Millionario and San Pastor, are located in the Chiquibul Forest Reserve in the Maya Mountains of south-central Belize, near to the Las Cuevas Research Station (Figure 1).

According to Wright's vegetation types (Wright et. al., 1959), the Millionario site is situated in "broadleaf forest rich in lime-loving species, deciduous seasonal forest 70-100 feet tall" and aproximately 3.4 km north-northwest of Las Cuevas Station. The San Pastor site is in "broadleaf forest rich in lime-loving species, deciduous/semi-evergreen seasonal forest 80-100 feet tall". It is located aproximately 3.5 km south of the station. Bird (1994), provides a more detailed description of these forest types and of their history with respect to fire and wind damage, as well as logging and

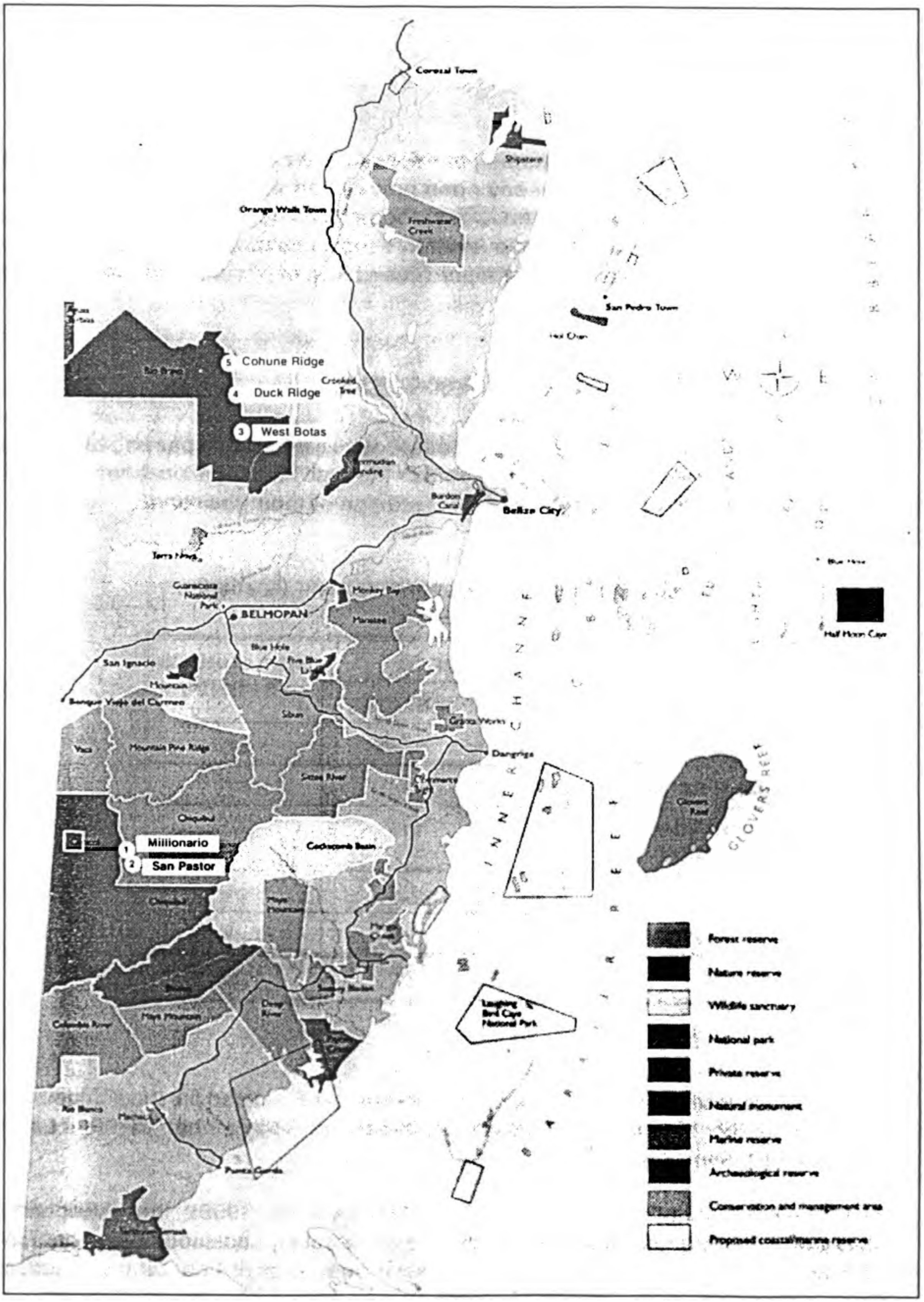

Figure 1. Locations of Permanent Sample Plot sites in Belize.
(N.B. Base map from "BELIZE Protected Areas" poster. Forest Department, NARMAP, Belize Zoo. Cubola Productions. 1994)

San Pastor, site of six Permanent Sample Plots.

chicle extraction. Bird also describes the area as hilly upland, at an elevation between 500 and 700 m asl, with annual rainfall estimated at 1,500 mm. He describes the geology as being mostly Cretaceous limestone with most of the drainage being underground.

The remaining three sites are located in the Rio Bravo Conservation and Management Area (RBCMA) which is owned and managed by PfB and situated in the northwestern part of the country. The plots are in relatively flat, low-lying terrain at an elevation of

approximately 20 m asl and in an area between the town of San Felipe and the old logging camp known as Hill Bank located at the extreme south-western end of the New River Lagoon (Figure ?).

Wright et. al. (1959), classified the vegetation type in the area as "broadleaf forest rich in lime-loving species, deciduous seasonal forest 50-70 feet tall", with clay soils developed on limestone. Hartshorn et. al. (1984) classify most of the RBCMA as being subtropical moist forest under the Holdridge Life Zone System. Although the area also has patches of low forest, known locally as "bajo", on poorly drained areas, the plot sites are in upland forest. The Cohune Ridge site is quite different from the other two as the forest here is a very young secondary forest dominated by the cohune palm (Orbignya cohune) and subject to frequent burning due to the agricultural areas surrounding it. The Duck Ridge and West Botas sites contain older secondary forest with more commercially interesting species and larger trees.

Brokaw et. al. (1995), describe the annual rainfall in the area as being approximately 1500 mm, with additional nighttime drip from condensation, and a dry season extending from January or February to May. Further details concerning the RBCMA and PfB's forest management goals and research agenda for the area are given by Brokaw et. al. (1995).

Selective logging, mainly for mahogany, has been occurring in the area for over a hundred years and ended in the RBCMA about 20 years ago. As in much of the rest of Belize, these forests have also been ravaged by hurricanes and fire.

MATERIALS AND METHODS

A separate document entitled "Permanent Sample Plot Methodology of CATIE's Silvicultural Treatment Project" (in preparation) has been prepared in order to describe in more detail all of the aspects associated with plot establishment and evaluation. Nevertheless, a short summary of this follows in order to briefly inform the reader of what was done and how.

Number of Plots and Distribution

As already shown in Table 1, each site contains 4 to 6 plots. Odd-numbered plots are those which have received the liberation treatment, while even-numbered plots are the controls where no intervention is applied. Care was taken to insure that paired plots were located in similar forest so that comparisons between treated and untreated controls could be made. Replicates have also been installed so that if there are a total of six plots at a site, three are control plots and three are treated plots in which silvicultural liberation of selected potential future-crop trees has been carried out. A total of 24 plots were established during the early part of 1995.

Plot Size and Design

Each of the plots is a 0.25 ha square measuring 50 x 50 m. Each plot is divided into 25 cuadrats, each measuring 0.01 ha (10 x 10 m). In each of these cuadrats all trees ≥ 10 cm dbh (diameter at breast height, i.e., 1.3 m above the ground) are numbered, tagged and evaluated. Each plot is surrounded by an additional 25 m wide buffer zone which represents a similar state and condition of forest to that found in the plot (Figure 2). This means that a treated plot actually contains 1 ha of treated forest, but only one quarter of this hectare is monitored.

The information collected for each tree includes individual tree number, common name, tree identity class, dbh, stem quality class, crown illumination class, crown form class, degree of woody-climber infestation, silvicultural treatment class, and other observations, and is noted on Field Form No. 1 (Appendix 2.). This data allows one to basically draw an identical and true representation of the state of each individual tree as found at the time of evaluation. The codes used for each of the different classifications are summarized on the reverse side of Field Form No. 1, but more detailed explanations of these can be found in the above mentioned document describing the PSP methodology.

Saplings (dbh 5.0 - 9.9 cm) and seedlings (height ≥ 30.0 cm and dbh ≤ 4.9 cm dbh) are sampled in each of five nested subplots of 25 square metres (5 x 5 m) and 4 square metres (2 x 2 m), respectively, in each plot (Figure 3). Individual saplings are counted and assessed as to the amount of illumination each is receiving, whereas seedlings are merely counted and the 2m x 2m subplot in which they are found is assessed as to the amount of illumination it receives. The information is collected using Field Form No. 2 (Appendix 3).

Evaluating seedlings in a 2 x 2m subplot in San Pastor.

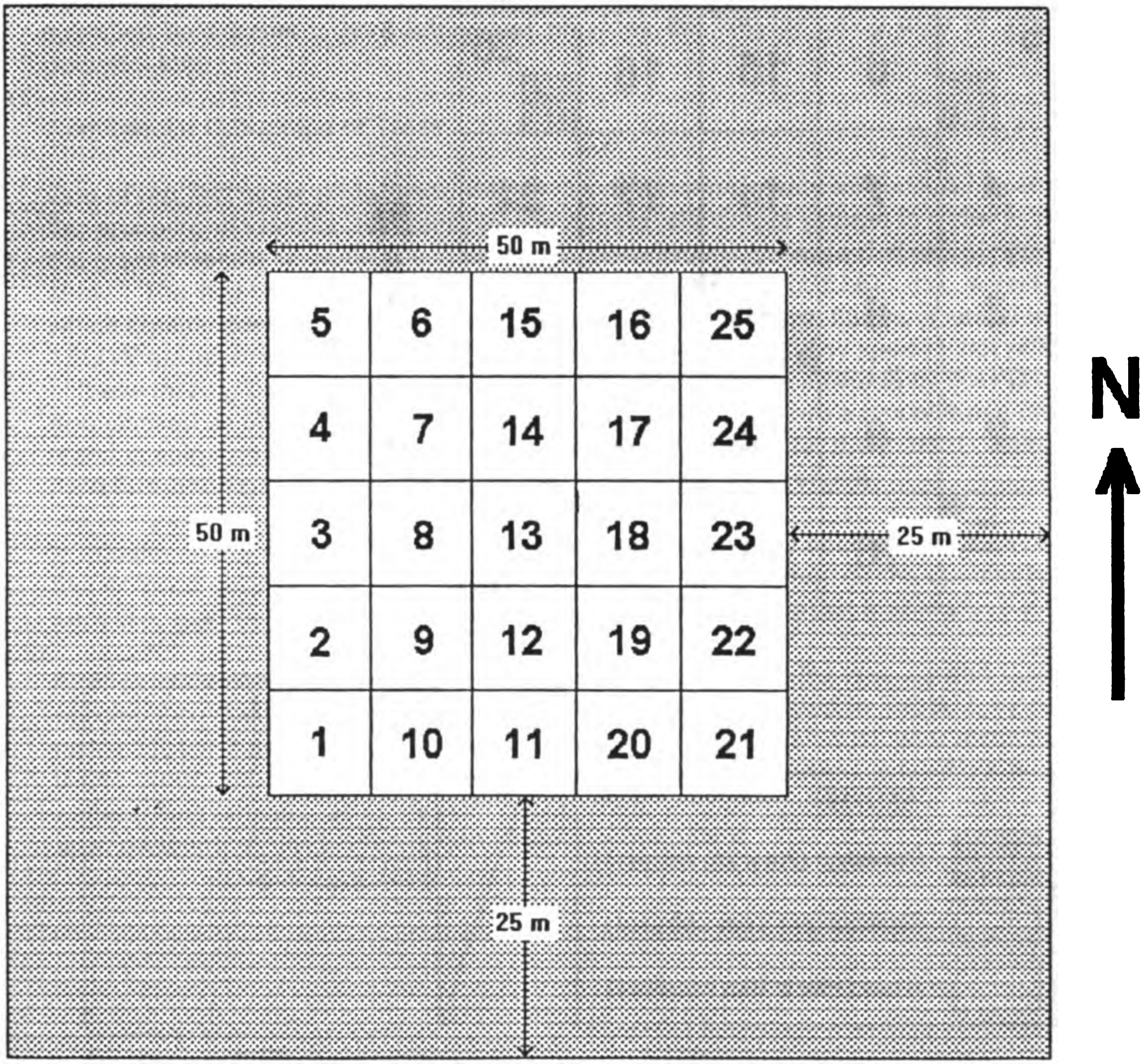

Figure 2. Quarter-hectare plot design and orientation, with 25m buffer zone.

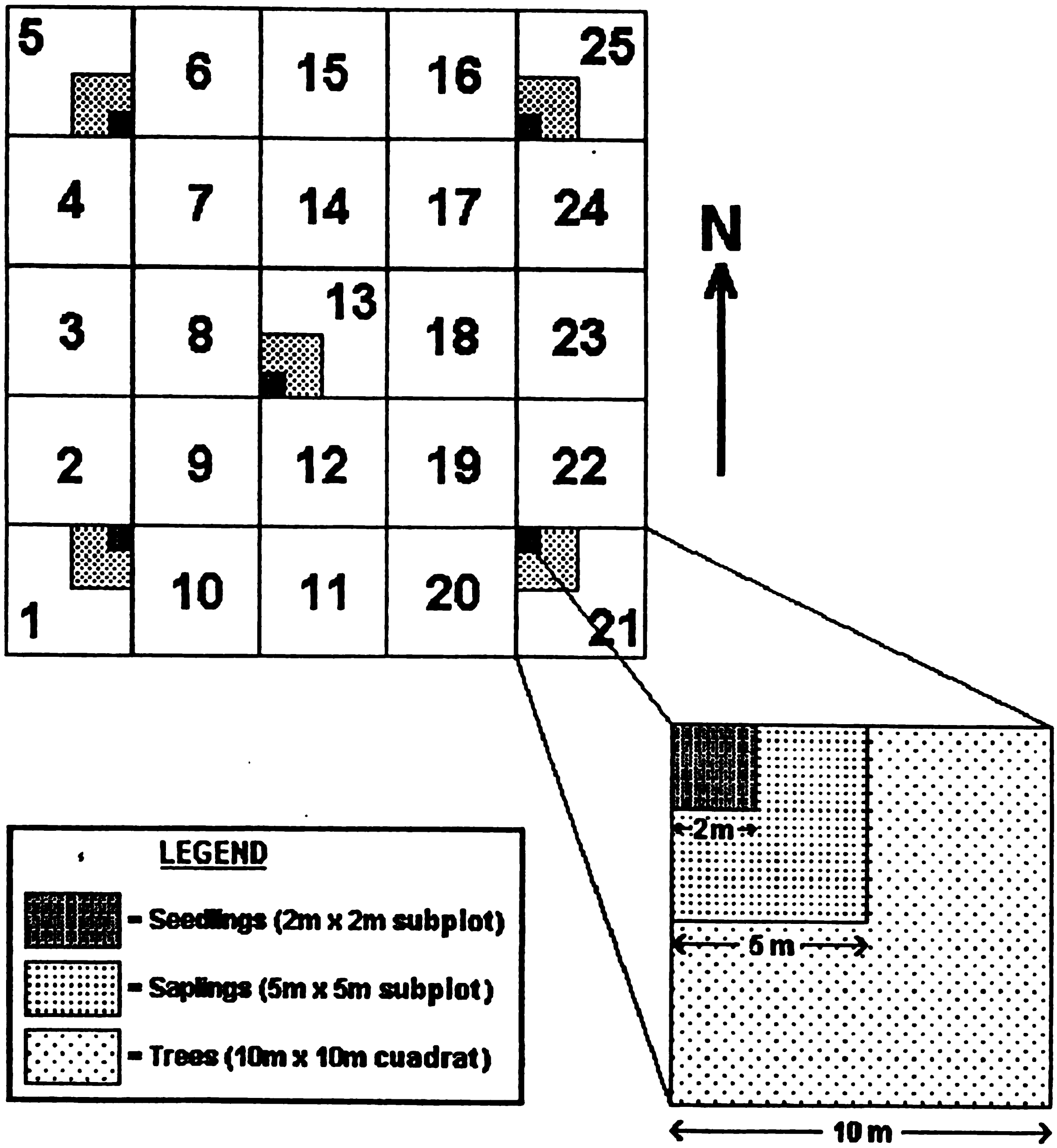

Figure 3. Arrangement of cuadrats and location, size and intensity of nested subplots.

All of this information is handled by SEMAFOR which has been specially designed for this purpose and to allow field records to be quickly digitized, organized and analized according to the needs of the researcher or forest manager. However, use of the specified field forms is mandatory and provides the key for being able to utilize this powerful tool.

Commercial Groupings of Trees

One of the first steps undertaken before the application of any silvicultural treatment is the grouping of species according to commercial classes or groups in order to simplify the great diversity of species encountered. Five groupings were defined for use in this study. The first three are coded as 1ELITE, 2PRIME and 3SELEC (i.e., select), all of which contain commercially valuable species but grouped from the most valuable, in the 1ELITE group, to those of least value, in the 3SELEC group. Any species not within one of these three groupings is considered of no current commercial value by the FD and PfB and classed as 5NOVAL in the species list. However, there are a few of these unvalued wood species which may have the potential to eventually enter the market. These have therefore been grouped as 4POTCO (i.e., potentially commercial).

In addition to the economic groupings for timber species, any species which have a non-timber forest-product use were also coded as NT (non-timber). Some species, such as sapodila, may be coded as one of the commercial timber species as well as a NT.

After considerable discussion and modifications, a species list was agreed upon. The species included in the five commercial groupings are outlined in Table 2, by common name. Table 2 also indicates if the species is one of the few which was recently added to the group of commercially valuable species. A more detailed list, with the scientific names, English and Spanish common names, and commercial groupings of all the species found at the 5 sites is contained in Appendix 4.

Table 2. Common names and commercial groups of valuable timber species.

COMMON NAME	COMMERCIAL GROUP	
	Since 1995	Since 1996
Bastard mahogany	1ELITE	
Black poisonwood	1ELITE	
Cedar	1ELITE	
Granadillo	1ELITE	
Mahogany	1ELITE	
Mayflower	1ELITE	
Palo mulato (Jobillo)	1ELITE	
Rosewood	1ELITE	
Bastard rosewood	2PRIME	
Billy webb	2PRIME	
Bitterwood	2PRIME	
Black cabbage bark	2PRIME	
Chicle macho	2PRIME	
Ironwood	2PRIME	
Male bullhoof		2PRIME
Mylady	2PRIME	
Nargusta	2PRIME	
Quamwood	2PRIME	
Salmwood	2PRIME	
Santa maria	2PRIME	
Sapodilla (Chicle, Zapote)	2PRIME	
Balsam	3SELEC	
Banak	3SELEC	
Breadnut		3SELEC

COMMON NAME	COMMERCIAL GROUP	
	Since 1995	Since 1996
Carbon	3SELEC	
Ceiba		3SELEC
Cramantee		3SELEC
Fiddlewood	3SELEC	
Fig		3SELEC
Glassywood	3SELEC	
Gumbolimbo		3SELEC
Hog plum		3SELEC
John crow bead (John crow wood)	3SELEC	
Mammee cerera (Mammee ciruela)		3SELEC
Mapola	3SELEC	
Monkey apple	3SELEC	
Negrito	3SELEC	
Prickly yellow	3SELEC	
Red breadnut	3SELEC	
Redwood	3SELEC	
San juan macho	3SELEC	
Silly young	3SELEC	
Timbersweet		3SELEC
Waika chewstick	3SELEC	
White cabbage bark	3SELEC	
White gumbolimbo		3SELEC
White poisonwood	3SELEC	
Wild mammee	3SELEC	
Yemeri (San juan)	3SELEC	

N.B. Appendix 4 contains a complete list of all tree species encountered, it also indicates 8 species of no timber value (5NOVAL) which are useful for NT.

Plot Evaluations

To date, there have been two measurements or evaluations, carried out on the plots. The first done immediately before treatment application in 1995, and the second approximately one year later, in 1996. Subsequent plot evaluations should be carried out annually or biannually and will allow the monitoring of changes in growth rates among individual trees and the quantification of the effects which the treatment had on liberated trees as compared to similar trees in non-liberated control plots. Information on mortality, recruitment and species composition (one aspect of biodiversity) is also obtainable from the enormous amount of data collected.

Description of the Liberation Treatment

Only trees $\geq$ 10 cm dbh receive the liberation treatment and not all individual trees of a commercial species necessarily need or merit liberation. Trees selected for liberation need to: **be of species defined as commercial (i.e., 1ELITE, 2PRIME or 3SELEC); be "complete" in form, with neither the stem nor the growing point dead or broken to an extent that future growth of either height or diameter will be limited; have at least 4 metres of straight stem free of defect; not be leaning more than 20 degrees from the vertical; and be stable and in strong condition.** An individual of a commercial species having poor form, for example, would therefore not be liberated, but merely left to fend for itself.

The treatment seeks out selected future crop trees and only removes competing trees of non-commercial species which are completely or partially overtopping the selected tree or physically touching it. The treatment also calls for the removal of any tree which is within two metres of the selected tree. A non-commercial ***tree*** is sometimes of a com-mercial ***species*** when the individual is ***not*** a selectable tree due to poor form, excessive lean, deformations, damage or rot. As sometimes occurs, when two selected trees stand closer than 2 m to each other, then the inferior or lower-valued of the two is eliminated.

Ordinarily, in order to maximize the productivity of selected future crop trees, one should apply liberation treatment to stands which have already been harvested of mature commercial timber, and where mature and overmature non-commercial individuals have also been eliminated. In our particular case we encountered a few mature and overmature trees of both commercial and non-commercial species, but no attempt was made to harvest these, if commercial, or eliminate them systematically, if non-commercial. Only non-commercial individuals who happened to be directly competing with a selected future crop tree were intentionally eliminated.

In the twelve treated plots established in Belize, the trees to be eliminated have simply been girdled. It was felt that the strong environmentalist concerns with which Belize is confronted might raise objections to the use of arboricides, and so the first application

Measuring the diameter at breast height (dbh) of a future crop tree.

of the treatment has relied only on girdling a wide band around each tree. If this does not kill most of the identified trees, then something like "Tordon", which is approved by the United States Department of Agriculture (USDA) for forestry use, should be applied. In any case, the dosage of this arboricide is very light and extremely localized.

Using a chainsaw to cut out unwanted trees is another option, but this is not recommended, as it can cause considerable damage to the future crop trees, especially if woody climbers have not been cut 12 months in advance. The damage is further increased if directional felling techniques are not utilized.

Three important points regarding the treatment application need to be highlighted for the purposes of this report. The first regards the classification of species into commercial groups. At the time of treatment application in 1995, the list of commercial species did not include timbers which could also be harvested for plywood, and so these species were not selected for treatment. However, by late 1995 additional species had been added to the commercial list, particularly at the request of PfB, since they were now certain of a secure market for these additional species. As a result, during the second evaluation of the plots in 1996, all those trees of these now commercial species which were found to be selected future crop trees, were also liberated. Unfortunately, it also occurred that one would encounter individuals of these newly commercial species which had been girdled the previous year in order to liberate a neighbouring selected tree, but this is bound to happen where markets are still developing. The important thing is that the treatment, although eliminating a few of these now commercial trees the year before, was not directed at removing all of them, only those which directly competed with a future crop tree. As a result there are still many of these trees in the forest. This case points to the importance of having a long-term outlook to forest management and to being as inclusive as financially possible when it comes to selecting and treating future crop trees.

The second point which needs mentioning concerns the buffer zones. For some reason (possibly lack of time and manpower) the buffer zones around the 12 treated plots were not treated at the time of the original treatment application in 1995. The buffers around the Millionario and San Pastor plots were, however, treated during this year's (1996) plot evaluations and included treatment of these newly commercial species. PfB has been notified of the need to carry out the same procedure in the buffers of its 6 treated plots as soon as convenient so that possible edge effects are ruled out in the future analysis of treatment effects.

The third and final clarification is in regard to the four plots at the Cohune Ridge site. Recall that during the first evaluation done in 1995 the commercial species list contained fewer species. When plots Nos. 1 and 3 at Cohune Ridge were considered for receiving the treatment application, it was found at that time that they were so poor and lacking in commercial individuals of the required minimum diameter of 10 cm, that it was decided to leave all 4 plots untreated for the time being. However, during the second evaluation in 1996, a larger number of selected future crop trees were found, due almost entirely to the inclusion of the new commercial species. It was therefore decided to apply the treatment to plots 1 and 3 at that time.

Cronology of Field Activities in PSPs

The following table summaries the sequence of activities carried out in the different PSP sites to date. It is recommended that some sort of log book of activities be kept by the FD and PfB so that future researchers and managers will be able to consult reliable records of what was done, where and when. SEMAFOR will maintain the dates associated with every new measurement undertaken, but these dates don't always correspond to when interventions such as logging or silvicultural treatments were applied.

Table 3. Cronology of activities in PSPs to date.

ACTIVITY	SITE				
	Millionario	San Pastor	West Botas	Duck Ridge	Cohune Ridge
PLOT ESTABLISHMENT	02/05/95	24/04/95	23/05/95	17/05/95	15/05/95
FIRST MEASUREMENT	02/05/95	24/04/95	23/05/95	17/05/95	15/05/95
TREATMENT APPLICATION IN PLOT	02/05/95	24/04/95	23/05/95	17/05/95	15/05/95
TREATMENT APPLICATION IN BUFFER STRIP	18/03/96	28/03/96	-	-	-
SECOND EVALUATION	18/03/96	28/03/96	26/02/96	19/02/96	16/02/96
TREATMENT OF NEW COMMERCIAL SPECIES	18/03/96	28/03/96	26/02/96	19/02/96	16/02/96
ACCIDENTAL GROUND FIRE	-	-	-	??/06/95	??/06/95

Above: Young mahogany trees selected for liberation (blue flagging tape).
Below: Competing trees around future crop trees are marked for elimination (red flagging tape)

PRELIMINARY RESULTS

Several points regarding the results of the PSP evaluations to date need to be made from the outset. It must be stressed that these results were obtained from the data collected in two evaluations of the plots, a period covering approximately twelve months. PSP data can give us an enormous amount of information regarding both the structure and dynamics of the forest *over time*, but since in this case the elapsed time is still quite short, one cannot yet hope to have more than a glimpse of what is going on with the dynamics of the forest. Nevertheless, very interesting details regarding the current structure of the forest at each site are already available from these PSPs.

When looking at the data regarding numbers of trees or basal areas per hectare, one should keep in mind that the purpose of these plots is not to provide inventory data. If this were the goal, then a larger number of plots would need to be established in order to provide statistically acceptable estimates. Nevertheless, care was taken to locate the plots in areas deemed typical of some particular forest type, so that the information still provides a rough estimate of what the entire forest is like.

Since these forests have been heavily disturbed in the recent past, one can also expect them to be developing successionally, regardless of any silvicultural treatment applied, and this should be evident in the results of the untreated control plots. As far as the effects of the liberation are concerned it is still too early to make a definitive statement as to their magnitude, although trends are already apparent in the treated plots.

Even within the untreated plots, differences in growth rates of different groupings of trees according to illumination classes, commercial groups or individual species, are made apparent by the data collected.

With a few more years of measurements these plots will be able to provide important and reliable data for the calculation of future volume yields of particular species or groups of species, as well as the recommended cutting cycles for these different forests. They will also clearly highlight the positive effects which the liberation treatment has had on determining these.

The following tables present data on various aspects of the forests at the different sites. Much more information is available through SEMAFOR for analysis by foresters and researchers interested in particular aspects or parameters evaluated. The purpose here has been to give the reader a sample of the type of information possible through the use of this field methodology and its accompanying tool. With each subsequent measurement of the plots, trends will be more clearly defined, and the necessary statistical verification for their support will be more apparent. For the time being, in-depth analysis will not be possible.

The Structure of the Forest at Each Site

Tables 4 to 8 present data from both the 1995 and 1996 measurements and reveal the structure of the forest at each of the different sites and also in the untreated versus the treated plots. Each table gives the diameter distributions of all trees (≥ 10 cm dbh), and also of only the future crop trees (silvicultural treatment class "11", i.e., selected trees of commercial species which have also been chosen for liberation). The average basal areas of all trees and of only the future crop trees are shown, as are the numbers of saplings (plants with dbh ≥ 5 cm and < 10 cm) and seedlings (plants at least 30 cm tall and with dbh < 5 cm). Note that the numbers for saplings and seedlings under the column for future crop trees are in fact totals for all commercially valuable species (i.e., 1ELITE, 2PRIME and 3SELEC) and one should not assume that all of these individuals will necessarily become future crop trees. Finally, the average number of recruits of all trees and of future crop trees is also indicated.

The diameter distributions of all trees indicate that at the start of this study the forest structure in the control plots closely resembles that of the treated plots in each of the sites. In general, average total basal area is also similar between control and treated plots.

The significant increase in number of future crop trees from 1995 to 1996 is almost entirely due to the fact that additional species were added to the commercially valuable list of trees for the 1996 evaluation, and it is impressive to note how the addition of a few more species to the list can increase the potential productive capacity of the forest. Future crop trees now constitute, on average, 17% of all trees in the Millionario plots, 25% of those at San Pastor, 37% of those at West Botas, 25% of those at Duck Ridge and 21% of those at Cohune Ridge. In time, the effects of the treatment application should increase the percentage of future crop trees.

The effects of the 1995 fires in Duck Ridge and Cohune Ridge are apparent in the total number of trees lost and subsequent basal area reductions. On average 14% of all trees and 10% of total basal area were lost at the Duck Ridge site (average of all plots), while at Cohune Ridge the figures were 19% and 15%, respectively.

The data also indicate that the trees in these forests are generally normally distributed (an inverted "J" curve is apparent if total number of trees is plotted against diameter class), allowing for policyclical management. In the case of Millionario and West Botas, these sites have an average of 13 and 14 future crop trees/ha, respectively, which are already greater than or equal to 40 cm dbh and which will soon form the next crop of trees. The other sites will generally have to wait longer until enough future crop trees come up through the diameter classes and reach maturity.

The number of saplings and seedlings of commercially valuable species generally also appear to be sufficient at each of the sites.

Table 4a. Structure of the forest at Millionario in plots 2, 4 and 6.

MILLIONARIO Results of Plot Nos. 2,4,6	No. Trees/ha			
	1995		1996	
dbh (cm)	All Trees	Future Crop Trees	All Trees	Future Crop Trees
>= 60	5	0	5	0
50-59.9	4	0	4	1
40 - 49.9	16	0	20	13
30 - 39.9	60	11	55	31
20 - 29.9	196	8	200	51
10 - 19.9	725	28	716	64
Total	1006	47	1000	160
Basal Area (m2/ha)	33.52	1.79	34.02	8.77
Saplings	800	*373*	693	*240*
Seedlings	7500	*1167*	10000	*833*

Recruits in 1996	
All Trees	Crop
13.3 of 716	7 of 64

N.B. Future crop trees correspond only to those having silvicultural treatment class "11", howev the figures for saplings and seedlings are for all commercially valuable species (i.e., 1ELIT 2PRIME AND 3SELEC) are not necessarily class "11".

Table 4b. Structure of the forest at Millionario in plots 1, 3 and 5.

MILLIONARIO Results of Plot Nos. 1,3,5	No. Trees/ha			
	1995		1996	
dbh (cm)	All Trees	Future Crop Trees	All Trees	Future Crop Trees
>= 60	0	0	0	0
50-59.9	3	0	3	0
40 - 49.9	17	5	17	11
30 - 39.9	43	11	45	24
20 - 29.9	204	19	207	49
10 - 19.9	653	24	625	65
Total	920	59	897	149
Basal Area (m2/ha)	26.92	3.02	26.95	13.35
Saplings	1173	*667*	1013	*587*
Seedlings	9333	*1667*	11000	*2667*

Recruits in 1996	
All Trees	Crop
9.3 of 625	5 of 65

N.B. Future crop trees correspond only to those having silvicultural treatment class "11", howev the figures for saplings and seedlings are for all commercially valuable species (i.e., 1ELIT 2PRIME AND 3SELEC) are not necessarily class "11".

Table 5a. Structure of the forest at San Pastor in plots 2, 4 and 6.

SAN PASTOR Results of Plot Nos. 2,4,6	No. Trees/ha			
	1995		1996	
dbh (cm)	All Trees	Future Crop Trees	All Trees	Future Crop Trees
>= 60	3	0	3	0
50-59.9	0	0	0	0
40 - 49.9	4	1	4	1
30 - 39.9	37	16	40	19
20 - 29.9	172	36	177	48
10 - 19.9	632	80	641	137
Total	848	133	865	205
Basal Area (m2/ha)	**21.81**	**4.55**	**22.80**	**6.32**
Saplings	1067	*347*	1120	*453*
Seedlings	14167	*3833*	17167	*4833*

Recruits in 1996	
All Trees	Crop
16 of 641	9 of 137

N.B. Future crop trees correspond only to those having silvicultural treatment class "11", however, the figures for saplings and seedlings are for all commercially valuable species (i.e., 1ELITE, 2PRIME AND 3SELEC) are not necessarily class "11".

Table 5b. Structure of the forest at San Pastor in plots 1, 3 and 5.

SAN PASTOR Results of Plot Nos. 1,3,5	No. Trees/ha			
	1995		1996	
dbh (cm)	All Trees	Future Crop Trees	All Trees	Future Crop Trees
>= 60	3	0	3	0
50-59.9	7	1	7	1
40 - 49.9	13	3	13	3
30 - 39.9	31	12	31	13
20 - 29.9	124	36	120	49
10 - 19.9	632	83	609	139
Total	810	135	783	205
Basal Area (m2/ha)	**22.43**	**4.96**	**22.21**	**6.56**
Saplings	1040	*267*	1360	*293*
Seedlings	17833	*3667*	22000	*4833*

Recruits in 1996	
All Trees	Crop
28 of 609	5 of 139

N.B. Future crop trees correspond only to those having silvicultural treatment class "11", however, the figures for saplings and seedlings are for all commercially valuable species (i.e., 1ELITE, 2PRIME AND 3SELEC) are not necessarily class "11".

Table 6a. Structure of the forest at West Botas in plots 2 and 4.

WEST BOTAS Results of Plot Nos. 2,4	No. Trees/ha			
	1995		1996	
dbh (cm)	All Trees	Future Crop Trees	All Trees	Future Crop Trees
>= 60	2.00	0	2	0
50-59.9	10	4	12	6
40 - 49.9	18	8	16	16
30 - 39.9	42	10	42	26
20 - 29.9	104	0	104	50
10 - 19.9	370	30	366	112
Total	546	52	542	210
Basal Area (m2/ha)	**20.73**	**3.5**	**20.90**	**10.53**
Saplings	480	*160*	400	*80*
Seedlings	12000	*3000*	14000	*3750*

Recruits in 1996	
All Trees	Crop
6 of 366	2 of 112

N.B. Future crop trees correspond only to those having silvicultural treatment class "11", however, the figures for saplings and seedlings are for all commercially valuable species (i.e., 1ELITE, 2PRIME AND 3SELEC) are not necessarily class "11".

Table 6b. Structure of the forest at West Botas in plots 1 and 3.

WEST BOTAS Results of Plot Nos. 1,3	No. Trees/ha			
	1995		1996	
dbh (cm)	All Trees	Future Crop Trees	All Trees	Future Crop Trees
>= 60	0	0	0	0
50-59.9	0	0	0	0
40 - 49.9	20	10	22	16
30 - 39.9	46	18	48	22
20 - 29.9	140	36	134	58
10 - 19.9	360	24	356	96
Total	566	88	560	192
Basal Area (m2/ha)	**20.06**	**5.52**	**19.83**	**9.00**
Saplings	1000	*520*	840	*400*
Seedlings	11000	*3000*	10250	*2500*

Recruits in 1996	
All Trees	Crop
6 of 356	6 of 96

N.B. Future crop trees correspond only to those having silvicultural treatment class "11", however, the figures for saplings and seedlings are for all commercially valuable species (i.e., 1ELITE,

Table 7a. Structure of the forest at Duck Ridge in plots 2 and 4.

DUCK RIDGE Results of Plot Nos. 2,4	No. Trees/ha			
	1995		1996	
dbh (cm)	All Trees	Future Crop Trees	All Trees	Future Crop Trees
>= 60	0	0	0	0
50-59.9	8	2	6	4
40 - 49.9	16	8	18	12
30 - 39.9	52	22	46	28
20 - 29.9	108	8	104 ·	34
10 - 19.9	500	48	422	98
Total	684	88	596	176
Basal Area (m2/ha)	**21.84**	**4.75**	**19.97**	**8.20**
Saplings	880	*560*	600	*400*
Seedlings	14750	*5000*	18000	*4750*

Recruits in 1996	
All Trees	Crop
10 of 422	4 of 98

N.B. Future crop trees correspond only to those having silvicultural treatment class "11", however, the figures for saplings and seedlings are for all commercially valuable species (i.e., 1ELITE, 2PRIME AND 3SELEC) are not necessarily class "11".

Table 7b. Structure of the forest at Duck Ridge in plots 1 and 3.

DUCK RIDGE Results of Plot Nos. 1,3	No. Trees/ha			
	1995		1996	
dbh (cm)	All Trees	Future Crop Trees	All Trees	Future Crop Trees
>= 60	0	0	0	0
50-59.9	4	0	6	4
40 - 49.9	14	4	10	0
30 - 39.9	60	14	54	26
20 - 29.9	146	20	130	34
10 - 19.9	490	28	412	58
Total	714	66	612	122
Basal Area (m2/ha)	**23.44**	**3.52**	**20.81**	**5.95**
Saplings	520	*200*	200	*80*
Seedlings	11250	*4000*	10250	*1500*

Recruits in 1996	
All Trees	Crop
6 of 412	2 of 58

N.B. Future crop trees correspond only to those having silvicultural treatment class "11", however, the figures for saplings and seedlings are for all commercially valuable species (i.e., 1ELITE, 2PRIME AND 3SELEC) are not necessarily class "11".

Table 8a. Structure of the forest at Cohune Ridge in plots 2 and 4.

COHUNE RIDGE Results of Plot Nos. 2,4	No. Trees/ha			
	1995		1996	
dbh (cm)	All Trees	Future Crop Trees	All Trees	Future Crop Trees
>= 60	0	0	0	0
50-59.9	0	0	0	0
40 - 49.9	16	0	16	0
30 - 39.9	56	0	50	2
20 - 29.9	58	0	44	10
10 - 19.9	386	0	296	50
Total	516	0	406	62
Basal Area (m2/ha)	**16.18**	**0.00**	**13.59**	**1.51**
Saplings	1120	*320*	240	*160*
Seedlings	4000	*250*	1500	*250*

Recruits in 1996	
All Trees	Crop
12 of 296	0 of 50

N.B. Future crop trees correspond only to those having silvicultural treatment class "11", however, the figures for saplings and seedlings are for all commercially valuable species (i.e., 1ELITE, 2PRIME AND 3SELEC) are not necessarily class "11".

Table 8b. Structure of the forest at Cohune Ridge in plots 1 and 3.

COHUNE RIDGE Results of Plot Nos. 1,3	No. Trees/ha			
	1995		1996	
dbh (cm)	All Trees	Future Crop Trees	All Trees	Future Crop Trees
>= 60	0	0	2	2
50-59.9	6	2	4	2
40 - 49.9	20	4	20	6
30 - 39.9	48	6	46	10
20 - 29.9	100	8	66	20
10 - 19.9	416	0	352	94
Total	590	20	490	134
Basal Area (m2/ha)	**19.12**	**1.87**	**16.63**	**5.00**
Saplings	1080	*600*	560	*400*
Seedlings	4500	*1250*	4750	*2000*

Recruits in 1996	
All Trees	Crop
20 of 352	12 of 94

N.B. Future crop trees correspond only to those having silvicultural treatment class "11", however, the figures for saplings and seedlings are for all commercially valuable species (i.e., 1ELITE, 2PRIME AND 3SELEC) are not necessarily class "11".

The Ten Most Abundant Species at Each Site

Tables 9 to 13 highlight the total number of trees/ha of the top ten commercially valuable species at each of the sites. They also indicate the proportion of total basal area which these occupy.

Mahogany figures prominently at the Millionario and San Pastor sites with 19 trees/ha. The West Botas site also contains considerable mahogany, with 11 trees/ha. The Duck Ridge plots contained only 3 mahogany trees/ha, placing the species in 21st place among the rest. At Cohune Ridge no mahogany trees (i.e., dbh ≥ 10 cm) were encountered.

The Millionario site has an enormous number of trees and basal area taken up by white poisonwood, making it, by far, the most common species at this site. Because of the abundance of this single species the total number of trees/ha of the top ten commercial species represents 70% of all the trees in the forest.

In all of the other sites, except Cohune Ridge, the top ten commercial species occupy more than 50% of the total basal area of all trees in the forest and from 70 to 95% of the basal area of all commercial species. Possibly because of the more disturbed nature of the site at Cohune Ridge and its younger forest, the top ten commercial species found there represent only 40% of the total number of all trees.

The total number of species found as trees (i.e., dbh ≥ 10 cm) ranged from a low of 39 at the Cohune Ridge, to a high of 63 at both Millionario and San Pastor (Table 14).

Table 14. Total number of tree species ≥ 10 cm dbh found at each site.

	SITE				
	Millionario	San Pastor	West Botas	Duck Ridge	Cohune Ridge
Commercial	29	25	25	26	18
Others	34	38	28	31	21
Total No. Sp.	63	63	53	57	39

Table 9. Top ten commercial species, in terms of total No. trees/ha, at Millionario. (Average of Plots 1,2,3,4,5, and 6).

	COMMON NAME	Number/ha	Basal Area % (of Commercial Sp.)
1.	White poisonwood	455	43
2.	Fiddlewood	57	11
3.	Nargust	33	13
4.	Black cabbage bark	32	5
5.	Hog plum	28	5
6.	Bastard mahogany	27	7
7.	Mahogany	19	4
8.	White gumbolimbo	10	1
9.	Fig	7	2
10.	Salmwood	7	1
	TOTAL	675	92
	Percentage of Entire Forest	70	70

Table 10. Top ten commercial species, in terms of total No. trees/ha, at San Pastor. (Average of Plots 1,2,3,4,5, and 6).

	COMMON NAME	Number/ha	Basal Area % (of Commercial Sp.)
1.	Nargusta	89	32
2.	Prickly yellow	54	7
3.	Banak	33	6
4.	Santa Maria	32	9
5.	White poisonwood	28	13
6.	Bastard mahogany	27	5
7.	Mahogany	19	9
8.	Fiddlewood	10	11
9.	Yemeri	7	3
10.	Mylady	7	1
	TOTAL	306	95
	Percentage of Entire Forest	37	53

Table 11. Top ten commercial species, in terms of total No. trees/ha, at West Botas. (Average of Plots 1,2,3 and 4).

	COMMON NAME	Number/ha	Basal Area % (of Commercial Sp.)
1.	Mylady	57	8
2.	Silly young, shf	53	6
3.	Wild mammee	38	8
4.	Nargusta	35	21
5.	Silly young, Caniste	30	6
6.	Chicle macho	19	5
7.	Breadnut	18	8
8.	Negrito	14	4
9.	Palo mulato, Jobillo	13	3
10.	Prickly yellow	11	2
	TOTAL	288	70
	Percentage of Entire Forest	52	52

N.B. Mahogany was the 11th most common species with 10 trees/ha.

Table 12. Top ten commercial species, in terms of total No. trees/ha, at Duck Ridge. (Average of Plots 1,2,3 and 4).

	COMMON NAME	Number/ha	Basal Area % (of Commercial Sp.)
1.	Silly young, shf	91	13
2.	Mylady	61	12
3.	Silly young, Sillon	34	10
4.	Silly young, Caniste	33	6
5.	Prickly yellow	22	7
6.	Black cabbage bark	20	11
7.	Breadnut	18	5
8.	Nargusta	17	7
9.	Gumbolimbo	15	4
10.	Negrito	15	3
	TOTAL	326	78
	Percentage of Entire Forest	47	52

Table 13. Top ten commercial species, in terms of total No. trees/ha, at Cohune Ridge. (Average of Plots 1,2,3 and 4).

	COMMON NAME	Number/ha	Basal Area % (of Commercial Sp.)
1.	Hog plum	56	24
2.	Breadnut	56	16
3.	Gumbolimbo	21	5
4.	Black poisonwood	20	4
5.	Fiddlewood	17	7
6.	Black cabbage bark	16	26
7.	Glassywood	15	3
8.	Fig	12	6
9.	Silly young, Caniste	5	1
10.	Timbersweet	5	1
	TOTAL	223	93
	Percentage of Entire Forest	40	33

Intensity of the Liberation Treatment at Each Site

Table 15 indicates the average total number of trees/ha girdled in the treated plots at each of the sites. Ordinarily the treatment is applied at one time, but since new species were added to the commercial species list after the first treatment-application, a second application to liberate these newly commercial species was carried out in 1996. The figures therefore indicate the number of trees left girdled (i.e., silvicultural treatment class "21") after the 1995 treatment application and then after the 1996 application.

In the case of the Millionario plots, selected trees of white poisonwood (a commercially valuable species) were *not* liberated, even though the silvicultural rules outlined would indicate that this should normally be done. The reason for this decision was due to the enormous number and dominance of trees of this species at this site. It was felt that there were so many potentially select individuals present of white poisonwood that the liberation of the other commercial species alone would benefit the white poisonwood as well. In other words, there was so much to choose from in this species that there was no need to favour specific individuals, as many were already receiving optimum illumination and, because of their dominance and high density, liberation would probably open up the canopy excessively.

It is important to point out that the total number of trees girdled is a *result* of the individual crop trees' needs for liberation at each site. It is *not* a pre-established goal based on some optimum total basal area.

These figures indicate that in order to liberate a future crop tree (see Tables 4 - 8), an average of 0.5 to 1.6 non-commercial trees need to be eliminated, depending on the site. Most of these girdled trees had not yet died after one year. Some had healed over and looked as lush as if nothing had happened to them. Others had wilting and/or few leaves and were in the process of dying. Subsequent evaluations will shed more light on the efficiency of girdling, but serious consideration should be given to the application of suitable and environmentally safe arboricides for quickly and efficiently eliminating unwanted trees.

Table 16, on the other hand, displays the average number of trees/ha of each commercial group which were killed by natural causes between the first and second measurements. At the same time it includes the figures for the average number of recruits entering the population (i.e., in the 10 - 19.9 cm diameter class) after one year. Note the large number of deaths caused by the fires which occurred at the Duck Ridge and Cohune Ridge sites. These deaths represent approximately 14% of all trees present at Duck Ridge and 22% of all trees present at Cohune Ridge in 1995.

With the information provided in the above tables it is possible to determine how many of the girdled trees were killed during the period. Table 17 gives some idea of the population dynamics at each site and calculates the number of trees killed by girdling as the sum of trees living in 1995 and recruits, minus the sum of naturally killed trees and trees alive in 1996. The efficiency of the treatment after one year varied from a high of 27% of girdled trees dead in San Pastor, to a low of 14% in West Botas and Duck Ridge. The efficiency at Millionario was 19 percent of girdled trees. Once again, this highlights the need for seriously considering the use of an acceptable arboricide for eliminating unwanted trees quickly and efficiently.

Changes in the Illuminations of Commercial Species during the period

Table 18 looks at the illuminations of the trees in the three commercially valuable groups. Instead of considering each of the 6 different illumination classes these have been grouped into three broader illumination groups. The first group contains trees in illumination classes 1 or 2. All of these trees are receiving full sunlight. The second group contains the partially illuminated trees of illumination class 3. The last group contains trees which receive insufficient illumination and is made up of illumination classes 4, 5 or 6.

Table 15. Average number of trees/ha girdled in treated plots at each site. (Silvicultural treatment class "21")

Year	1ELITE	2PRIME	3SELEC	4POTCO	5NOVAL	TOTAL (No./ha)	No. Girdled/ Crop Tree
	Millionario (plots 1, 3 and 5)						
1995	1.3	12.0	56.0	-	22.7	92.0	
1996	5.3	17.3	157.3	-	62.6	242.5	1.6
	San Pastor (plots 1, 3 and 5)						
1995	-	4.0	18.7	-	61.3	84.0	
1996	1.3	12.0	29.3	1.3	141.3	185.2	0.9
	West Botas (plots 1 and 3)						
1995	-	6.0	16.0	2.0	4.0	28.0	
1996	-	12.0	48.0	6.0	38.0	104.0	0.5
	Duck Ridge (plots 1 and 3)						
1995	-	2.0	32.0	4.0	20.0	58.0	
1996	-	12.0	46.0	6.0	44.0	108.0	0.9
	Cohune Ridge (plots 1 and 3)						
1995	-	-	-	-	-	0.0	
1996	2.0	6.0	34.0	12.0	18.0	72.0	0.5

Table 16. Average number of trees dead by natural causes after one year, at each site.

Plots	1ELITE	2PRIME	3SELEC	4POTCO	5NOVAL	TOTAL DEAD	Recruits/ha
	No./ha						
	Millionario						
2,4,6	5.3	0.0	5.3	0.0	8.0	18.6	13.3
1,3,5	0.0	1.3	6.7	0.0	4.0	12.0	9.3
	San Pastor						
2,4,6	0.0	0.0	0.0	0.0	10.7	10.7	28.0
1,3,5	0.0	2.6	1.3	0.0	14.7	18.6	16.0
	West Botas						
2,4	0.0	0.0	0.0	0.0	10.0	10.0	6.0
1,3	2.0	0.0	4.0	0.0	2.0	8.0	6.0
	Duck Ridge						
2,4	2.0	12.0	38.0	2.0	44.0	98.0	10.0
1,3	2.0	18.0	34.0	6.0	38.0	98.0	6.0
	Cohune Ridge						
2,4	4.0	0.0	22.0	2.0	92.0	120.0	12.0
1,3	6.0	0.0	16.0	2.0	94.0	118.0	20.0

N.B. Results of the fires at Duck Ridge and Cohune Ridge in 1995 are clearly evident.

Table 17. Population dynamics (No. Trees/ha).

SITE	Total No. Trees Alive in 1995	Death by Girdling	Death by Natural Causes	Recruits in 1996	Total No. Trees Alive in 1996
Plots	A	B = A-C+D-E	C	D	E
Millionario	A (from Table 6)	B = A-C+D-E	C (from Table 18)	D (Table 18)	E (from Table 6)
2,4,6	1007	0	19	13	1001
1,3,5	920	18	12	9	899
San Pastor	A (from Table 7)	B = A-C+D-E	C (from Table 18)	D (Table 18)	E (from Table 7)
2,4,6	848	0	11	28	865
1,3,5	809	23	19	16	783
West Botas	A (from Table 8)	B = A-C+D-E	C (from Table 18)	D (Table 18)	E (from Table 8)
2,4	546	0	10	6	542
1,3	566	4	8	6	560
Duck Ridge	A (from Table 9)	B = A-C+D-E	C (from Table 18)	D (Table 18)	E (from Table 9)
2,4	684	0	98	10	596
1,3	714	8	98	6	614
Cohune Ridge	A (from Table 10)	B = A-C+D-E	C (from Table 18)	D (Table 18)	E (from Table 10)
2,4	516	0	120	12	408
1,3	590	0	118	20	492

N.B. Note that no trees were girdled in the Cohune Ridge plots in the first treatment applicatioi

Table 18. Changes in the illuminations of trees of commercial species at each site.

		ILLUMINATION CLASSES											
		Full Illumination (Illumination Classes 1+2)				Partial Illumination (Illumination Class 3)				Poor Illumination (Illumination Classes 4+5+6)			
Millionario		% of All Trees			% of All Trees / % of Commercial	% of All Trees			% of All Trees / % of Commercial	% of All Trees			% of All Trees / % of Commercial
Plots	Year	1ELITE	2PRIME	3SELEC	Total	1ELITE	2PRIME	3SELEC	Total	1ELITE	2PRIME	3SELEC	Total
2,4,6	1995	3.3	2.0	9.0	14	2.8	2.8	33.1	39	1.2	1.7	18.6	22
					19				52				29
2,4,6	1996	3.3	1.8	6.4	12	2.1	2.7	33.9	39	1.3	2.0	20.9	24
					15				52				32
1,3,5	1995	1.2	3.3	11.5	16	1.3	5.8	25.5	33	0.7	4.1	21.1	26
					21				44				35
1,3,5	1996	1.5	2.6	7.9	12	1.3	6.2	29.0	37	0.4	4.4	20.9	26
					16				49				34
SanPastor													
2,4,6	1995	0.9	3.6	5.7	10	1.6	10.7	14.3	27	0.8	5.0	5.5	11
					21				55				23
2,4,6	1996	0.9	3.1	4.6	9	1.5	10.2	14.6	26	0.8	5.9	6.7	13
					18				55				28
1,3,5	1995	2.1	5.4	2.6	10	1.6	8.4	10.4	20	1.0	2.9	6.0	10
					25				50				24
1,3,5	1996	1.9	5.8	2.4	10	2.6	8.9	11.1	23	0.6	2.5	5.6	9
					25				55				21
W. Botas													
2,4	1995	2.9	7.4	5.9	16	0.7	11.4	17.2	29	0.4	5.9	8.4	15
					27				49				25
2,4	1996	2.2	6.7	1.8	11	1.5	10.3	18.5	30	0.4	7.7	11.9	20
					18				50				33
1,3	1995	1.5	9.9	3.9	15	2.1	13.8	17.7	34	1.1	3.9	15.9	21
					22				48				30
1,3	1996	0.7	11.1	1.8	14	2.9	12.5	16.8	32	0.8	3.9	19.3	24
					20				46				34
Duck R.													
2,4	1995	0.6	5.2	4.1	10	1.8	8.5	16.7	27	0.6	2.6	17.8	21
					17				47				36
2,4	1996	0.6	5.7	3.0	9	1.7	8.4	15.4	26	0.7	3.0	19.8	24
					16				44				40
1,3	1995	0.9	7.3	7.0	15	1.1	5.0	13.4	20	0.9	4.8	13.5	19
					28				36				36
1,3	1996	1.0	6.9	4.6	13	1.3	6.5	14.7	23	0.7	3.6	13.7	18
					24				43				34
Cohune R.													
2,4	1995	0.0	0.0	5.4	5	2.3	0.4	19.0	22	0.8	0.0	5.4	6
					16				65				19
2,4	1996	1.0	0.0	6.4	7	1.5	0.5	20.7	23	0.5	0.0	5.4	6
					21				63				16
1,3	1995	1.4	4.4	5.8	12	2.0	2.4	26.8	31	1.7	0.3	9.1	11
					22				58				21
1,3	1996	0.8	5.7	9.4	16	1.6	2.0	31.4	35	2.4	1.2	8.2	12
					25				56				19

Given that most of the girdled trees have not yet died, one cannot expect the illuminations of all selected trees to have changed much at this point in time. However, the data collected gives a good idea of the proportion of commercial species trees under the different illumination groups before the treatment application.

The table indicates, for each illumination group, the proportion of all trees within each of the three commercially valuable groups. For example, the first line in the table (Millionario) says that trees in the 1ELITE, 2PRIME and 3SELEC commercial groups which are under illumination group 1+2, represent 3.3, 2.0 and 9.0 percent, respectively, of the total number of trees. As an illumination group this represents 14% of all trees, but 19% of all commercial species trees (i.e., either 1ELITE, 2PRIME or 3SELEC). The same is shown for illumination group 3 and finally illumination group 4+5+6. Summing the totals for all trees across a line (i.e., 14 + 39 + 22) we can determine the proportion of all trees which are 1ELITE, 2PRIME and 3SELEC. The sum of the totals for commercial species should add up to 100 percent (i.e., 19 + 52 + 29). By looking at these proportion we can see for example how the proportion of commercial species trees in the fully or partially illuminated groups decreased from a total of 71% (i.e., 19 + 52) in the control plots at Millionario in 1995, to 67% (i.e., 15 + 52) in 1996. Similar figures for the treated plots are 65% in 1995, and also 65% in 1996. At all of the other sites, with the exception of West Botas, the proportion of fully or partially illuminated commercial species trees in treated plots improved over the one-year period. The opposite occurred in the control plots at all sites except Cohune Ridge. In general, this points to an improvement in the illumination of commercial trees, as expected with the treatment.

A better analysis would be to consider the changes in the illuminations of only the future crop trees within these groups, since these are the ones at which the treatment is specifically directed, but it is still too soon after the treatment application to see any impressive changes.

Annual Growth Increment

Hutchinson and Wadsworth (in press), state that since stem basal area, at least in some species, is directly related to crown size and possibly also to root extension, then the stem's increment in basal area as a percentage of the tree's average basal area during the period, seems to be an indicator of the efficiency with which a tree utilizes the light, nutrients and water available to it. Volume increment would be the best indicator of growth efficiency, but when precise height measurements are difficult to obtain then **Percent Basal Area Increment** is the next best indicator, especially since it also appears to be not highly correlated to a tree's diameter.

The annual Percent Basal Area Increment is therefore calculated for each tree according to the following formula:

$$\text{Annual \% Basal Area Increment} = \frac{\text{Average Annual Increment}}{(\text{Initial} + \text{Final Basal Areas})/2} \times 100$$

where:

$$\text{Average Annual Increment} = \frac{\text{Final Basal Area (1996)} - \text{Initial Basal Area (1995)}}{\text{Number of Years } (=1)}$$

The following set of tables shows how growth rates, expressed in annual percent basal area increment, differ for different groupings of trees at each site. Differences between treated and untreated plots appear, but these are not yet conclusive since so little time has elapsed since treatment application. Nevertheless, interesting differences are apparent among the different illumination classes for different groupings of trees.

The first of these tables (Table 19) summarizes the average annual growth increment of the following groupings of trees, for each site and for untreated versus treated plots:

1) **all trees** found in control versus treated plots at each site;

2) all **future crop trees** (i.e., silvicultural treatment class "11");

3) all **non-commercial trees** (i.e., silvicultural treatment class "99");

4) all trees of **1ELITE** commercial group;

5) all trees of **2PRIME** commercial group;

6) all trees of **3SELEC** commercial group;

7) all trees of **4POTCO** commercial group;

8) all trees of **5NOVAL** commercial group;

9) all **mahogany** trees

Table 19. Average annual growth (1995-1996) of trees at each site in % basal area increment (% BA Incr.).

	Millionario		San Pastor		West Botas		Duck Ridge		Cohune Ridge	
	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.
ALL TREES										
Control Plots	693	3.0	598	3.6	236	2.7	245	3.4	174	7.4
Treated Plots	443	2.9	409	3.9	210	3.6	240	3.6	195	7.3
ALL FUTURE CROP TREES										
Control Plots	104	2.7	138	4.0	102	2.7	81	4.0	30	10.0
Treated Plots	98	2.9	146	5.1	88	3.8	59	3.7	61	7.7
ALL NON-COMMERCIAL TREES										
Control Plots	589	3.1	459	3.5	134	2.7	164	3.1	144	6.8
Treated Plots	345	2.8	263	3.3	122	3.5	181	3.5	134	7.1
ALL TREES OF COMMERCIAL GROUP 1ELITE										
Control Plots	45	3.1	21	5.9	10	2.5	5	3.1	5	12.5
Treated Plots	17	4.0	28	9.4	11	2.0	9	3.3	11	4.5
ALL TREES OF COMMERCIAL GROUP 2PRIME										
Control Plots	45	2.3	115	3.5	63	3.0	48	3.9	1	5.4
Treated Plots	72	2.9	87	4.3	67	3.3	46	3.8	18	5.3
ALL TREES OF COMMERCIAL GROUP 3SELEC										
Control Plots	430	3.4	157	4.5	78	2.9	96	3.8	59	9.1
Treated Plots	244	3.1	84	3.6	76	4.4	75	4.1	97	8.5
ALL TREES OF COMMERCIAL GROUP 4POTCO										
Control Plots	4	5.8	-	-	3	1.0	-	-	9	9.8
Treated Plots	2	1.7	1	0.0	3	2.4	-	-	5	4.1
ALL TREES OF COMMERCIAL GROUP 5NOVAL										
Control Plots	169	2.1	305	3.1	82	2.5	96	2.7	100	5.9
Treated Plots	103	2.3	209	3.2	53	3.3	110	3.1	64	6.8
ALL MAHOGANY TREES										
Control Plots	18	5.5	20	6.2	5	1.6	2	3.1	-	-
Treated Plots	11	5.1	24	10.2	3	1.7	1	2.7	-	-
	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.

N.B. At Cohune Ridge the liberation treatment was not applied until 1996, therefore the results listed show growth rates of plots which are all untreated for this site.

The growth rates for the Cohune Ridge site reflect only untreated plots since the treatment was only applied in 1996, therefore no comparison between control and treated plots should be made at this time.

In general, future crop trees have higher average growth rates than the average for all trees or for all non-commercial treees, regardless of whether they are in control or treated plots. This may be a reflection of the better form which these trees have and the more favourable growing conditions in which they were originally found, all of which caused their being selected as future crop trees in the first place.

Of note, and as expected, are the faster growth rates in the Cohune Ridge plots where the number of trees and total basal area are very low and a younger forest is present.

At all of the sites, more time is needed for the girdled trees in the treated plots to die and for the liberated trees to respond before any definitive conclusions can be made.

Tables 20 - 24 further break down the growth rates shown in Table 19 according to illumination groups. For each of the sites eight tables summarize the growth rates for different groupings of trees according to the different illumination groups and for control versus treated plots. The reader should be warry of those growth rates which are based on only a small number of trees.

On average, all the future crop trees are growing faster in the treated versus the control plots, except for those in the Duck Ridge and Cohune Ridge sites. The Cohune site was not treated until this year, so no further comments can be made regarding its growth rates even though it was also struck by fire, whereas in the Duck Ridge site the fire may have had some detrimental effect in the treated plots.

In the sites where no fires occurred, i.e., Millionario, San Pastor and West Botas, the growth rate of all future crop trees was higher in the treated plots only one year after application and with only 14 to 28 percent of girdled trees already dead. Although it is still early to see the complete effect of the treatment, at least this favourable trend is already apparent.

Another way to see how increased illumination levels are favourable for growth is to look at the growth rates of the same grouping of trees under the three different illumination groups. In general all future crop trees under illumination 1+2 are growing faster than those under illumination 3, and these in turn faster than those under 4+5+6. The silvicultural treatment applied is directed at increasing the proportion of future crop trees which receive illumination 1+2. If all of these can be made to receive this higher level of illumination, then the future crop trees in the forest will be growing at their maximum productivity. More time is required to realize this flux in the illumination of selected future crop trees which have been treated, but the growth rates of trees under the different illumination groups already provides clear evidence of the benefits of striving for this.

Table 21a. Average annual growth (1995-1996) of all future crop trees (i.e., silvicultural treatment class "11") at San Pastor by illumination classes.

SAN PASTOR	All Trees		All Future Crop Trees		All Future Crop Trees Illumination 1+2		All Future Crop Trees Illumination 3		All Future Crop Trees Illumination 4+5+6	
	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.
Control Plots	598	3.6	138	4.0	30	7.1	81	3.7	27	1.0
Treated Plots	409	3.9	146	5.1	49	6.6	83	4.7	14	2.8

Table 21b. Average annual growth (1995-1996) of all non-crop trees (i.e., silvicultural treatment class "99") at San Pastor by illumination classes.

SAN PASTOR	All Trees		All Non-Crop Trees		All Non-Crop Trees Illumination 1+2		All Non-Crop Trees Illumination 3		All Non-Crop Trees Illumination 4+5+6	
	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.
Control Plots	598	3.6	459	3.5	59	5.4	239	4.3	161	1.7
Treated Plots	409	3.9	263	3.3	23	4.2	137	3.8	103	2.4

Table 21c. Average annual growth (1995-1996) of all trees of commercial group 1ELITE at San Pastor by illumination classes.

SAN PASTOR	All Trees		All 1ELITE Crop Trees		All 1ELITE Crop Trees Illumination 1+2		All 1ELITE Crop Trees Illumination 3		All 1ELITE Crop Trees Illumination 4+5+6	
	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.
Control Plots	598	3.6	21	5.9	6	7.0	10	7.5	5	1.4
Treated Plots	409	3.9	28	9.4	11	11.0	15	8.7	2	5.9

Table 21d. Average annual growth (1995-1996) of all trees of commercial group 2PRIME at San Pastor by illumination classes.

SAN PASTOR	All Trees		All 2PRIME Crop Trees		All 2PRIME Crop Trees Illumination 1+2		All 2PRIME Crop Trees Illumination 3		All 2PRIME Crop Trees Illumination 4+5+6	
	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.
Control Plots	598	3.6	115	3.5	18	7.8	63	3.5	34	1.2
Treated Plots	409	3.9	87	4.3	27	5.8	50	3.8	10	3.2

Table 22e. Average annual growth (1995-1996) of all trees of commercial group 3SELEC at West Botas by illumination classes.

WEST BOTAS	All Trees		All 3SELEC Crop Trees		All 3SELEC Crop Trees Illumination 1+2		All 3SELEC Crop Trees Illumination 3		All 3SELEC Crop Trees Illumination 4+5+6	
	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.
Control Plots	236	2.7	78	2.9	5	2.0	45	2.8	28	3.1
Treated Plots	210	3.6	76	4.4	4	4.2	34	4.3	38	4.6

Table 22f. Average annual growth (1995-1996) of all trees of commercial group 4POTCO at West Botas by illumination classes.

WEST BOTAS	All Trees		All 4POTCO Crop Trees		All 4POTCO Crop Trees Illumination 1+2		All 4POTCO Crop Trees Illumination 3		All 4POTCO Crop Trees Illumination 4+5+6	
	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.
Control Plots	236	2.7	3	1.0	-	-	1	1.3	2	0.8
Treated Plots	210	3.6	3	2.4	1	3.4	1	3.0	1	1.0

Table 22g. Average annual growth (1995-1996) of all trees of commercial group 5NOVAL at West Botas by illumination classes.

WEST BOTAS	All Trees		All 5NOVAL Crop Trees		All 5NOVAL Crop Trees Illumination 1+2		All 5NOVAL Crop Trees Illumination 3		All 5NOVAL Crop Trees Illumination 4+5+6	
	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.
Control Plots	236	2.7	82	2.5	9	1.4	39	2.8	34	2.3
Treated Plots	210	3.6	53	3.3	7	5.3	25	2.8	21	3.2

Table 22h. Average annual growth (1995-1996) of all mahogany trees at West Botas by illumination classes.

WEST BOTAS	All Trees		All Mahogany Trees		All Mahogany Trees Illumination 1+2		All Mahogany Trees Illumination 3		All Mahogany Trees Illumination 4+5+6	
	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.	No. Trees	% BA Incre.
Control Plots	236	2.7	5	1.6	4	2.0	-	-	1	2.0
Treated Plots	210	3.6	3	1.7	-	-	3	1.7	-	-

SECTION II
PRODUCTION RATES AND COSTS OF APPLYING LIBERATION TREATMENT

OBJECTIVES OF THE OPERATIONAL LIBERATION TREATMENT STUDY

The purpose of this short study was to determine the production rates and costs of applying liberation treatment on an operational scale to forest similar to that found in the PSPs.

Even after the results of the PSPs begin to show how the liberation treatment can significantly increase the productivity of released future-crop trees, the widespread application of liberation will only be possible if the long-term benefits of the treatment are found to be cost effective.

This short study attempts to determine the production rates and costs of applying the treatment via two different methods. The first, involves simply girdling the unwanted trees and is the more environmentally "safe" and, at the present time in Belize, also the most socially acceptable method. The second, utilizes an approved arboricide to efficiently kill the unwanted trees, and it is expected that the widespread use of any arboricide in Belize would require a strong campaign to educate the public on the important role which herbicides can play in sustainable forest management.

Given that the study was carried out in two relatively small areas of forest, one at San Pastor and the other at West Botas, and with personnel recently trained in the application of the treatment, one can safely say that the estimates given here are conservative and that one could expect field crews to easily match these production rates and surpass them after they have been doing this kind of activity for more than a few days.

MATERIALS AND METHODS

Plot Layout

In order to demarcate the study area a 300 x 200 m (i.e., 6 ha) block was laid out in the San Pastor site and this was further divided into 8 strips, each 25 metres wide.
A small portion of this area (215 x 25m = 0.54 ha) was utilized for training a FD crew in the required procedures before they actually carried out the treatment application. The study area in West Botas was smaller (100 x 100m = 1 ha), with strips there being only 20m in width. A small piece of red flagging tape was strung approximately every 20m along the lines in order to make the lines visible.

Methods Used For Eliminating Trees

Two different methods for eliminating unwanted trees were utilized in this study. The first simply involved girdling or ring-barking, as it is also called. The second involved making only a few machete cuts into the bark and wood of the tree (more cuts for larger trees), and then squirting a one part "Tordon" to ten-part water solution of arboricide into these gashes. Care was taken so as not to spill solution or apply more than could be absorbed by the cuts. In addition to these machete cuts, a one-half-inch-diameter pointed steel rod was driven into the wood to about a one-inch depth at a downward sloping angle and arboricide was also squirted into these holes. Each tree received at least two holes, but larger trees could have up to four or more.

At the San Pastor site, both methods for the elimination of trees were studied, each in different parts of the demarcated area. In the case of simple girdling, a 340 x 25m (i.e., 0.85 ha) area was treated in this fashion. A portion of it using a 3-man crew from the FD, and another portion using a 4-man crew.

The 3-man crew was made up of a "booker", a tree identifier, and a "chipper" who did the actual girdling. The only difference between the 3-man crew and the 4-man crew was an extra chipper in the 4-man crew. Since the complete girdling of sometimes large and often irregular-shaped trees is hard work that also needs to be done with personal safety in mind, it was thought that two chippers could more easily keep up to the progress of the tree identifier.

The role of the booker was to record the information on the number and diameter class of future crop trees liberated and also of the trees to be eliminated. The commercial groupings of each of these was also recorded, as was the distance covered and the time required to treat it. All of this information was recorded on Field Form No. 4 (Appendix 5).

In fact, the use of a booker is not essential for the marking and treatment of forest. The tree identifier and one or two chippers can easily carry out the work, but until more experience is gained it may be useful to track the progress of the crews and record information on the number and type of trees encountered. Nevertheless, one should keep in mind the fact that the use of a booker increases the cost of treatment application without contributing directly to the progress of the activity. He may in fact slow a crew down as he trys to keep up to them. In the results presented in this study the costs of including or excluding the booker will be presented.

The treatment study at the West Botas site considered only the girdling of trees due to PfB's heightened concern for a possible public disapproval with respect to the use of chemicals in their forestry operations.

RESULTS

The results of the operational treatment application are summarized in Appendix 6 and Table 25. The information contained in Appendix 6 is obtained from Field Form No. 4 and describes the commercial groups and diameter classes of all trees affected by the operational treatment study at each of the two sites. It reflects the fact that the liberation of future crop trees requires the elimination of not only individuals of the 5NOVAL commercial group but also a few from the more valuable commercial groups. The data from this appendix was utilized to generate some of the figures utilized in Table 25.

Table 25 contains a lot of basic information from each of the two sites where the operational treatment study was carried out, as well as data pertaining to the two methods utilized for the elimination of trees. It also indicates the lower costs possible when a booker is not included in the crew and when two chippers are utilized instead of only one. Note that in each of the situations a tree identifier also forms part of the crew.

One should be careful when interpreting the results as the number of trees to eliminate/ha varies greatly from a low of 77 in the West Botas site, to a high of 230 in the area where poisoning was done in San Pastor. Nevertheless, if one looks at the San Pastor site and compares the total cost per ha of girdling using one chipper and booker, with that for poisoning, also with one chipper and booker, then it is clear that poisoning is considerably cheaper at a total cost of only B$ 89.14/ha, versus 114.74 for girdling. Girdling is 29% more costly per unit area and, its effectiveness, as pointed out in the first section of this report, is questionable. If a booker is not utilized the total cost per ha is only B$ 71.84 and a two-man crew could treat 100 ha of forest in only 69.2 days. The time required by a two-man crew to girdle 100 ha of forest would be 111.8 days, or 62% longer.

Although poisoning was found to be cheaper, the area where it was applied encountered the highest number of trees to eliminate per future crop tree (i.e., 1.7). This also means that more costly flagging tape was required.

Eventually, once the effects of the treatment application have had a chance to demonstrate themselves, the efficiency (percentage of trees killed) of the two methods can be determined and compared and the costs of the operations adjusted accordingly.

Another interesting observation is that the cost of treating the natural forest and liberating potential future crop trees so that they might grow at twice their current rate, is ridiculously low if one considers the increase in value which this will create. For example, even in the worst case scenario of West Botas, with only 80 future crop trees per ha, each of which will contain at least one 4-metre-length log at harvest time, for the cost today of B$ 75.61 we can increase the productivity of these trees so that they might possibly contain twice as much wood as unliberated trees in the same amount of time. Surely, even an increase as small and conservative as 10% in the productivity of these trees will easily pay for today's investment.

Table 25. Production rates and costs of treatment application.

	SITE							
	SAN PASTOR						WEST BOTAS	
	GIRDLING ONLY				POISONING		GIRDLING ONLY	
DESCRIPTION	Booker + 1 Chipper	No Booker 1 Chipper	Booker + 2 Chippers	No Booker 2 Chippers	Booker + 1 Chipper	No Booker 1 Chipper	Booker + 2 Chippers	No Booker 2 Chippers
Strip Width (m):	25	25	25	25	25	25	20	20
Length (m):	106	106	234	234	453	453	500	500
Area (ha):	0.27	0.27	0.59	0.59	1.13	1.13	1.00	1.00
Crew Size (No. Labourers):	3	2	4	3	3	2	4	3
Elapsed Time (hrs):	2.37	2.37	2.73	2.73	6.27	6.27	3.92	3.92
Future Crop Trees (No.):	36	36	69	69	157	157	80	80
Trees to Eliminate (No.):	59	59	97	97	260	260	77	77
Future Crop Trees/ha:	136	136	118	118	139	139	80	80
Trees to Eliminate/ha:	223	223	166	166	230	230	77	77
Labour Cost/manday (B$):	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Labour Cost/man-hr (B$):	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13
Blue Flagging (rolls/ha treated):	2.6	2.6	2.3	2.3	2.7	2.7	1.5	1.5
Red Flagging (rolls/ha treated):	4.9	4.9	3.7	3.7	5.1	5.1	1.7	1.7
Red Flagging (Demarcation)(rolls/ha marked	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Arboricide Mixed Solution Needed/ha (gal):	0.515	0.515	0.383	0.383	0.531	0.531	0.178	0.178
Arboricide Solution Utilized per ha (gal):					0.601	0.601		
Cost of Arboricide Solution/gal of mix (B$):	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20
PRODUCTIVITIES								
Treated Area/hr (ha) =	0.1118	0.1118	0.2143	0.2143	0.1806	0.1806	0.2551	0.2551
Treated Area/8-hr workday (ha) =	0.89	0.89	1.71	1.71	1.44	1.44	2.04	2.04
Time Required by Crew to Treat 1 ha (hrs) =	8.94	8.94	4.67	4.67	5.54	5.54	3.92	3.92
Man-hours Required to Treat 1 ha =	26.83	17.89	18.67	14.00	16.61	11.07	15.68	11.76
Man-days Required to Treat 1 ha =	3.35	2.24	2.33	1.75	2.08	1.38	1.96	1.47
Treated Area/manday (ha) =	0.27	0.40	0.73	0.98	0.70	1.04	1.04	1.39
Liberated Trees/workday =	32	32	118	118	227	227	163	163
Trees Eliminated/workday =	53	53	166	166	376	376	157	157
No. Eliminated Trees/Future Crop Tree =	1.6	1.6	1.4	1.4	1.7	1.7	1.0	1.0
Minutes req'd by crew to eliminate 1 tree =	10.2	10.2	1.7	1.7	0.9	0.9	1.5	1.5
Costs								
Labour Cost/ha (man-days) =	3.35	2.24	2.33	1.75	2.08	1.38	1.96	1.47
Labour Cost/ha (B$) =	83.84	55.90	58.33	43.75	51.90	34.60	49.00	36.75
No. man-days to treat 100 ha =	335.4	223.6	233.3	175.0	207.6	138.4	196.0	147.0
No. Days for Crew to Treat 100 ha =	111.8	111.8	58.3	58.3	69.2	69.2	49.0	49.0
Cost of Flagging Tape/ha (B$) =	7.90	7.90	6.30	6.30	8.11	8.11	3.61	3.61
Cost of Arboricide Solution/ha (B$) =					6.13	6.13		
Cost of Demarcation/ha (B$) =	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
Total Cost per ha Treated (B$) =	114.74	86.80	87.63	73.05	89.14	71.84	75.61	63.36
Cost per Future Crop Tree (B$) =	0.84	0.64	0.74	0.62	0.64	0.52	0.95	0.79

FINAL RECOMMENDATIONS

Now that each of the PSPs has been established, treated and passed its second annual measurement their corresponding databases have been checked for errors and a reliable permanent record of the structure and dynamics of the forest at each of the sites can easily be maintained. The difficult work of establishing the plots has been completed and it will now be a relatively simple process to maintain them and do periodic evaluations and maintenance. More importantly, any information required of the plots can be quickly and easily accessed at the touch of a button thanks to SEMAFOR.

Since the effects of the silvicultural treatment will take some time yet to follow their course, it is recommended that the PSPs be evaluated every year for the next four years, if possible. After this initial 5-year period of observation the trends will have demonstrated themselves statistically with a high degree of confidence and subsequent measurements could be done after longer time periods of two or three years.

It may be prudent to contact CATIE's Natural Forest Management Unit prior to the next plot evaluations and possibly even invite CATIE's technical personnel to assist or to provide a very short refresher course and in-service training in the field measurement as well as the data input techniques.

Since the information obtained from the plots will be of continuing interest to all forest managers and researchers in the Region, it would be fruitful to all concerned if the FD and PfB shared their data and allowed CATIE to update its own copy of the Belizean databases and possibly have these formally incorporated into CATIE's network of key research and demonstration sites throughout the region. There is also the possibility of having CATIE process the Belizean field data since it can do this much more rapidly than most.

Although some might want to wait until the PSPs provide enough information to justify the application of liberation treatment on a large scale, others might consider beginning with relatively small areas of forest and proceeding immediatley with their treatment. The benefits of liberation have already been documented by CATIE, and elsewhere throughout the world, and, if the treatment is applied properly, there really shouldn't be a fear of something going disastrously wrong. The information from the plots will mostly cuantify the magnitude of the positive effects which the treatment will spark, primarily among the selected future crop trees, and to a lesser extend among the rest of the trees in the treated forest.

The two methods described for the elimination of competing trees, although relatively cheap, could benefit from further experimentation in order to perfect the most cost-efficient alternatives. The best way to achieve this is to start applying the treatment and learning from experience what works best, when and where. Environmentally friendly arboricides exist and the use of these needs to be seriously considered since they can

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play an important role in guaranteeing an efficient, cost-effective and rapid response to the treatment.

The results of the operational treatment application indicate the very low cost of treating the degraded forests of Belize, and this seems like a small and timely investment in the future of Belize's forests.

The good news, at the very least, is that the forests *are* in fact growing and that even without silvicultural treatment the information provided by the PSPs provides the evidence that lets us know by exactly how much. This information in itself is critical to sound forest management and is greatly lacking throughout the entire Latin American Region. If for some reason liberation treatment is not carried out in the future, one should not discard the PSP methodology and database system and its ability to continue to provide valuable information regarding changes in forest structure and dynamics, be they due to human interventions or natural causes.

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CATIE's Technical Team in Belize

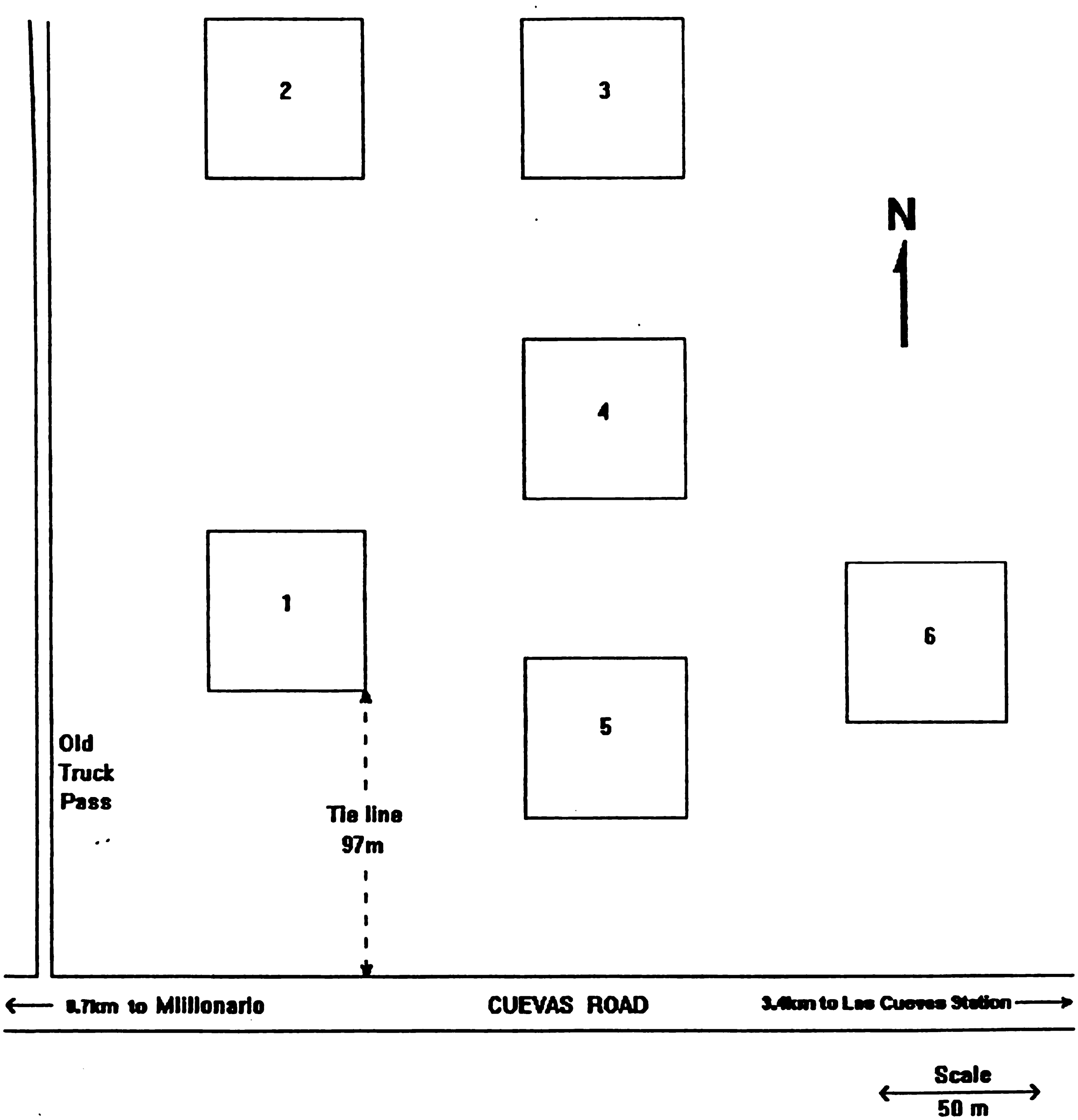
Hugo Brenes (as Technical Field Assistant); Ian D. Hutchinson (Silviculturalist)

Francisco Pacheco (Tree Identifier); Paul Martins (Project Director); Hugo Brenes (Computer Programmer)

Appendix 1

Diagrams of Individual Plot Locations at Each Site and Corresponding GPS Readings

MILLIONARIO SITE
Diagram of Plot Locations



CHIQUIBUL FOREST RESERVE.
Plot demarcation: Millionario
Location: 0.7 km. from Millionario junction to Cuevas.

PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
1	E: 2-87-836 N: 18-53-111	97 100	3 N 273 W	360 N 270 W	To SE corner

PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
2	E: same as N: above	237 100	3 N 273 W	360 N 270 W	To SE corner

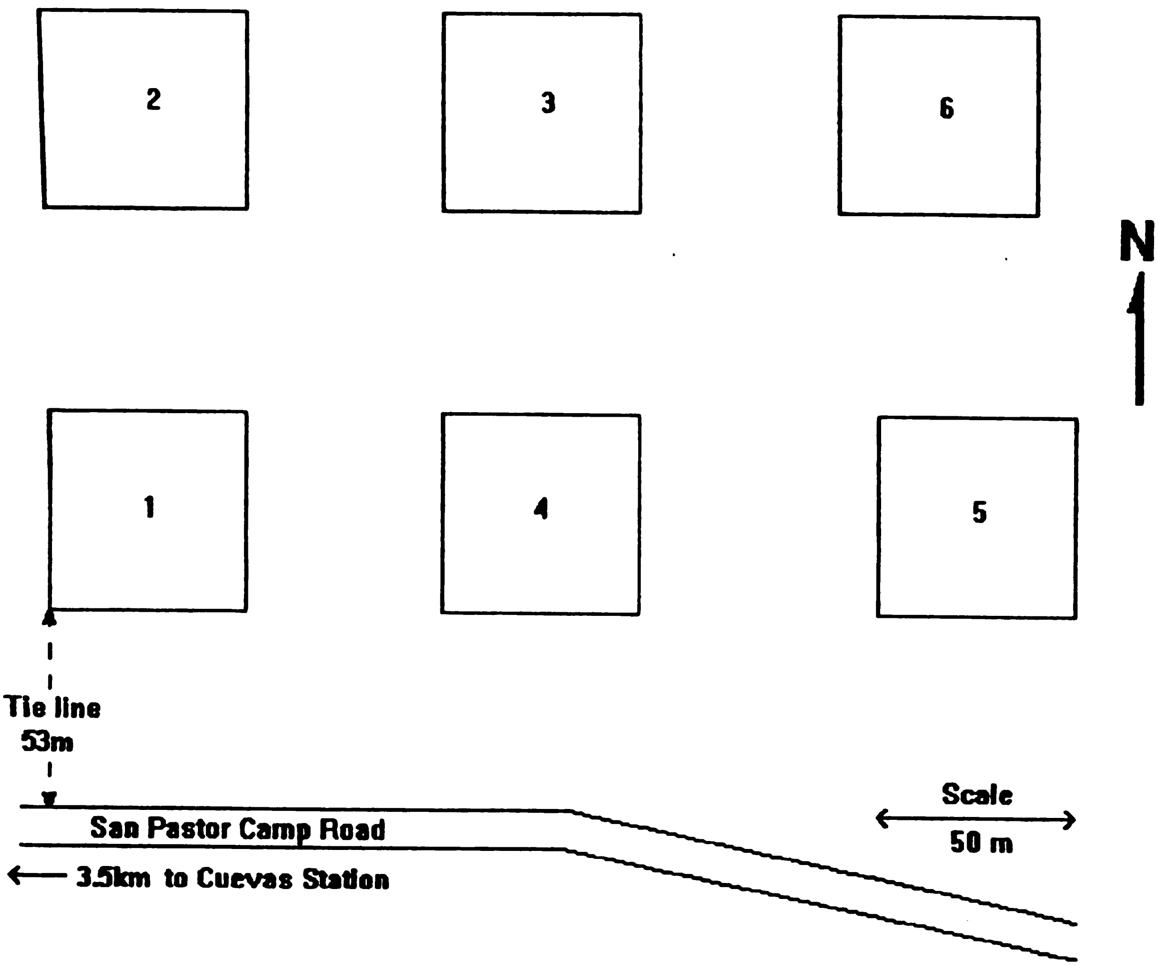
PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
3	E: same as N: above	237	3 N	360 N	To SE corner

PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
4	E: same as N: above	137	3 N	360 N	To SE corner

PLOT ID	START OF TIE LINE.UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
5	E: same as N: above	37	3 N	360 N	To SE corner

PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
6	E: same as N: above	67 50	3 N 93 E	360 N 90 E	To SW corner

SAN PASTOR SITE
Diagram of Plot Locations



CHIQUIBUL FOREST RESERVE.
Plot demarcation: San Pastor
Location: 3.1 km. from main junction.

PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
1	E: 2-88-486 N: 18-48-700	53	3 N	360 N	To SW corner

PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
2	E: same as N: above	153	3 N	360 N	To SW corner

PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
3	E: same as N: above	153 100	3 N 93 E	360 N 90 E	To SW corner

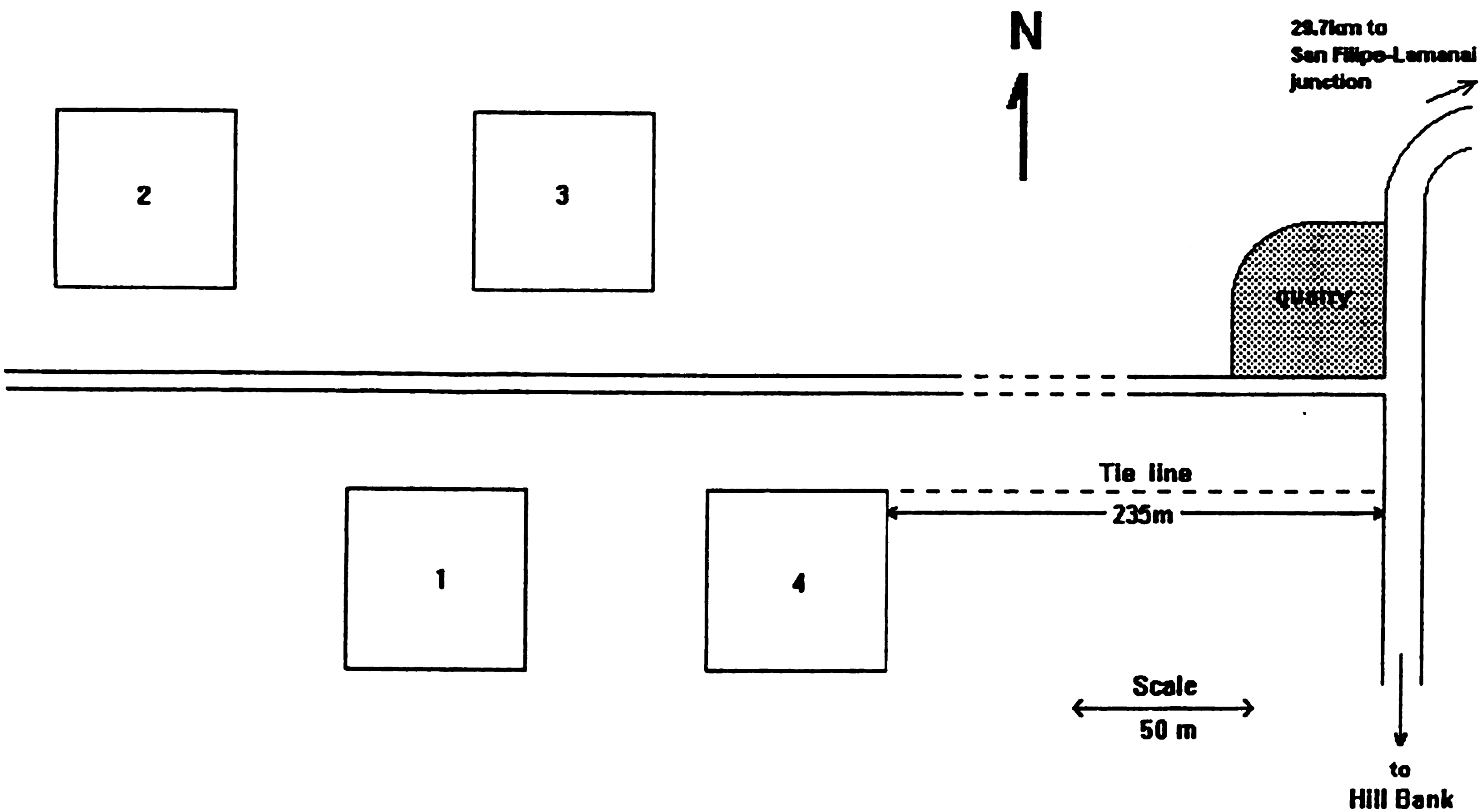
PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
4	E: same as N: above	53 100	3 N 93 E	360 N 90 E	To SW corner

PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
5	E: same as N: above	53 210	3 N 93 E	360 N 90 E	To SW corner

PLOT ID	START OF TIE LINE. UTM	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
6	E: same as N: above	153 200	3 N 93 E	360 N 90 E	To SW corner

WEST BOTAS SITE

Diagram of Plot Locations



PROGRAMME FOR BELIZE.
Plot demarcation: West Botas
Location: 29.7 km. from San Felipe-Lamanai junction.

PLOT ID	START OF TIE LINE.LONGLAT	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
1	17-37-26 N 088-44-23 W	335	273 W	270 W	To NE corner

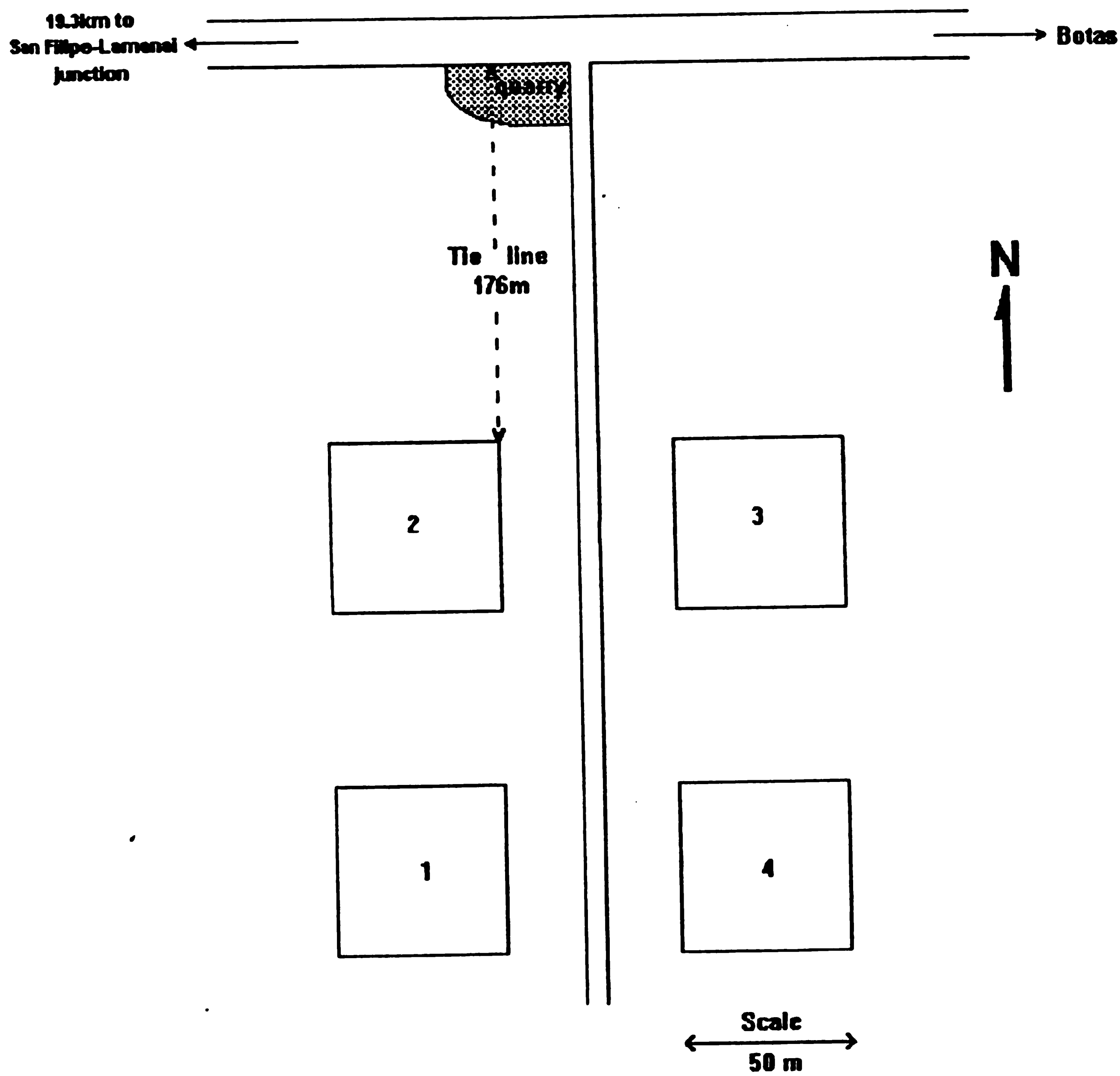
PLOT ID	START OF TIE LINE.LONGLAT	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
2	same as above	385 99 31	273 W 3 N 273 W	270 W 360 N 270 W	To SE corner

PLOT ID	START OF TIE LINE.LONGLAT	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
3	same as above	385 99 50	273 W 3 N 93 E	270 W 360 N 90 E	To SW corner

PLOT ID	START OF TIE LINE.LONGLAT	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
4	same as above	235	273 W	270 W	To NE corner

DUCK RIDGE SITE

Diagram of Plot Locations



PROGRAMME FOR BELIZE.
Plot demarcation: Duck Ridge
Location: 19.3 km. from San Felipe-Lamanai junction.

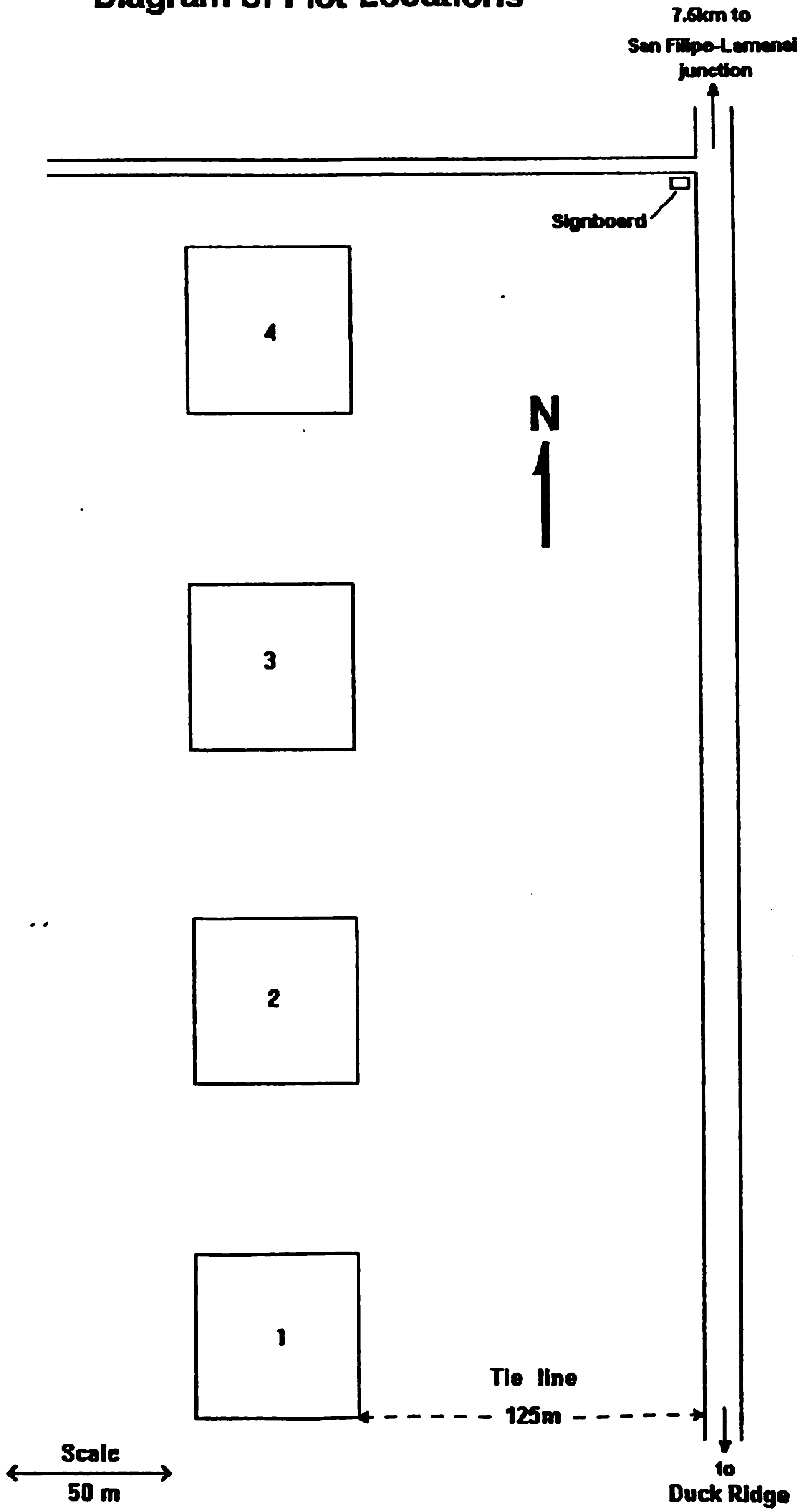
PLOT ID	START OF TIE LINE.LONGLAT	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
1	17-42-16 N 088-45-38 W	276	183 S	180 S	To NE corner

PLOT ID	START OF TIE LINE.LONGLAT	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
2	same as above	176	183 S	180 S	To NE corner

Plots 3 and 4 were not done.

COHUNE RIDGE SITE

Diagram of Plot Locations



PROGRAMME FOR BELIZE.
Plot demarcation: Cohune Ridge
Location: 7.5 km. from San Felipe-Lamanai junction.

PLOT ID	START OF TIE LINE.LONGLAT	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
1	17-48-10 N 088-46-41 W	125	273 W	270 W	To SE corner

PLOT ID	START OF TIE LINE.LONGLAT	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
2	same as above	125 100	273 W 3 N	270 W 360 N	To SE corner

PLOT ID	START OF TIE LINE.LONGLAT	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
3	same as above	125 200	273 W 3 N	270 W 360 N	To SE corner

PLOT ID''	START OF TIE LINE.LONGLAT	DISTANCE (M)	BEARING TRUE	BEARING MAGNETIC	COMMENT
4	same as above	125 300	273 W 3 N	270 W 360 N	To SE corner

Appendix 2

Field Form No.1
(for all trees in a cuadrat)

RENARM/PBN - CATIE: PRODUCTION NATURAL FOREST.
Trees DBH > 10 cm: Cuadrat 10 x 10 m (0.01 ha)
Name of site: ______________________

FORM NO.1. 11/julio/92

Country Code No. ☐☐ Treatment Code No. ☐☐☐☐☐☐☐☐

Site Code No ☐☐☐ No. of Expt. ☐☐☐☐☐

Plot No. ☐☐☐☐☐ No. Cuadrat ☐☐

FOREST TYPE: ____________
Tree-namer: ____________
Measurer: ____________
Booker: ____________

DATE :	day	mth	yr	STOCKED
Calendar :				1. Yes
Decimal :				9. No

DIAGNOSTIC SAMPLE		
DBH 50 + cm		
Sp:	Cl. Stem Quality	
LEADING DESIRABLE		
OTHRUSE:	TIMBER: (10-49 cm dbh)	
Class L.D.(1,2,3,9): Sp: Cl. Illumn. L.D: DBH:	Class L.D.(1,2,3,9) Sp: Cl. Illumn. L.D: DBH:	
Cl. Illumn. centre of subplot: (1.3 m): (9)		

DENSIOMETRO (1.3m ht)	1. Light	% S	5. Light	% S	13. Light	% S	21. Light	% S	25. Light	% S

Consec. Tree No.	IDENT Stem Ident Cl. (4)	NAME Common name	COMMERC. GRP. Timber	COMMERC. GRP. OTHRUSE	DESCRIPTION OF INDIVIDUAL TREE DIAM DBH (cm)	STEM Qual. Class (5)	HEIGHT (m)	CROWN Illumn (3)	CROWN Form (6)	Woody Climbers (7)	SILVICULTURAL TRMT. (8)	OBSERVATIONS

OTHRUSE includes: Edible fruits of commercial value (FRU,FR)-Fruits eaten by wildlife (FRUFAU)-Comercial Latex (LTX,LX)-
Medicinal use (MED,ME)-Beefarming (POL,PO).

RENARM/PBN,CATIE. CODE NUMBERS, FORM NO.1: PRODUCTION IN NATURAL FORESTS. 11/enero/93

1. STUDY LEVEL	CODE NO.
10 x 10 m Trees	1
5 x 5 m Saplings	2
2 x 2 m Seedlings	3

2. LEADING DESIRABLE	CODE NO.
Tree 10–49 cm dbh	1
Sapling 5–9 cm dbh	2
Seedling –4 cm dbh	3
Plot. without L.D.	9

3. CROWN ILLUMINATION	CODE NO:
Emergent	1
Full-vertical illum	2
Part-vertical illum	3
Full o excl. lateral	4
Oblique o part. illum	5
No direct illum	6

4. STEM IDENTITY CLASS	Stem: Com-plete	Stem: Bro-ken	Stump: Bro-ken	Stump: Cut	Not Found
TREES: (10+cm dbhob) Subplots 10 x 10 m (0.01 ha)					
Tree, alive standing	111	112	113	114	119
Tree, alive inclined <29°	121	122			129
Tree, alive inclined 30+°	131	132			139
Curved stem (half-moon)	141	142			149
Tree, fallen alive	151	152	153		159
Tree, standing, dead	161	162	163	164	169
Tree, fallen, dead	171	172	173		179
COPPICES: (10+cm dbhob)					
Coppice, alive standing	211	212	213	214	219
Coppice, alive inclined <29°	221	222			229
Coppice, alive standing 30+°	231	232			239
Coppice, alive fallen	241	242	243		249
Coppice, alive dead	251	252	253	254	259
Coppice, dead fallen	261	262	263		269
Stem : Total height four metres or more Stump: Total height less than four metres					
PALMS: (height to top of woody s tem)					
Alive, stand. 2+m total height	511	512	513	514	519
Alive, fallen, 2+m tot. ht.	521	522	523	-	529
Dead, 2+m tot. ht.	531	532	533	534	539
Alive, stand. 0.30–1.99m tot.	551	552	553	554	-
Alive, fallen 0.30–1.99m tot.	561	562	563	-	-

5. STEM QUALITY CLASS	CODE NO.
Currently commercial	1
Commerc. in future	2
"2" on top of "6"	3
Deformed	4
Damaged	5
Decayed	6

6. CROWN FORM	CODE NO.
Complete circle	1
Irregular circle	2
Half-circle	3
Less than ½ circle	4
Few branches	5
Mainly coppice sprouts	6
Alive without crown	7

7. WOODY CLIMBERS	CODE
A. None visible on trunk:	
a) None visible in crown	1
b) Visible in crown	2
c) Cover 50+% of crown area	3
B. Loose on/along trunk:	
a) None visible in crown	4
b) Visible in crown	5
c) Cover 50+% of crown area	6
C. Clasping trunk:	
a) None visible in crown	7
b) Visible in crown	8
c) Cover 50+% of crown area	9

8. SILVICULTURAL TREATMENT	CODE NO.
1. TO BE LIBERATED:	(BLUE)
ACCORDING TO LIST: Tree selected for Libn.	11
2 TO BE REMOVED:	(RED)
Tree chosen to be cut or poisoned	21
3. NEW RECRUITS (YEAR)	80 (yr)
9. NOT AFFECTED BY TRMT.	(NO TAPE) 99

Appendix 3

Field Form No. 2
(for saplings and seedlings in nested subplots)

RENARM/PBN, CATIE: PRODUCTION NATURAL FORESTS.
Trees DBH > 10 cmcc: Cuadrat 10 x 10 m (0.01 ha)

FORM NO.2. 11/July/92

Name of site: ______________________________

Country Code No [ ][ ]   Treatment Code No. [ ][ ][ ][ ][ ][ ][ ][ ]

Site Code No [ ][ ][ ]   No. of Expt. [ ][ ][ ][ ][ ]

Plot No. [ ][ ][ ][ ][ ]   No. Cuadrat [ ][ ]

FOREST TYPE: ____________________
Tree-Namer: ____________________
Measurer: ____________________
Booker:

DATE :	day	mth	yr
Calendar :			
Decimal :			

	1:A NE
2:B SW	

NATURAL REGENERATION: TALLY OF LIVE STANDING INDIVIDUALS

S A P L I N G S
(5.0 - 9.9 cm dbhob. Subplots 5 x 5 m.)
(0.0025 Ha) - (x 400)

STOCKED: 1. Yes / 9. No

Con-secutive Tree No.	COMMON NAME	COPPICES	PLANTS	CL. ILLUMN	OBSERVATIONS

S E E D L I N G S
(30 cm tot. ht - 4.9 cm dbhob. Subplots 2 x 2 m)
(0.0004 Ha) - (x 2500)
(Illumination class of (Subplot):____________)
Depth of humus layer (cm): _________

STOCKED: 1. Yes / 9. No

COMMON NAME	COPPICES	PLANTS	OBSERVATIONS

CROWN ILLUMINATION CLASSES:	CODE		CODE
Emergent	1	Full excl. lateral	4
Full vertical	2	Oblique	5
Partly vertical	3	Indirect illumn only	6

APPENDIX 4

COMMON AND SCIENTIFIC NAMES OF TREES FOUND IN STP PERMANENT SAMPLE PLOTS

NOMBRE COMUN	COMMON NAME	FAMILY	SPECIES	COMMERCIAL GROUP
Chechen negro	Black poisonwood	Anacardiaceae	Metopium browneii	1ELITE
Pasac macho	Negrito macho	Anacardiaceae	Mosquitoxylon	5NOVAL
Jobo	Hog plum	Anacardiaceae	Spondias	3SELEC
Anona de montaña	Wild custard apple	Annonaceae	Anona	5NOVAL
Candelero	Annonaceae	Annonaceae	Cymbopetalum	5NOVAL
Yaya	Lancewood	Annonaceae	Malmea	5NOVAL
Sastante	Polewood	Annonaceae	Xylopia	5NOVAL
Malerio blanco	White mylady	Apocynaceae	Aspidosperma	2PRIME
Malerio colorado	Mylady	Apocynaceae	Aspidosperma	2PRIME
Flor de chombo	Zopilote	Apocynaceae	Plumeria	5NOVAL
Cojon de caballo	Huevos de caballo	Apocynaceae	Stemmadenia	5NOVAL
Mano de leon	White gumbolimbo	Araliaceae	Dendropanax	3SELEC
-	Cow okra	Bignoniaceae	Parmentiera	5NOVAL
Ceiba	Ceiba	Bombacaceae	Ceiba	3SELEC
Amapola	Mapola	Bombacaceae	Pseudobombax	3SELEC
Laurel negro	Salmwood	Boraginaceae	Cordia alliodora	2PRIME
Chacaj colorado	Gumbolimbo	Burseraceae	Bursera	3SELEC
Copal	Copal	Burseraceae	Protium	5NOVAL NT
Chintoc blanco	Celastraceae	Celastraceae	Wimmeria	5NOVAL
Aceituno peludo	Pigeon plum	Chrysobalanaceae	Hirtella	5NOVAL
Aceituno	Wild pigeon plum	Chrysobalanaceae	Hirtella	5NOVAL
Canchan	Nargusta	Combretaceae	Terminalia	2PRIME
Cajeton	Fiddlewood	Euphorbiaceae	Alchornea	3SELEC
Luin macho	Male bullhoof	Euphorbiaceae	Drypetes brownii	2PRIME
Chechen blanco	White poisonwood	Euphorbiaceae	Sebastiana longicuspsis	3SELEC
Encino	Oak	Fagaceae	Quercus	5NOVAL
-	Paletillo	Flacourtiaceae	Casearia	5NOVAL
Baquelac	Flacourtiaceae	Flacourtiaceae	Laetia	5NOVAL
Tamay	Dandruff tree	Flacourtiaceae	Zuelania	5NOVAL
Santa maria	Santa maria	Guttiferae	Calophyllum brasiliense	2PRIME
Achiotillo	Old william	Guttiferae	Vismia	5NOVAL
-	Palo mulato	Lacistemaceae	Astronium graveolens	1ELITE
Sosni	Timbersweet	Lauraceae	Licaria (Nectandra, Ocotea)	3SELEC
Laurel blanco	Lauraceae	Lauraceae	-	5NOVAL
Chichipate	Billy webb	Fabaceae	Sweetia panamensis	2PRIME
Manchiche	Black cabbage bark	Fabaceae	Lonchocarpus castilloi	2PRIME
Pico de loro	Black cabbage bark	Fabaceae	Lonchocarpus	2PRIME
Quisainche	Black cabbage bark	Fabaceae	Lonchocarpus	2PRIME
Palo amarillo	Black cabbage bark	Fabaceae	Lonchocarpus	2PRIME
Colorin	John crow bead	Fabaceae	Ormosia	3SELEC
Hormigo	Granadillo	Fabaceae	Platymiscium yucatanum	1ELITE
Danto	Bitterwood	Fabaceae	Vatairea lundellii	2PRIME
Catalox	B. rosewood	Caesalpinaceae	Swartzia cubensis ?	2PRIME
Llora sangre	B. rosewood	Caesalpinaceae	Swartzia cubensis ?	2PRIME
Subin colorado	Cockspur	Mimosaceae	Acacia	5NOVAL
Cola de coche	Barba jolote	Mimosaceae	Pithecelobium arboreum	3SELEC
Gesmo	Leguminosae	Mimosaceae	Lysiloma	4POTCO
Okbat	Leguminosae	-	-	5NOVAL
Palo espinudo	Leguminosae	-	-	5NOVAL
Suj	B. mahogany	-	Carapa guianensis	1ELITE
Papaturro	Wild grape	Polygonaceae	Cocoloba	5NOVAL
Papaturro blanco	Wild grape	Polygonaceae	Cocoloba	5NOVAL
Papaturro hoja chica	Wild grape	Polygonaceae	Cocoloba	5NOVAL
Isote de montaña	Candlewood	Liliaceae	Dracaena	5NOVAL
Cacho de venado	Jug:(half.crown)	Melastomaceae	Mouriri	5NOVAL
-	Jug:	Melastomaceae	Mouriri	5NOVAL
Cedro	Cedar	Meliaceae	Cedrela odorata	1ELITE
Cedrillo	Cramantee	Meliaceae	Guarea excelsa	3SELEC
Caoba	Mahogany	Meliaceae	Swietenia macrophylla	1ELITE
Chile malache	Wild lime	Meliaceae	Trichilia	5NOVAL
-	Carbon del rio	Meliaceae	Trichilia	5NOVAL
Guarumo	Trumpet tree	Moraceae	Cecropia	5NOVAL
Amate	Fig	Moraceae	Ficus	3SELEC
Copo	Strangler fig	Moraceae	Ficus	5NOVAL
Matapalo	Strangler fig	Moraceae	Ficus	5NOVAL
Manax	Wild cherry	Moraceae	Pseudolmedia	5NOVAL NT
Ramon colorado	Red breadnut	Moraceae	Trophis	3SELEC
-	Banak	Myristiaceae	Virola koschnyi	3SELEC
Huele bien	Myrsinaceae	Myrsinaceae	Ardisia	5NOVAL
Chilonche	Myrtaceae	Myrtaceae	Eugenia	5NOVAL
Pimienta gorda	Allspice	Myrtaceae	Pimienta	5NOVAL NT
Guayabillo	Myrtaceae	Myrtaceae	-	5NOVAL

NOMBRE COMUN	COMMON NAME	FAMILY	SPECIES	COMMERCIAL GROUP
Carboncillo sierra	Ochnaceae	Ochnaceae	Ouratea	5NOVAL
Quina	Quinine	Quiinaceae	Quina	5NOVAL
-	Waterwood	Rhizophoraceae	Cassipourea	5NOVAL
Son	Wild mammee	Rubiaceae	Alseis yucatanensis	3SELEC
Testap	Glassywood	Rubiaceae	Guettarda combsii	3SELEC
-	Rubiaceae	Rubiaceae	Psychotria	5NOVAL
Saltemuche	John crow redwood	Rubiaceae	Simira	4POTCO
Naranjillo	Prickly yellow	Rutaceae	Zanthoxylon	3SELEC
Lagarto	Prickly yellow	Rutaceae	Zanthoxylon	3SELEC
Chile chichalaca	Huesillo	Sapindaceae	Allophylus	5NOVAL
Chonte	Grande betty	Sapindaceae	Cupania	5NOVAL
Zacuayum	Boyjob	Sapindaceae	Matayba	5NOVAL
Jaboncillo	Soapseed	Sapindaceae	Sapindus	5NOVAL
Guava	Kenep	Sapindaceae	Talisia	4POTCO
Siquiya	Star apple	Sapotaceae	Chrysophyllum	4POTCO
Chico zapote	Sapodilla	Sapotaceae	Manilkara	2PRIME NT
Chiquibul	Chicle macho	Sapotaceae	Manilkara chicle	2PRIME NT
Silion	Silly young	Sapotaceae	Pouteria	3SELEC
Caniste	Silly young; caniste	Sapotaceae	Pouteria durlandii	3SELEC
Sapotillo hoja fina	Silly young, shf	Sapotaceae	Pouteria recticulata	3SELEC
Zapote hoja chica	Sapotillo	Sapotaceae	Pouteria	5NOVAL
Zapote mamey	Mammee ciruela	Sapotaceae	Pouteria	3SELEC
Tempisque	Sapotaceae	Sapotaceae	-	5NOVAL
Huele de noche	Solanaceae	Solanaceae	Cestrum	5NOVAL
Ixcajaguai	Solanaceae	Solanaceae	Cestrum	5NOVAL
Pasac hembra	Negrito	Simaroubaceae	Simarouba glauca	3SELEC
Pixoy	Bay cedar	Sterculiaceae	Guazuma	5NOVAL
Chique	River craboo	Theaceae	Ternstroemia	5NOVAL
Jolol	Mntn. mojo	Tileaceae	Luehea	5NOVAL
Campac	Moho	Tileaceae	Trichospermum	5NOVAL
Yaxnik	Fiddlewood	Verbenaceae	Vitex	3SELEC
Cafe silvestre	Wild coffee	Violaceae	Rinorea	5NOVAL
San juan	Yemeri	Vochysiaceae	Vochysia guatemalensis	3SELEC
Bojon blanco	G/bojon blanco	-	-	5NOVAL
Palo de diente	G/palo de diente	-	-	5NOVAL
Pataxte	G/pataxte	-		5NOVAL
Pocsiquil	G/pocsiquil	-		5NOVAL
Sabasche	G/sabasche	-		5NOVAL
Sapamuche	G/sapamuche	-		5NOVAL
Yaxochoc	G/yaxochoc	-		5NOVAL
Xate macho	Xate	Palmae	Chamaedorea	5NOVAL NT
Corozo	Cohune	Palmae	Orbignya	5NOVAL NT
Botan	Bayleaf thatch palm	Palmae	Sabal mauritiiformis	5NOVAL NT
Guano	Bayleaf thatch palm	Palmae	Sabal mauritiiformis	5NOVAL NT
Waterwood	Waterwood	Flacourtiaceae	Zuelania guidonia	5NOVAL
Silion	Silly young, silion	Sapotaceae	Pouteria amigdalina	3SELEC
-	Desconocido	-		5NOVAL
-	Fabaceae	-		5NOVAL
-	G/roble	-		5NOVAL
-	Carboncillo sierra,	-		5NOVAL
-	G/cante	-		5NOVAL
-	G/chulunte	-	--	5NOVAL
-	G/coloc	-	--	5NOVAL
-	G/guaiatup	-	--	5NOVAL
-	G/guatap	-		5NOVAL
-	G/paletillo	-		5NOVAL
-	G/guaya	-		5NOVAL
-	Rosewood		Dalbergia stevensonii	1ELITE
-	Mayflower		Tabebuia pentaphylla	1ELITE
-	Ironwood		Dialium guianense	2PRIME
-	Quamwood		Schizolobium parahybum	2PRIME
-	Breadnut	Moraceae	Brosimum alicastrum	3SELEC
-	Redwood		Erythroxylon	3SELEC
-	Carbon		Tetragastris stevensonii	3SELEC
-	John crow wood		Ormosia	3SELEC
-	Monkey apple		Licania platypus	3SELEC
-	Balsam		Myroxylum	3SELEC
-	Waika chewstick		Symphonia globulifera	3SELEC
-	San juan macho		Ilex	3SELEC
-	White cabbage bark		Andira	3SELEC
-	G/cedrillo hoja fina	Meliaceae	Guarea	5NOVAL
-	G/chacaj blanco	Bruseraceae	Bursera	5NOVAL
-	Breadnut	Moraceae	Brosimum alicastrum	3SELEC
-	Cream tree	Sapotaceae	Mastichodendron	5NOVAL
-	Mammee cerera	Sapotaceae	Pouteria	3SELEC

Appendix 5

Field Form No. 4 - Liberation Treatment

CATIE/Silvicultural Treatment Project

FIELD FORM No. 4 - LIBERATION TREATMENT

Strip Width (m): ________ LOCATION: ______________________________ DATE: ______________________

Strip Length: 10,20,30,40,50,60,70,80,90,100,110,120,130,140,150,160,170,180,190,200,210,220,230,240,250,260,270,280,290,300

Time Start: ___________ Time Stop: ___________ Sheet No: ______

SELECTED TREES (Blue)

	DIAMETER SIZE CLASS (cm)						
	10-19.9 (1)	20-29.9 (2)	30-39.9 (3)	40-49.9 (4)	50-59.9 (5)	>= 60 (6)	TOTAL
ELITE							
PRIME							
SELECT							
TOTAL:							

ELIMINATED TREES (Red)

	(1)	(2)	(3)	(4)	(5)	(6)	TOTAL
ELITE							
PRIME							
SELECT							
NOVAL							
TOTAL:							

Appendix 6 - Trees Affected By Operational Treatment

Marking and girdling of trees at San Pastor with a 3-man crew (1 chipper).

	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	>= 60	Total
Selected Trees							
ELITE	12	14	2			1	29
PRIME	33	24	6	1			64
SELECT	7	4	1				12
Total:	**52**	**42**	**9**	**1**	**0**	**1**	**105**
Eliminated Trees							
ELITE			1				1
PRIME	10	1	2				13
SELECT	2	2					4
NOVAL	102	26	7	2		1	138
Total:	**114**	**29**	**10**	**2**	**0**	**1**	**156**

Marking and girdling of trees at San Pastor with a 4-man crew (2 chippers).

	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	>= 60	Total
Selected Trees							
ELITE	12	14	2			1	29
PRIME	33	24	6	1			64
SELECT	7	4	1				12
Total:	**52**	**42**	**9**	**1**	**0**	**1**	**105**
Eliminated Trees							
ELITE			1				1
PRIME	10	1	2				13
SELECT	2	2					4
NOVAL	102	26	7	2		1	138
Total:	**114**	**29**	**10**	**2**	**0**	**1**	**156**

Marking and girdling of trees at West Botas with a 4-man crew (2 chippers).

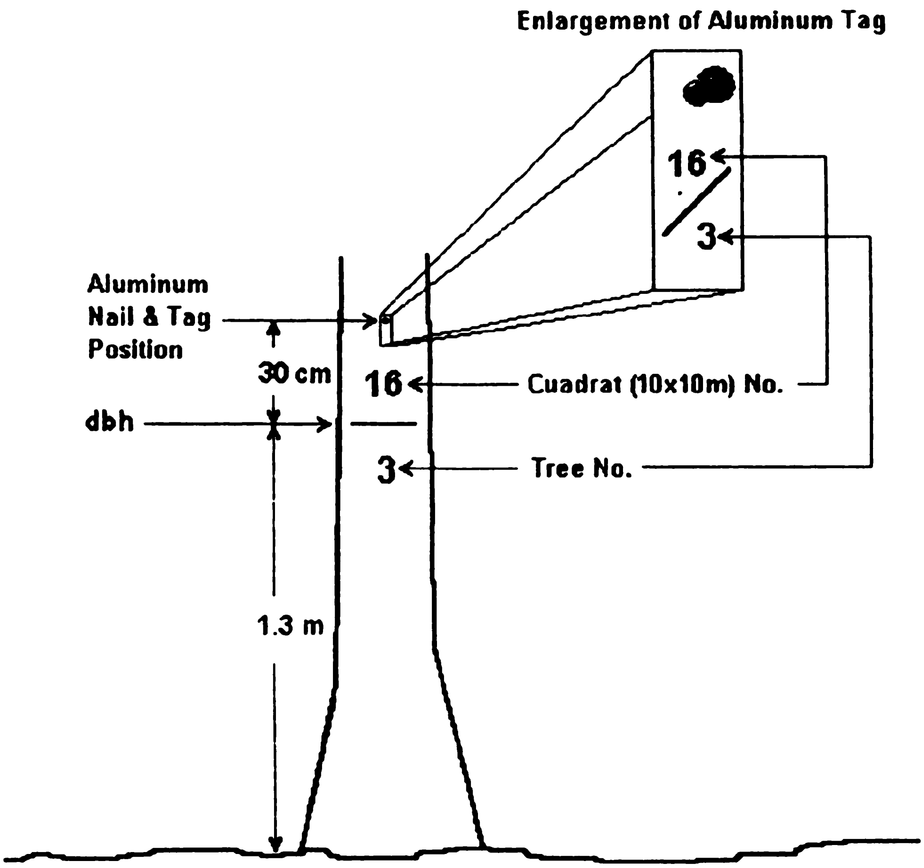
	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	>= 60	Total
Selected Trees							
ELITE		4		1	1		6
PRIME	10	18	11	10	4		53
SELECT	5	10	2	1	1	2	21
Total:	**15**	**32**	**13**	**12**	**6**	**2**	**80**
Eliminated Trees							
ELITE							0
PRIME	1	3	2				6
SELECT	6	1					7
NOVAL	47	16		1			64
Total:	**54**	**20**	**2**	**1**	**0**	**1**	**77**

Marking and poisoning of trees at San Pastor with a 3-man crew (1 chipper).

	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	>= 60	Total
Selected Trees							
ELITE	12	18	11	1	1		43
PRIME	32	36	12	4	1		85
SELECT	10	12	3	1	2	1	29
Total:	**54**	**66**	**26**	**6**	**4**	**1**	**157**
Eliminated Trees							
ELITE							0
PRIME	18	9	1				28
SELECT	8		1				9
NOVAL	174	33	10	5	1		223
Total:	**200**	**42**	**12**	**5**	**1**	**1**	**260**

Appendix 7

Location of Tree Identification Numbers and Aluminum Tags



Location of Tree Identification Numbers and Aluminum Tags