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A RESOURCE ASSESSMENT OF THE PILOT CHICLE HARVEST IN THE RIO BRAVO CONSERVATION AND MANAGEMENT AREA, BELIZE, 1993-94.

TECHNICAL REPORT

PROGRAMME FOR BELIZE

April 1994

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A Report To
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By

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The pilot project was funded by the United States Agency for International Development through Fountain Forestry Incorporated, US and Fountain Renewable Resources Ltd., UK. I am extremely grateful to these organisation for their support in this work. The work was guided at all stages by Roger Wilson, PFB Technical Director whose work was invaluable from conception to completion.

I am very grateful to Bart and Barbara Romero for their support and for being such good hosts at the research station. This gratitude extends to all those who work either at or for the station and who keep it running smoothly.

The project succeeded because of the efforts of those who worked directly with it. This applies particularly to Tivo Cowo Sr. and Tivo Cowo Jr. - chiclero and chiclerito - and trainees Claudia and Mario. The rangers - Benjamin, Rodas, Cesar and Roberto - and John Masson always had valuable advice and support.

Every one within Programme for Belize helped the project succeed because of the enormous enthusiasm which they have for the aims and objectives of the organisation, which cannot fail to infect anyone that works at Rio Bravo.

EXECUTIVE SUMMARY

In 1993 Programme for Belize commenced a pilot of harvest of chicle from the Rio Bravo Conservation and Management Area (RBCMA), in NW Belize. Chicle is the latex of the sapodilla, *Manilkara zapota* a dominant tree in the principal forest type of Rio Bravo. At the same time, studies on the sapodilla population were begun with the dual objectives of baseline resource assessment and the establishment of a monitoring system for population health and latex yields once harvesting is underway. The following report presents the results of the resource assessment aspects of this work.

Chicle is to be harvested from one particular management zone of the RBCMA namely the UZ1 which covers an area of approximately 13,000 Ha. The preliminary harvest procedure is an area rotation system over 6 years, giving working areas of 2,166 Ha per year. The pilot harvest took place in three blocks whose boudaries were cut prior to the start of the work. They were around 360 Ha in area and were established close to the northern entrance of the RBCMA in what will be the first chicle working area of the UZ1. Consistent with current regulations, only trees of greater than 30 cm diameter at breast height (dbh) were harvested during the pilot work. Only one chiclero worked on the project.

The data presented are taken from permanent experimental plot pairs which were established randomly within the first two working blocks, and are presented in the context of latex yield figures from the pilot harvest. In addition some temporary samples were taken elsewhere in the first working area to indicate the applicability of the pilot study results over the whole working area.

Population status:

Generally speaking the population, which has been harvested consistently for at least 80 years and last harvested 9 years ago, is in good health with sound demography for this type of species, and population densities which compare well to figures quoted in previous research. Of the harvestable population 97% had been tapped at least once and 73% more than 3 times. The population characteristics found are shown in table A. For definitions of terms see glossary.

Although the population structure is generally sound exhibiting the expected 'reverse J histogram for such a species, there is some evidence that trees between 20and 29 cm dbh are slightly under-represented in the population, a matter which should be monitored in the future.

Table A. The summarised results of the chicle pilot harvest taken from the experimental plots only.

	Mean	Reliable minimum estimate
Population Density (Ha^{-1})	32.2	25.7
Harvestable population (Ha^{-1})	13.5	9.4
Productive population (Ha^{-1})	5.3	3.5
Yield per productive tree (lbs)	1.72	1.56

Applicability of the data:

Although these figures are generally good, it was found that the population density in the pilot study was somewhat higher than that in the temporary samples (mean = 23.6) which implies that the population, and thus latex yield, of the first working area as a whole may be lower than is suggested by the pilot results. The temporary sample was too small to give fully significant data so that this contention must be tested in future work.

The problems of making yield projections:

The product of the productive population and the yield per productive tree gives the productive potential of a forest area. It was thought that this would be a useful figure in the prediction of latex yield for management planning. In the first two blocks, a total area of approximately 240 Ha, the pilot harvest produced 725 lbs. The theoretical yield from the productive potential would be 1,339 lbs, an over estimate of some 85% of the actual figure.

This discrepancy has been accounted for by two factors:
i) the study did not account for variations in density under different forest types as it was assumed to be the same throughout, and
ii) the nature of harvesting by the chiclero is not as efficient as theory would have it, where all productive trees would be harvested. Areas with very few trees, counted in the productive potential, would not be harvested at all by the chiclero who would search for those areas with higher densities of trees. There may also be areas which he did not cover at all, regardless of densities. Mr Cowo harvested some 6% of the adult population whereas the results indicated that the productive population was around 10% of the adult population

Accounting for forest type would only partially resolve the situation. Ultimately the best way to understand potential yields is to continue harvesting all areas and keep good records of the yield from those areas. In the future a relationship may be found between this productivity and the productive potential which could then be a useful working figure. Although obsolete for yield projections, the productive potential remains a useful concept for monitoring population health and for comparison of different areas.

Management of personnel:

The pilot harvest was a great success in terms of the relationship between PFB and the chiclero, a matter which will be important if the harvest is to work as PFB would like.

Mr Cowo covered some 20 hectares per week on average, a figure which will be useful in the deployment of personnel in harvesting the annual working areas. To cover 2,166 Ha at the same area rate will be take 109 chiclero weeks of work. This is 4 chicleros for a whole season or 25 for 5 weeks.

Financial turnover:

Despite the difficulties of yield projections, some attempt was made to estimate financial turnovers of the operation. It is considered that this will be in the range US$8,902 to US$ 19,623 per year. The wide extreme presented is due to the difficulty of yield projection as outlined above.

Recommendations:

1) The area rotation system remains the most suitable working method of chicle harvesting.

2). As the financial forecasts show, the operation is bound to be economically marginal, especially in the early years and this must be reflected in the level of investment made in the future. It should be a low-input operation.

3) *a priori* inventory, using the productive potential, is not a suitable method for the evaluation of the chicle harvesting operation. The 'suck and see' approach where pilot harvests are used to establish the productivity of forest areas is the most prudent.

4) With harvesting underway PFB can slowly build a detailed knowledge base on each working area which will refine management planning in the future.

5) Although the population is in good health it is my opinion that some form of rest would improve the chicle productivity of the RBCMA. This 'rest' is already proposed in that PFB will only harvest trees over 30 cm dbh. This will increase the productive population and reduce the level of damage therein making the population more productive.

6). The application of this and other regulations requires a good working relationship with the chicleros which should not be underestimated by PFB.

7). Formal research should be performed, with external funding, on aspects such as optimum rest periods, optimum tree size for harvesting, regeneration of trees following harvesting and the period during the season when yields are maximal.

SECTION A

INTRODUCTION

1. INTRODUCTION

1.1. Chicle as part of the management of Rio Bravo.

Chicle, the latex of the sapodilla, *Manilkara zapota*, forms an important part of the proposed management plan at the Rio Bravo Conservation and Management area (RBCMA). Harvesting latex to supply the chewing gum industry is thought to be a benign form of income generation which can be achieved with the minimum of impact on the ecology of the area. In this way it is consistent with the philosophy of integrated conservation and development which is proposed by Programme for Belize (PFB) for the RBCMA.

Harvesting in Rio Bravo can only proceed on the basis of a well informed, well designed and well monitored management system. The management of sapodilla for the production of chicle has been fully reviewed for PFB by Oliver (1992). This showed that the scientific information available for use in the development of a 'wise-use' management plan is limited. Ecological sustainability in chicle production cannot be assured until certain local baseline research is completed and a full monitoring procedure is in place.

1.2. The pilot chicle harvest in Rio Bravo.

With a view to developing such a management system PFB began ,in October 1993, a pilot chicle harvest in the UZ1 zone of the 110,000 acre parcel of the RBCMA close to the North Gate. The aim of this was to produce 1,200 lbs of chicle in the first season as a trial for a future production system over the whole area. Initially a series of (approximately) 1 km^2 working blocks were established as the basic compartments for harvesting (fig 1.1). The pilot harvest was completed by January 31st 1994.

Primarily a feasibility study, the pilot harvest also provided PFB with the opportunity to experience the logistical aspects of chicle production. More importantly it was a good opportunity to produce some of the required information on the sapodilla resource and to relate this directly to the production of chicle from a specific area. This would then be used in the development of a 'wise-use' management system.

Whilst the pilot study was underway, therefore, a consultancy visit was made to undertake baseline research on the pilot harvest area, with the dual aims of producing resource data and establishing a system of monitoring to evaluate the long term effects of harvesting on that resource.

The monitoring work is dealt with in detail in an accompanying report. This report will concentrate solely on the presentation of resource information for PFB and the use of this in the development of a suitable management system.

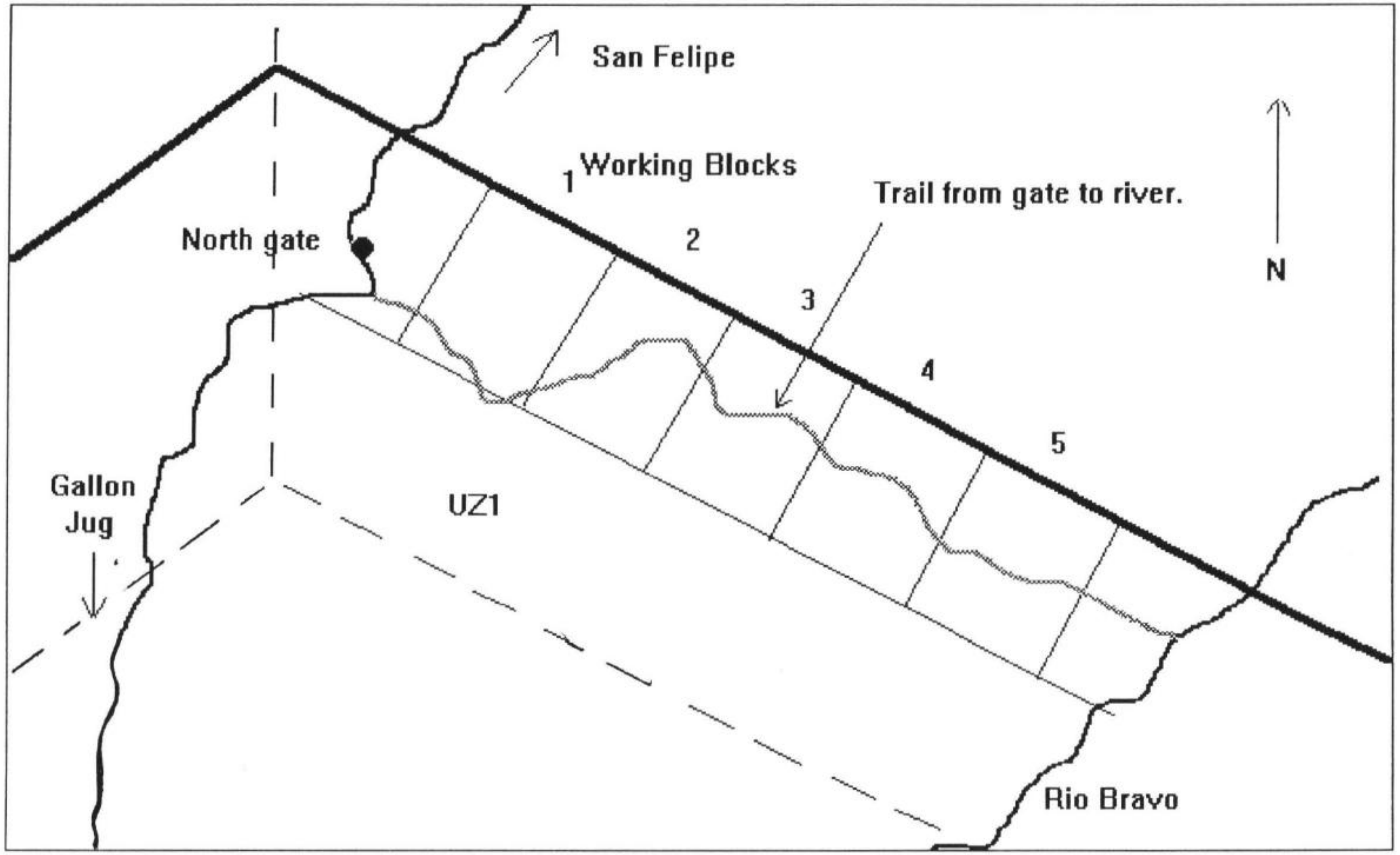


Figure 1.1. The northern part of the 110,000 acre parcel showing part of the UZ1 NTFP zone and the 1 km^2 working blocks.

1.3. The pilot study as a resource assessment.

The first objective of the pilot study was to enable Programme for Belize (PFB) to assess the feasibility of chicle harvesting in the RBCMA: will production be adequate to make it worthwhile and is the operation workable? Should it be considered feasible, information would then be needed to plan the harvesting operation.

The central element of these objectives is yield forecasting: knowing the quantity of chicle which can be produced from all parts of the RBCMA. The harvest itself would obviously produce data on yields from a given area of forest but it was essential that this was applied to detailed knowledge of the resource itself. Only in this way could the pilot study be applied to yield forecasting in other areas.

The central concept of the work was the 'productive potential' of the area. Any area of forest contains a certain number of productive trees: the productive population. Knowing this, the average yield per tree of the productive population can be used to predict the yield from a given area. Once the productive potential is known the actual yield produced during the pilot study could be compared to it to assess the usefulness of the figure in yield projection. Also, by sampling the population beyond the pilot study area, the representativeness of the pilot study could be assessed.

There were also certain other important aspects of the resource assessment. Having been harvested for nearly 100 years, it was important that the quality or health of the population was assessed to ensure that the resource would be able to stand further harvesting now. This would also throw some light on the impact of past harvesting on the resource. The same information would enable PFB to consider the likely changes in yields over time, given that their own harvesting would be less intensive than in the past.

1.4. Components of the resource assessment.

Completion of the resource assessment required the following information from the pilot study area and the temporary sample area outside:

i) population density;
ii) population structure;
iii) harvestable population;
iv) productive population; and
v) yield per productive tree.

i) Population density.

The first and most important aspect of the resource is the density of adult trees on the ground. Knowledge of this is important because it provides a basis for comparison of resource availability in different areas. It is also an important aspect of population health which can be used to assess the status of this population when compared to densities found in previous studies.

It has been reported that this forest type generally has an average sapodilla population density of around 30 trees per hectare. Lundell (1930) reports a density range of 24-29 per hectare. Conservation International in Peten report density ranges of 30-40 per hectare (CI 1991). Previous studies in the Rio Bravo area have suggested a density of 32 trees per hectare.

ii) Population structure.

Another important aspect of population health is the demography. This is the number of individual trees in each size class. In a dominant shade bearing tree in its native habitat one would expect a population consisting of a number of small individuals and only few large ones with an intergrade of the size classes in between. Such a population produces a characteristic 'reverse j' histogram when numbers in each size class are plotted. Conservation International found the population in the Maya Biosphere reserve to be consistent with this structure, (Reining and Heinzman 1991). Figure 1.2 shows the typical populaiton structure which would be expected for this type of species.

iii). The harvestable population.

Regulations in Belize, and indeed throughout the chicle producing region, state that only trees of greater than 30 cm diameter at breast height (dbh) may be tapped for chicle. In this pilot study PFB have adhered rigidly to this stipulation as a means of safe-guarding the health of the sapodilla population. This will continue if full scale harvesting is to take place.

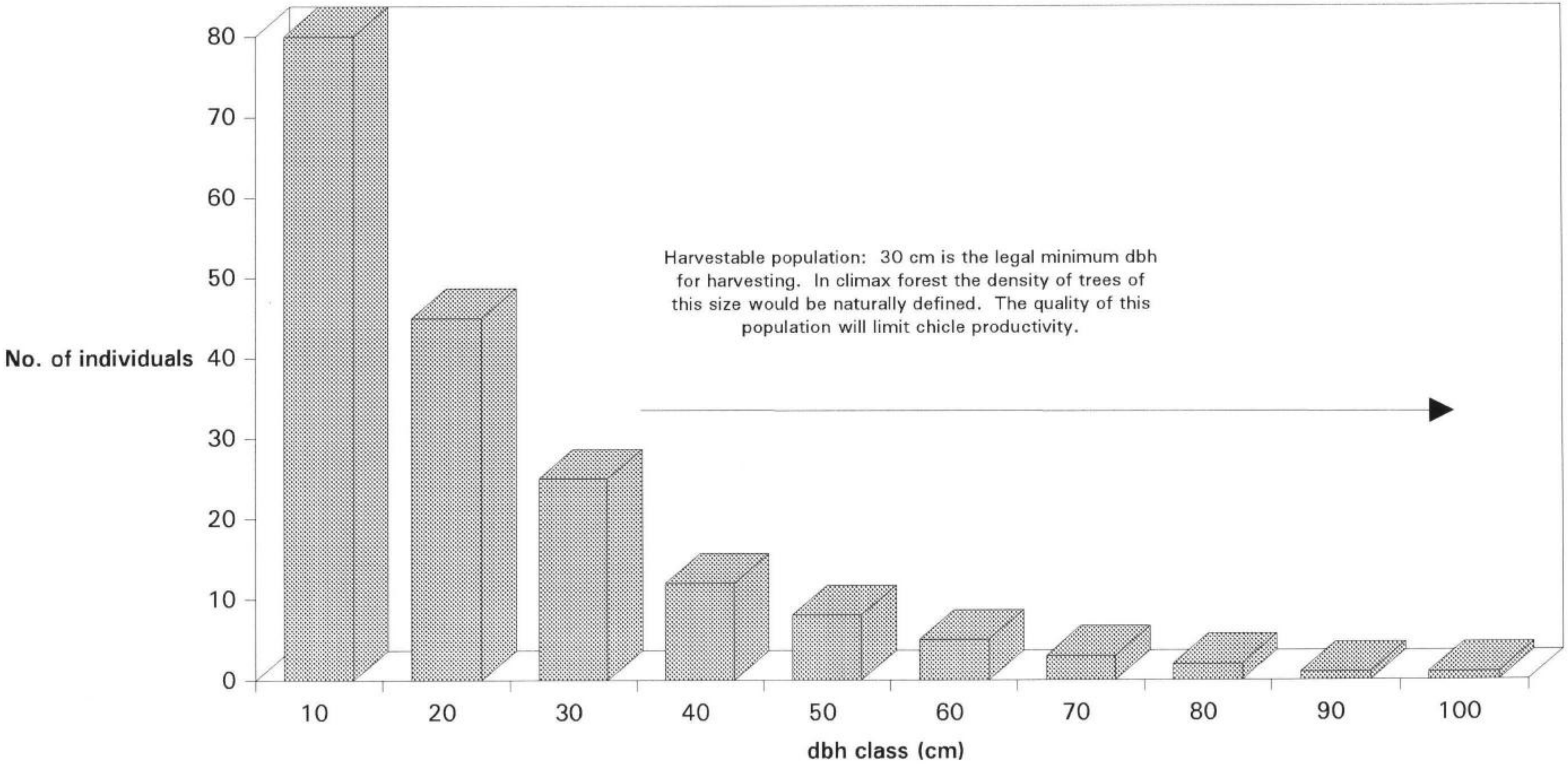
This means that only a certain proportion of the population is, OR WILL EVER BE, available to produce chicle: that over 30 cm dbh. Here this is termed the 'harvestable population' as it represents the absolute maximum number of trees which are available to produce chicle.

The harvestable population is set by the natural limits of this forest type. For management this should be considered a fixed proportion of the population which will not increase (figure 1.2.). It will only decrease if a negative impact results from harvesting or some other environmental catastrophe. This provides the upper limit to chicle productivity.

iv). Productive population.

As stated in the review of chicle harvesting by Oliver (1992), at any time only certain trees within the population are productive. This is partly genetic, as some trees are

Figure1.2 : diagramatic representation of a healthy population of M. zapota trees in native climax forest showing the harvestable population.



more apt to produce chicle than others, and partly a result of the treatment of the trees in the past.

A tree may not be productive at present if:

a) it is not naturally an abundant producer of latex,
b) the natural form of the tree is poor (e.g. the trunk is curved so that latex would not run straight),
c) it was recently harvested,
d) it has been harvested so many times before that no more latex is available,
e) damage from previous treatment is such that the productive surface of the trunk is inadequate to achieve any yield.

Whilst the harvestable population is set by the natural limits of this forest type, the productive population is more dependent on management factors. This is the aspect of the population in which management can most clearly influence the yield from a given area of forest and partly why adequate recovery periods result in sustained or increased yields . It is a key aspect of yield sustainability.

In 1930 Lundell reported a productive population of 5 trees per hectare for Honey Camp estate, NE Belize.

v) Yield per productive tree.

Yield is notoriously difficult to study in laticiferous species. Yield of latex varies between trees, season, time of day, weather conditions and even the chiclero. It must be assessed over a very long period to achieve a meaningful working statistic.

Being so widely spaced within the forest area it is impractical to undertake any yield evaluation system based on the weight taken at each individual tree. Also the weight of chicle before boiling is meaningless in resource management terms as it depends on the amount of water in the latex which may vary with such factors as rainfall at the time of harvesting.

In this study the processed weight of chicle was used as the basis for yield assessment and this was given an average per tree by keeping account of the number of trees tapped to produce that amount. Whilst the processed weight may have some variation in water content it is the most meaningful figure in terms of yield especially as it is on this basis that it is actually sold.

By continuing the assessment of yield over a long period it is expected that a reasonably consistent working figure for the yield per tree could be produced.

Ultimately development of the management system depends on continued evaluation of the resource as harvesting takes place. This resource assessment was just the first stage in this process and it should be remembered throughout that it does not in any way represent a reliable *a priori* inventory for chicle harvesting.

2. AIMS AND OBJECTIVES OF THE TWO MONTH PILOT STUDY.

The aim of the two month study was to assess the resource management aspects of the pilot chicle harvest with a view to developing a long term, sustained yield management system for chicle harvesting throughout the 'UZ1' management zone of the Rio Bravo area. Within this there were four central areas:

i). To assess the sapodilla population within the study area to ensure that it attains the level and quality which would be expected. This required analysis of:

a) population density;
b) population structure;
c) the harvestable population; and
d) the productive population;

ii). To evaluate chicle yields and the factors which combine to produce certain yields from certain areas. The aims were to quantify:

a) the yields per productive tree; and
b) the yield from a given area of forest.

iii). to assess the applicability of this information within the development of a management plan for chicle throughout the Rio Bravo UZ1 management zone. This required:

a) relating projected figures from 1 and 2 above to the actual production from the pilot study.
b) analysis of populations beyond the pilot study area,

iv). To institute a system to monitor the sapodilla population following this harvest in order to assess the sustainability of chicle harvesting. This required:

a) establishing permanent experimental plots to continuously monitor the sapodilla population;
b) establishing a system to monitor the yield per productive tree.

As the objectives show, the two month study had both short term and long term aims: to assess the resource now and to set up a monitoring system for the future. The methodology adopted thus reflects this dual purpose. Because the area of the pilot study was relatively small and time relatively short, the assessments made on population and yield were taken from the baseline data established in the permanent experimental procedure.

In the report that follows only the collection of baseline management data is discussed directly. The permanent sample procedure is dealt with in detail in an accompanying report.

SECTION B

METHODOLOGY

3. METHODOLOGY

In line with the stated objectives there were three distinct experimental areas for the short term work:

1. Population assessment,
2. Yield evaluation,
3. Applicability of the pilot data.

3.1. Population assessment.

Analysis of the sapodilla population was made on a series of 0.25 Ha square plots as shown in figure 3.1. These were established in pairs for the split-plot design of the permanent monitoring system. One of the pair in each case was assigned as the control plot in which no harvesting took place. Around the control plot a 25m wide buffer area was set up in which no harvesting took place and also no measurement. The idea of this was to buffer the control plot from any extraneous influence of the harvest in the surrounding area. This was known as the control frame.

As figure 3.1. shows, the 0.25 Ha plot in both harvest and control plots was divided into 4 (25m x 25m) quadrats. This enabled statistical comparison with the temporary sample data discussed below (section 3.3) and will provide the same compatibility with any future studies using variable plot shapes based on $(25m)^2$ quadrats. The plot pairs were randomly located throughout the first two working blocks. Their exact location is shown in figure 3.2.

Within the plots collection of data was based on the data sheet shown in appendix A. Only certain of these parameters applied to the population assessment as follows:

i) Population density.

Population density was assessed per quadrat. Numbers of individuals above 10 cm dbh were counted in each quadrat. In the final analysis the mean and reliable minimum densities were established per quadrat and then multiplied by 16 to give a density per hectare.

ii) Population structure.

Analysis of population structure requires assessing the number of individuals representing each size class within the population. Each adult tree encountered was measured for diameter at breast height (dbh). Individuals were then assigned to 10 cm size classes which ran 10-19 cm, 20-29 cm, 30-39 cm and so on up to >100 cm.

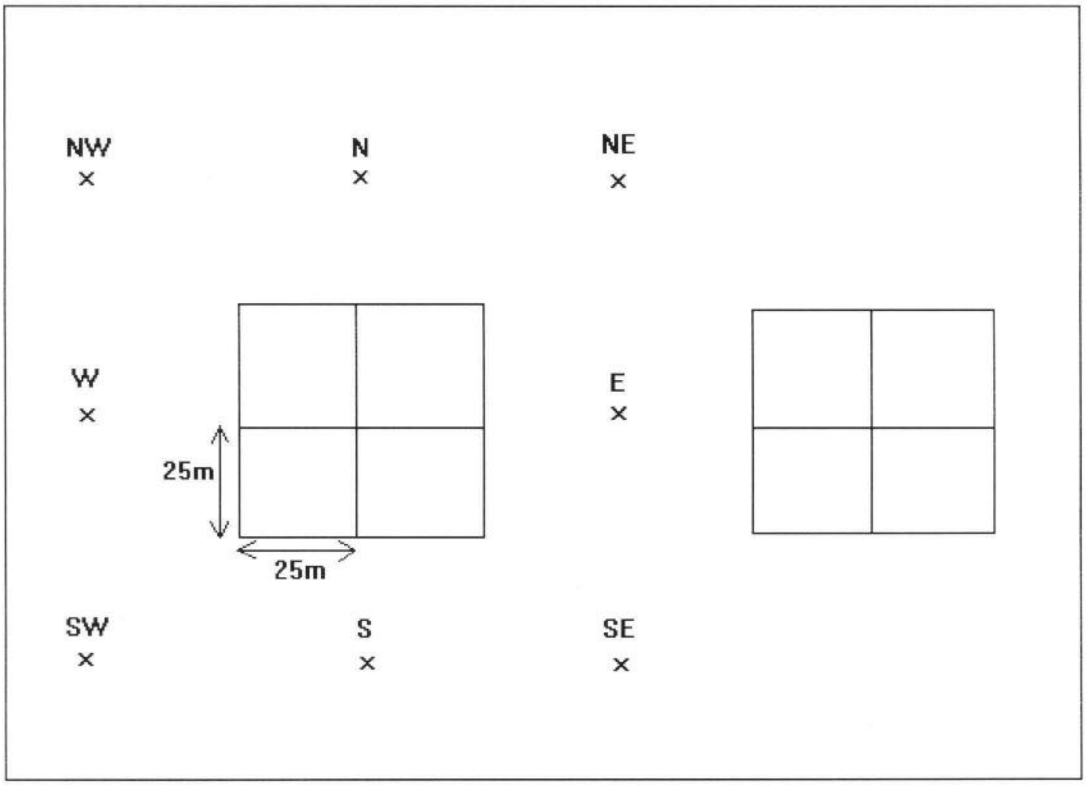


Figure 3.1.a) design of paired experimental plots made up of 4 quadrats of 25m x 25m

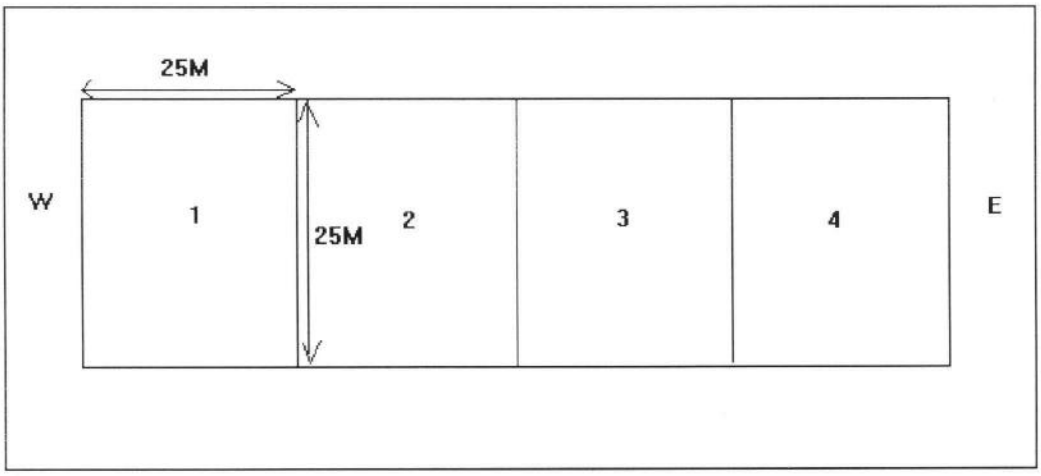


Figure 3.1. b). Design of temporary sample plots with compatible 25m x 25m quadrats.

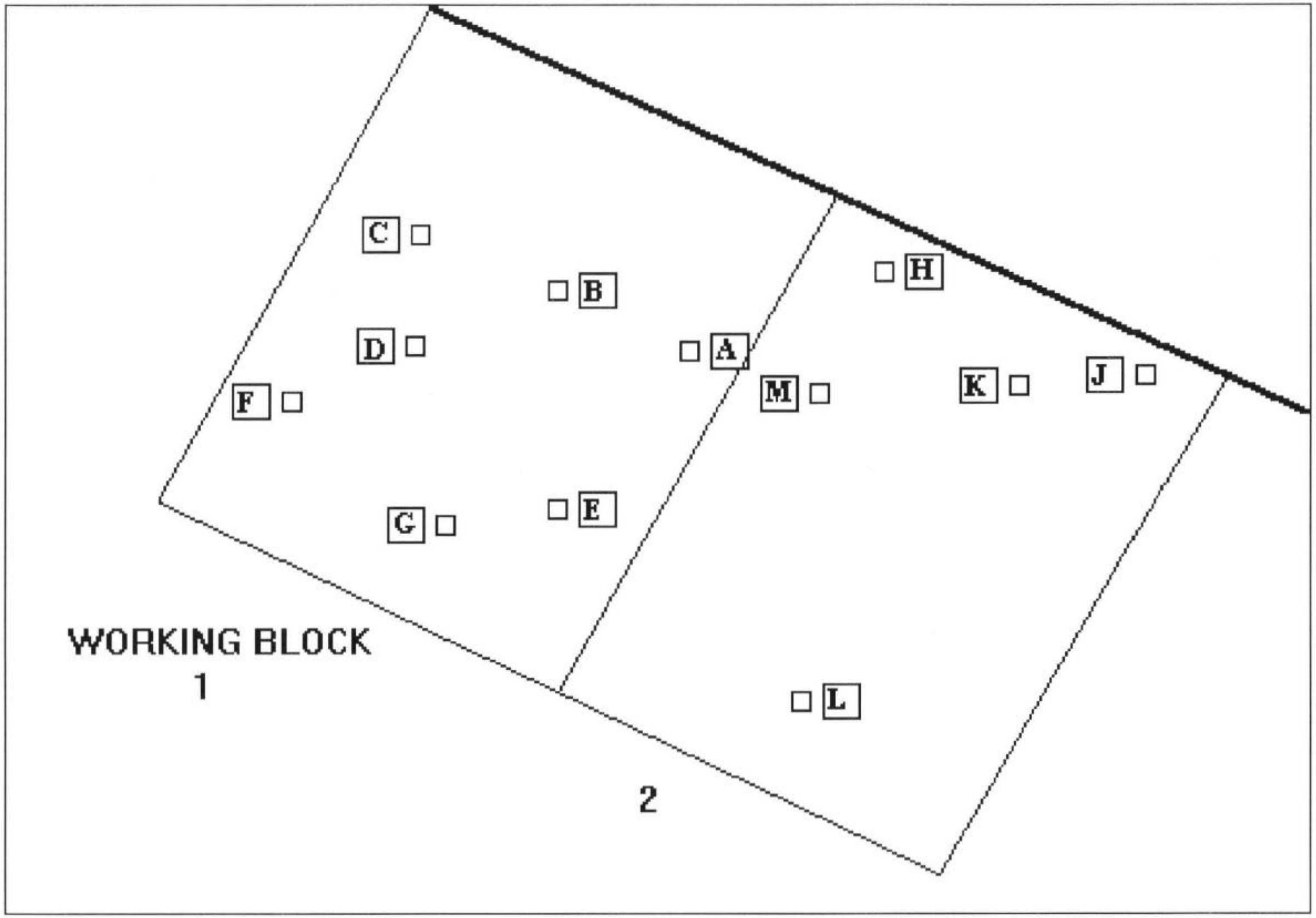


Figure 3.2. Working blocks 1 and 2 showing the position of the experimental plot pairs. The control plot has the larger area of the pair.

iii) Harvestable population.

Assessing harvestable population is simply a combination of the previous two sections. The density of trees over 30 cm diameter was established for each quadrat. The mean and reliable minimum figures from all quadrats assessed was then multiplied by 16 to give a harvestable population density per hectare.

iv) Productive population.

For each individual within the harvestable population an assessment was made of its productivity. Productivity is a subjective assessment as it is to a great extent a value judgement by the chiclero. The method of assessing this was, as far as possible, the same as that used by chicleros.

First examination was made of the trunk. If the stem was badly curved (such that latex would not run down the tree) or too short (less than 5m tapping height) it was said to be unproductive. If the bark had a medium (10-30% of surface) or high (>30% of surface) level of damage then it was also considered unproductive. If both stem and bark were adequate a test cut was made into the bark to examine the latex content of the bark. If the latex was sufficient to well up and drip from the cut it was considered productive, otherwise it was not.

Assessment of the productive population was made with the help of a chiclero's son who has had some direct experience of selecting and harvesting chicle form this forest type. This helped to make the assessment here consistent with that used by chicleros.

3.2. Yield evaluation.

Yield evaluation was a fairly simple procedure but will require long term usage to produce a figure of the necessary accuracy.

On each Sunday the chicle harvested during the week was processed by simply boiling off the excess water of the sample. This is a habitual procedure for chicleros during the harvesting season. The weight of processed chicle blocks was then taken on the following day when they had cooled down and the residual moisture content had evened out. Measurement was made with a simple hand-held scale.

During the harvesting week the chiclero was asked to keep a tally of the trees which he harvested. This could then be linked to the total processed yield for the week to produce a mean dry weight per PRODUCTIVE tree.

3.3. Assessing the applicability of the pilot data.

a) Comparing projected and real yields.

Having performed the resource assessment within the pilot study area reliable minimum estimates were then available for productive population density and the yield per productive tree enabling an estimate to be made of the potential yield of the productive population. This is the productive potential. This was then compared to the results of yield in the pilot study where defined areas of approximately 120 hectares were being used.

b) Comparing the resource in the pilot study to that outside.

The results of the pilot study are worthless if no comparison is made between the area subjected to the pilot study and some sample of the rest of the area which will be used for chicle harvesting.

To this end some temporary sampling was made of the forest area between the two working blocks in the pilot study and the Rio Bravo to the south east. The exact location of the temporary plots is shown in figure 3.3a. These were located on a systematic basis although, as no prior knowledge of the area was available, this can be considered to approximate a random sample and thus be comparable to the pilot study data.

The plots themselves were 25m x 100m transects divided, again, into 25m quadrats for comparison with the pilot data. The transects were consistently oriented east-west as shown in figure 3.1b. The data collected was identical to that in the pilot and monitoring data (appendix A).

As an addendum to the population health data of the pilot study the temporary samples were also assessed for their sapling populations. This was simply to provide PFB with some knowledge of the juvenile pool of the population and thus the future recruitment to the adult population.

3.4. Statistical aspects of the study.

The design of the study made the evaluation of population in the study area statistically accountable. As presented the permanent experimental plots were established on a stratified random sample, the strata being the working blocks cut for chicle harvesting. Temporary samples were performed systematically in order to cover the whole area concerned. It is considered that these were sufficiently approximate to the random to make the normal analyses appropriate and the data compatible to those of the experimental plots. Population data was assumed to approximate the noraml distribution.

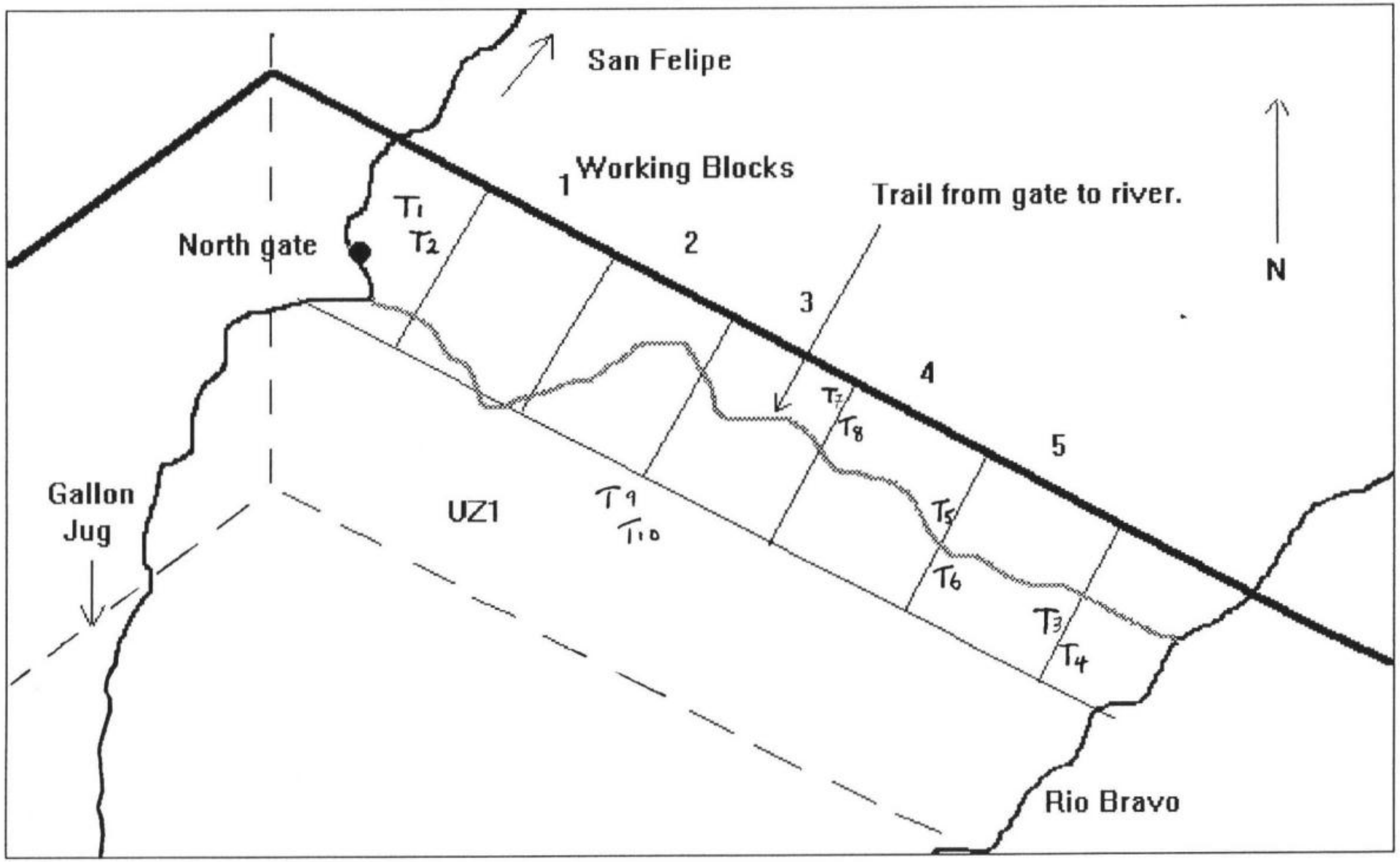


Figure 3.3. Positions of temporary plots in relation to the experimental plots and all working blocks.

The study was intended to produce density data with 95% confidence of being within the stated standard error range. The sample size of the study was limited by time which in turn limited the statistical precision of the work. Rather than defining a required precision for the work (i.e. a target standard error range) and then performing the necessary number of samples, the number of samples allowed by time was achieved and the results presented with the relevant precision in each case. In the long term, the work can be targeted to achieve further precision if required. It should be remembered that this is a pilot study.

It is intended that the data be used in the form of 'reliable minimum estimates' (RME). The RME of a statistic is the figure at the lower end of the confidence range for the sample mean. It therefore gives the minimum expected value of, for example, population density and therefore a prudent estimate of the population of an area.

SECTION C

RESULTS AND DISCUSSION.

4. STUDIES ON SAPODILLA POPULATION CHARACTERISTICS IN THE PILOT AREA.

4.1. The population of the pilot study area.

Table 4.1 presents all the relevant population data produced from the plots within the study area. **It is imperative that this data is viewed in the light of the discussion which follows and not used in this raw form.** It should also be remembered that the study, because of its scale, does not represent a full and reliable inventory of chicle production from the Rio Bravo area. The aim of the work was to assess the pilot study and its applicability in yield projection over a wider area in Rio Bravo.

Results are presented with the respective 'Reliable Minimum Estimate' (RME) of each value. Ths is the mean minus the confidence interval of this study. The RME is the figure at the lower end of this confidence range and it is this which should be used as a conservative estimate of the relevant figures so that over estimates of yield potential are avoided. This means that 95 time out of 100 the mean of a sample taken in this area will have a population of greater than 29.5 per Ha in which there will be 11.9 trees per Ha of greater than 30 cm dbh and 4.4 productive trees.

Table 4.1. Details of the sapodilla population in the pilot chicle harvest area, (all population data in trees per hectare).

	Average	Reliable Minimum Estimate (95% conf.)	Precision
Density	32.3	25.7	+/- 10.4%
Harvestable popn. (trees > 30 cm dbh)	13.5	9.4	+/- 15.2%
Productive popn.	5.3	3.5	+/- 16.7%

4.2. Adult population density.

The first indicator of the potential level of chicle productivity from the area is the adult population density of sapodilla. Table 4.1. shows that the mean density of adult sapodilla in the study area is 32.3 trees per hectare with a reliable minimum of 25.7. As will be discussed later (section 10) this is broadly comparable to other studies, both past and present, which have been completed in similar forest types. This shows, as expected, that Rio Bravo is as well stocked as other chicle producing areas. The precision of this figure is reasonably good. In most forest inventories a precision of +/- 20% is considered tolerable (Dawkins 1958).

More directly relevant to management is the proportion of that population which is available to produce chicle. This is a function of both the size of trees and their individual productivity.

4.3. The harvestable population.

This study found that the mean harvestable population in the study area was 13.5 trees per hectare with a reliable minimum of 9.4.

The harvestable population is set by the natural limits of this forest type. For management this should be considered a fixed proportion of the population which will not increase. It will only decrease if a negative impact results from harvesting or some other environmental catastrophe. This provides the upper limit to chicle productivity.

Figures for harvestable population, because the mean values are lower, comes out slightly less favourably at 15.2%. Again this is reasonable.

4.4. Productive population.

The average productive population in the study area was found to be 5.3 trees per hectare with a reliable minimum of 3.5. The precision was further lower in this sample at 16.6% however this is still reasonable.

Of the harvestable population 97% had been tapped at least once and 73% had been tapped more than three times. This indicates why the productive population is so much lower than the harvestable population. If this level of harvesting could be reduced in the lower size classes then those entering the harvestable population will be more productive thus raising the yield per hectare. This key aspect of sustainability will be discussed further later.

5. THE HEALTH OF THE POPULATION.

5.1. Population structure.

Figure 5.1. shows the number of trees in each diameter size class within the whole studied population. This demographic patter represented by the 'reverse J' is as would be expected for a shade-bearing, dominant species in its native habitat. A similar shaped curve was produced for each of the temporary and permanent samples.

This indicates that the population is generally in good health and that the consistent chicle harvesting over the last 100 years has not affected the sapodilla population structure. Having said this, the numbers in the 20-29 cm dbh class of figure 5.1. do perhaps appear to be slightly less than would be expected. It is not possible to say whether this is real or simply an aberration of this sample. Unfortunately no growth and yield data is available to link this size class with a particular time period. It is something which should be monitored in future work.

5.2. Regeneration.

The relevance of the curve in figure 5.1. is that there are abundant young trees being recruited to the adult population which indicates that harvesting has not had a major impact on the ability of the population to reproduce over the 100 year period of harvesting. This fact is supported by regeneration studies which were performed in the temporary samples. Figure 5.2. shows the same curve for the temporary samples only. This shows that the sapling population in these plots was abundant and observation suggested that there were abundant saplings and seedlings throughout the study area.

FIGURE 5.1.: The adult population structure of sapodilla in the pilot harvest area, (for trees over 10cm dbh).

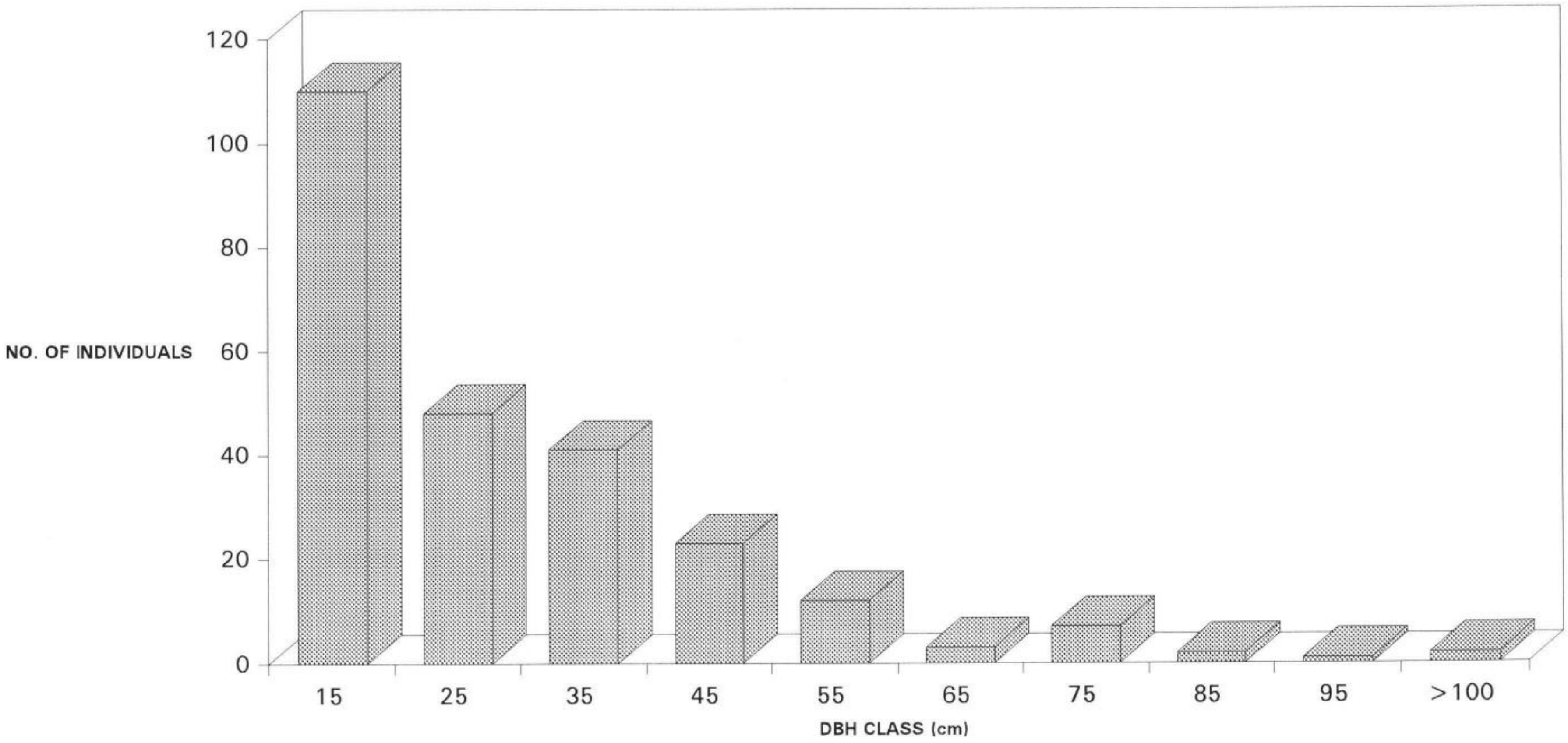
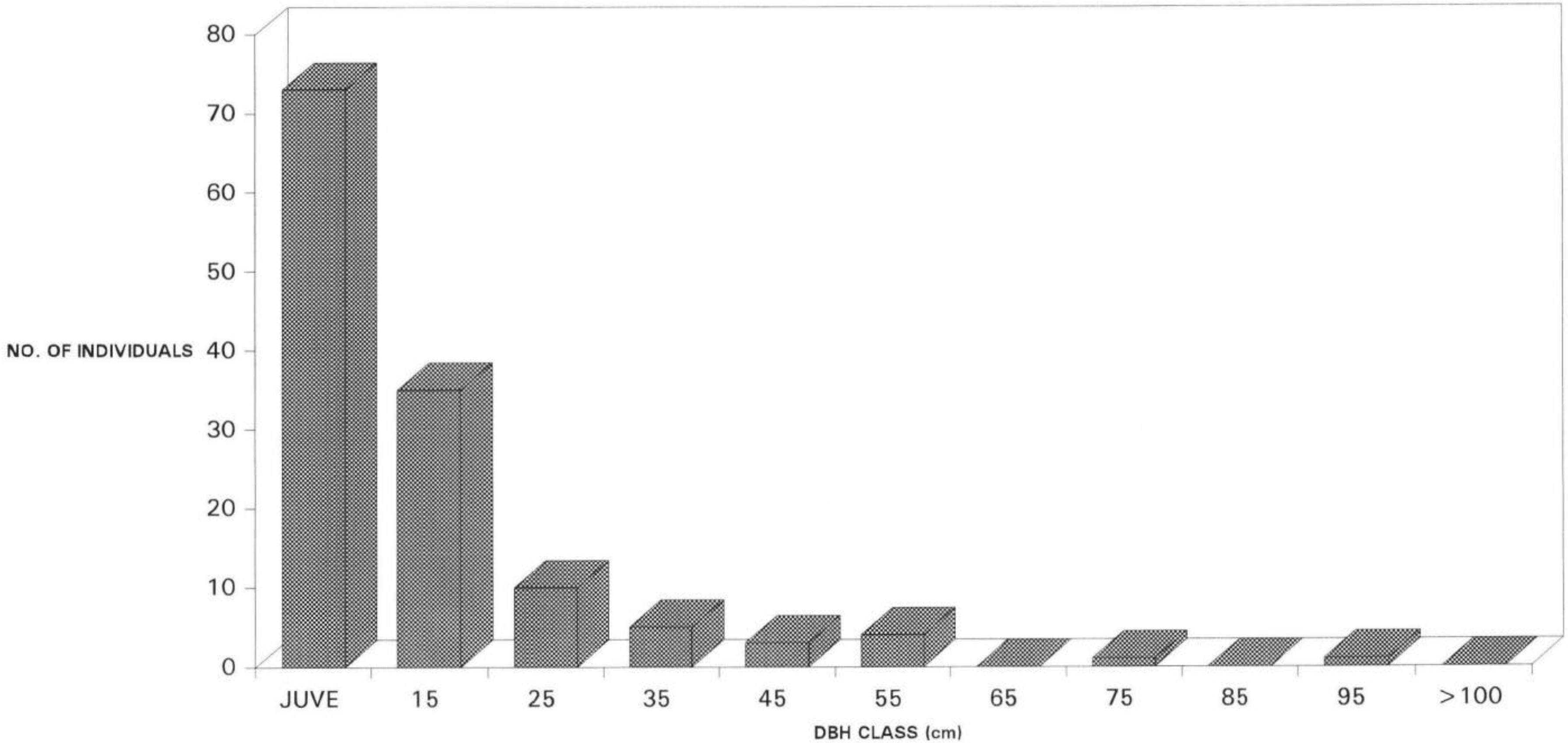


FIGURE 5.2: Population structure of the temporary samples in which limited regeneration studies were also undertaken.



6. YIELDS PER PRODUCTIVE TREE.

6.1. Yields from individual trees.

Table 6.1. shows the characteristics of the chicle harvest over the 15 weeks of the work. The consultancy visit ended at the end of week 6 of the harvest.

Table 6.1. details on the yield of chicle produced during the pilot chicle harvest.

	Week	Processed weight (lbs)	Trees harvested	Dry weight per productive tree. (lbs
Working Block 1.	1	62	42	1.48
	2	86	59	1.46
	3	83	59	1.41
	4 and 5	115	82	1.40
Working block 2.	6	84	55	1.53
	7 and 8	189	104	1.82
	9	106	50	2.12
Working block 3.	10 and 11	124	73	1.7
	12	107	51	2.1
	13	103	51	2.03
	14	101	37	2.73
	15	103	73	1.41
Totals		**1263.5**	**736**	**1.72**

Table 6.1. shows that the total yield of the harvest was 1,263 lbs meaning that the target production for the trial, 1200 lbs, was met by February 4th. The mean dry yield per productive tree was 1.72 lbs with a range of 1.3 lbs from highest to lowest.

Although at this stage this represents a small sample it is producing a fairly consistent yield per productive tree. The data thus far is adequate enough to produce a RME of 1.56 lbs per tree at 95% confidence. The variance, however, was much less in the first 5 weeks of measurement, during the consultancy visit, than subsequently. Figure 6.1. shows how the variance of the data increases after the visit. It is possible that some change occurred, either in the measurement of the chicle or the harvesting process. Alternatively it may just be a chance event. The results must be taken as they are, however it is worth noting the variation for future reference and comparison with later data.

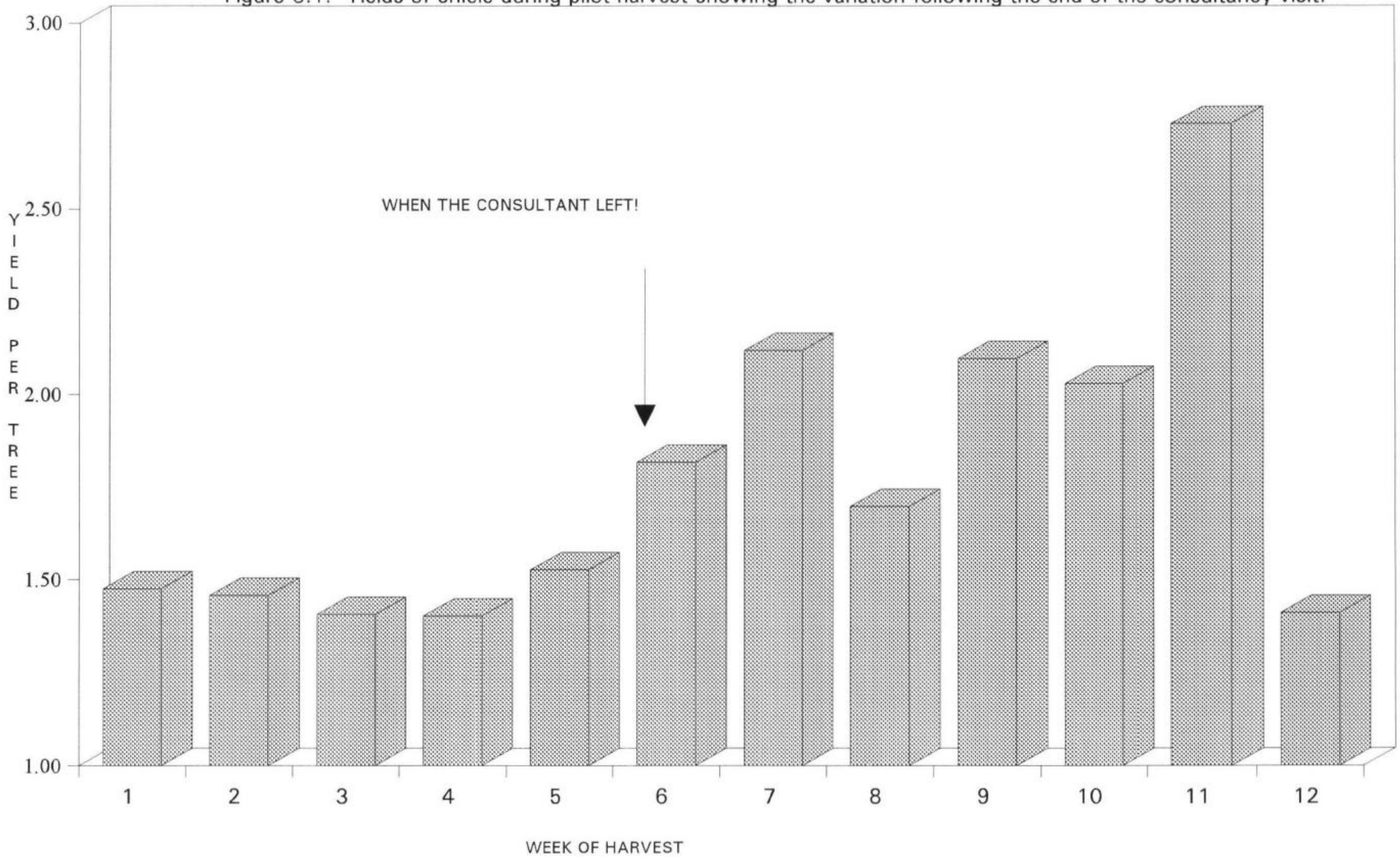
The variability of chicle yield is such that this must be monitored over a long period before PFB can make confident use of the data

Yields vary with:

a) individual trees,
b) time of day,
c) time of year,
d) weather conditions, and
e) chiclero

In this study all of these have been more-or-less constant and until the same statistic is tested under variations in these conditions, such figures for yield per tree should not be widely applied.

Figure 6.1. Yields of chicle during pilot harvest showing the variation following the end of the consultancy visit.



7. THE USE OF THESE DATA IN YIELD PROJECTIONS.

The underlying assumption of this work is that resources measured on the ground can be used directly to produce yield projections for certain forest areas. The pilot study which has combined chicle production with resource assessments enables us to assess the validity of the data for use in management. The following sections show that the link is not entirely straightforward.

7.1. Yields from large areas of forest.

An examination of real and projected yields from forest areas shows the difficulties of making any good management projections based on population density and yield per tree - the productive potential - as was assumed in the development of this work.

In this pilot study Mr Cowo produced 725 lbs of dry chicle from the first two working blocks. These blocks cover an area of approximately 240 hectares. Table 7.1. compares the actual production rates for the sapodilla population with that projected by the studies carried out on the same area. Block 3 has not been included because it is not certain that the block area was exhausted.

Table 7.1. Actual production rates from working blocks 1 and 2 (240 Ha) compared to those projected from productive potential, (data for projections uses RME from pilot sample in each case).

	Actual	Projected
Productive population (trees per hectare)	2.0	3.58
Yield per unit area (lbs per hectare)	3.02	5.58
Total Yield in 240 Ha (lbs)	725	1,339

This highlights the inadequacy of yield projection in the management of chicle. For this block the overall yield would have been overestimated by 614 lbs which would be a costly error, especially if repeated over larger areas. It is worth noting that the yield from block 3 was considerably higher than the previous two: at completion 538 lbs had been removed from some 120 Ha. This is still, however, 131 lbs less than the projected reliable minimum estimate of 669 lbs per block.

The problem here is twofold:

a) In the bottom half of the first block is a significant area of bajo and transitional forest. The inventory data such as it is most relevant to upland forest type as this is the most abundantly measured type in the sample. As both bajo and transitional have lower harvestable populations of sapodilla (see table 8.2.) projections made using this inventory data are too high in this case. This could be corrected to some extent if a detailed knowledge of the areas of different forest types on the ground and their harvestable populations was known. Some data on this is presented in section 8.

b) Correction would not be complete however as part of the problem lies in the behaviour of the chiclero. An inventory, having selected a particular site for sampling, will then measure the population on the ground and include the data even if there is only one tree. If this tree is productive this is another which is included in the productive population.

A chiclero on the other hand, seeing only one tree in an area, will not bother to enter into it. It isn't worth his effort to search for the one or two productive trees which might be there. He is better off going into another area where the trees are more abundant. His harvesting is therefore not as efficient as the inventory would like him to be so the yield in reality is lower than projected by the inventory.

This behaviour is akin to 'optimal foraging' theory in wild animals and is the focus of some study with chicle harvesting in Peten. The results of this may shed some light on this problem to PFB. In the mean time it is difficult to suggest any resolution. Perhaps in temporary sampling a threshold of trees in the plot must exist for the data to be counted in the analysis. If the plot does not reach this threshold population then it is given a value of zero in the evaluation. This would take time to develop accurately and may still not produce reliable data.

In the case of Mr Cowo it is probable that his harvest was less efficient as well because he knew that there were other working blocks available exclusively to him which would be resource abundant. In fact there was no limit to the area of land which he could harvest so he was bound to be less efficient at exploiting what was there. Mr Cowo harvested only 6 % of the population compared to the assessed productive population of 11%.

The answer lies in developing an entirely different approach to management which will be discussed later (section 9.2).

7.2. The applicability of population data over a wider area.

Section 7.1. shows the inadequacy of population data for making yield projections. Although this method has proven difficult to apply it is still possible that the pilot study results themselves could be used as a more appropriate yield predictor. The question then is...

'How representative is the pilot study of the productivity of Rio Bravo as a whole?'

This was the aim in performing temporary samples outside of the pilot study area. The results of this work are shown in table 7.2. It suggests that the sapodilla population in the pilot study area was more abundant than other parts of the same working area. These differences are all statistically significant: due to something other than chance. There is no difference between the sample strategy which could have induced this difference: the quadrat size, shape and orientation were consistent.

Table 7.2. Variation in sapodilla populations between the permanent and temporary samples in this study.

	Permanent	Temporary
No of quadrats	96	40
Mean density	32.3	23.6
Mean harvestable population.	13.5	6.0
Mean productive population.	5.3	1.2

The results in table 7.1. indicate that the pilot study is taking place in an area with a particularly abundant sapodilla population. Further afield in the first chicle working area the population appears to be less abundant. It implies that if the yield data from the pilot study were to be applied over the rest of the Rio Bravo it would over estimate the potential chicle productivity.

The implication of this result is very important. Not only the population data produced from the pilot study but also the chicle yields produced from the area must be applied with great care in the formulation of a management plan for chicle. It appears from this that the pilot study will show characteristics of the most productive forest area and that other areas may not produce as much chicle. It is presently too early to say this with full confidence as the temporary sample is relatively small. FURTHER TEMPORARY SAMPLES ARE NEEDED TO PRODUCE RELIABLE FIGURES FOR SAPODILLA POPULATION CHARACTERISTICS AND THUS YIELD POTENTIAL OVER THE WHOLE OF THIS AND OTHER WORKING AREAS.

8. VARIATION WITH FOREST TYPE.

The discrepancy between potential and actual yield in the pilot sample was blamed partly on the fact that the forest type in part of block 1 was different and probably less well endowed with sapodilla. For this reason it is important, in the long term, that management information provides details on resource abundance within the various forest types of Rio Bravo. This can then be used in conjunction with the vegetation maps produced by Brokaw and Mallory (1993) to provide more informed management projections. It must be stated that this will only go part way: the location of forest types from vegetation maps will never provide a good basis for yield projections from specific areas, even if detailed data was available for each. It will only allow better informed decision making.

Although this was not a central objective, two forest types were encountered during the study: upland and upland/bajo transitional. Table 8.1. compares population details in the two using mean figures.

Table 8.1. A comparison of the sapodilla population in two forest types in Rio Bravo, (all data in trees per hectare).

	Upland	Transitional
No. of quadrats	108	28
Mean density	32.0	21.0
Mean harvestable population	12.6	6.2
Mean no. of productive trees.	4.6	2.2

At this stage it is too early to highlight this as a statistically significant difference between the two forest types as the number of quadrats for the transitional forest type was very low. As Brokaw and Mallory (1993) point out the definition of transitional forest anyway is highly nebulous and its qualities will vary depending on a site's position in relation to pure 'bajo' or pure 'upland' forest. This makes it very hard to determine the nature of the sapodilla population in any area defined as 'transitional'. Transitional is the most abundant forest type in the UZ1 zone.

Having said this, observation suggested that where the forest took on more bajo character the stocking of sapodilla, particularly the harvestable population, was somewhat lower.

Other information sources can be used to make provisional statements on the variation of the sapodilla population with forest type. Table 8.2. shows the potential of each forest type as chicle producer communities. This is produced from both observations on the ground and general literature and is not here isolated to particular sources. No distinction was made between dry upland and mesic upland in this pilot study.

Table 8.2. Variation in sapodilla populations in the various forest types in Rio Bravo.

	Stocking	Chicle production potential
Upland	High	Good
Transitional (Up/Bajo)	Low-good	Poor-good
Bajo	Moderate-good	Poor
Cohune Ridge	Absent	None
Cohune Riparian	Absent	None

This shows that the ideal forest type for chicle production is the upland forest type. As mentioned transitional appears to be variable depending on the specific area. Whilst bajo tends to be well stocked with sapodilla the size is such that it is not a forest type which should be considered within the harvestable population. It is generally accepted, (e.g. Lamb 1967, and Brokaw and Mallory 1993) that cohune ridge and cohune riparian in their pure form are devoid of sapodilla.

Within the proposed UZ1 zone the two most abundant forest types are the upland and transitional types. On the other hand the area of the pilot study is principally upland forest type. As already discussed the fact that transitional appears to have a lower resource abundance than upland suggests that the results of the pilot should be applied with care to other blocks where transitional forest makes up a significant proportion.

SECTION D.

IMPLICATIONS OF THE RESULTS FOR MANAGEMENT

9. DEVELOPING SATISFACTORY YIELD PROJECTIONS.

It was stated in the introduction that one of the most important aspects of the pilot harvest and associated resource assessment was to equip PFB with the information to undertake yield projections for the UZ1 zone. One of the most important considerations in the analysis of the work, therefore, is how the study may be used for this purpose. It is clear from the discussion so far that this is far from simple.

9.1. Difficulties of using the pilot study for yield projection.

It was assumed on commencing this work that knowing the productive potential of an area (productive population density x latex yield per productive tree), a reasonable approximation of the actual yield could be made. On the contrary the pilot study has shown that the potential yield is unlikely to be fulfilled by actual harvesting and that in this case there would have been an over-estimate of some 85%. As discussed this can be overcome to some extent by a detailed analysis of the resource abundance in the various forest types of the area however this can only be part of the solution as much depends on the behaviour of the chiclero.

An alternative would be to apply the yields of the pilot harvest itself, which took place in a defined area and accounts chiclero behaviour, to the whole of the NTFP zone of Rio Bravo. The temporary sampling, however, indicates that, because the pilot harvest seems to have taken place in a particularly abundant area of sapodilla, this method too may make an over-estimate of the total resource abundance.

9.2. Working towards satisfactory yield projection.

It is apparent from this work that the use of productive potential, even allowing for forest type variation, will never be a reliable method for yield projection.

Ultimately data from actual harvests will be the only satisfactory method. If this requires that the first few harvests from Rio Bravo are performed with some risk then this may have to be. In time, management experience will increase and with constant monitoring of production from defined areas, more refined estimates can be made.

Before writing off this harvest as too risky to extrapolate, the discrepancy found in the temporary sample must be checked. More temporary sampling is required to add data to what was a relatively small sample. It may still be that the temporary sample is underestimating the overall resource base rather than the pilot sample overestimating it. The former was, after all a much smaller sample than the latter. This work can be done by the trainees, who are now trained in the techniques used, and will not need additional consultancy visits.

Once this is complete then a better informed decision can be made on how to proceed. If the discrepancy is indeed real then it may be advisable that a further pilot harvest is completed in a different area to quantify the effect that lower population densities can have on chicle productivity from a given area.

9.3. Making yield projections from the pilot study.

Although there is some risk associated with it, it is, nevertheless worthwhile attempting to use the data to make yield projections for the whole of the UZ1 zone. For this two scenarios will be used:

a) Using the pilot harvest production directly throughout the UZ1 area.

b) Applying the actual proportion of the population harvested in the pilot work to the 'worst scenario' RME of the temporary samples.

Neither method makes any allowance for forest type variation, assuming that this variation is accounted within the respective means.

The UZ1 zone is approximately 130 km² or 13,000 hectares in extent. The proposed management system is an area rotation based on a six year rest period for each area. 6 areas are thus pre-defined throughout UZ1 each of which are (13,000/6) 2166 Ha in extent. Thus 2166 hectares are available annually for the production of chicle. the price available for chicle is currently US$3 per pound. What latex yield can be expected from each and therefore what income based on current price?

<u>Scenario a: direct use of pilot harvest data.</u>

Blocks 1 and 2 of the pilot harvest, an area of approximately 240 hectares, produced 725 lbs of chicle:

Rate of production = 3.02 lbs per hectare

Projected production: <u>6,541 lbs per year</u>.

Financial turnover: <u>US$ 19,623 per year.</u>

<u>Scenario b: applying the proportion of the population harvested in the pilot work to the 'worst scenario' population density RME of the temporary samples.</u>

i) In block 1 the proportion of the population harvested was:

population density (trees per Ha) (32) x 240 Ha = 7,680

no of trees harvested = 451

proportion of the population harvested = (451/7680) x 100

= <u>5.87 %</u>

ii) From the temporary sample the RME population density of working area 1 = 15.0 trees per hectare.

Of these the productive population = 5.87% of 15.0 = 0.88 trees per hectare.

Yield per productive tree (RME) = 1.56 lbs

Rate of production = 1.37 lbs per hectare.

Total annual production from each area = <u>2,967 lbs per year</u>

Annual financial turnover = <u>US$ 8,902 per year</u>

It seems reasonable to state that these, at least in the early years of the operation may be the best and worst scenarios of chicle production. Obviously the actual production will be somewhere between the two. It should be emphasised that the projection needs further research and development and is not a fool-proof recommendation. These figures are very sensitive to changes in inventory values. The temporary plot values are currently very imprecise which partly explains the very low value in scenario b.

10. OBSERVATIONS ON CHICLE SUSTAINABILITY FROM THIS STUDY.

10.1. Comparison of this data with that from the past.

It has already been mentioned that the sound demography of sapodilla in this study implies that 100 years of harvesting has not hindered the ability of the population to reproduce. This ability is a key factor in the sustainability of the operation. A further indication of the impact of harvesting over time can be gained from comparing all of this data with that produced from similar studies in the past.

In the 1920's the chicle development company completed the most serious research much of which was published by Lundell (1930). Table 10.1. presents the results of this compared to the current study.

Table 10.1. Population characteristics from 1930 compared to those of the current study (all figures are sample means).

	1930	Present
Population density (trees per Ha)	24-29	23-32 [1]
Productive popn. (trees per Ha)	5	4
Yield per tree (lbs)	1	1.76

1 These extremes are taken from the mean figures for the permanent (higher) and temporary (lower) samples.

Although these show slight discrepancy on the productive population it should be considered broadly similar as Lundell was making an estimate of this at the time.

Figures for yield per tree are slightly increased. Work in Mexico in 1991, in an area repeatedly harvested for chicle showed similar yield levels to that of Lundell (500 g per tree) (CI - personal communication). It may be that the productive trees in Rio Bravo are showing the benefits of having been rested for the last ten years.

10.2. Implications of the comparison.

This information can be looked at in two ways:

a) This evidence implies that the 60 intervening years of harvesting have left the population unchanged in terms of its ecological structure and its main characteristics of production. In fact one aspect, the yield per tree, appears to have risen. On this basis the operation can be considered to be broadly sustainable and can continue from now with similar production patterns without any problem.

b) Lundell, however, was writing at a time of high exploitation and he, like most authors at the time, described the forests as exhausted and over harvested. It could be said then that in the 60 intervening years the same forest type remains exhausted and that a period of rest is required before true sustainability is achieved and the yields optimised. As already pointed out 97% of the harvestable population has been tapped at least once and 73% have been tapped more than three times. This will seriously undermine the productivity of the harvestable population.

10.3. The possibility of further rest to increase yields.

The fact that these figures are similar to those of 1930 as well as general observations on the sapodilla population at Rio Bravo do suggest that a period of further rest may benefit this population. That is not to say that the operation as it is unsustainable, and causing irreparable damage to the resource, but there seems little doubt that yields from forest areas could be increased further if longer recovery was allowed.

Providing a rest, however, does not necessarily mean that harvesting cannot take place. The fact that PFB are proposing to adhere rigidly to the 30 cm lower harvesting limit does, in itself, represent a rest and will allow the population to recover its productivity and produce, in the long term, higher overall yields.

The current harvest of the harvestable population, as already stated, is cutting trees which have already been tapped at least once and, in 73% of cases, more than three times. If the limit is strictly applied then all trees entering the harvestable population would not have been tapped at all before. This does two things:

i) It increases the proportion of the harvestable population which is productive i.e. the productive population; and

ii) it increases the unit productivity of this productive population

It would therefore give much higher overall yields. Trees being harvested later in life may also be in a better position to recover from the first tap so that they can maintain that productivity level through to subsequent harvests.

11. OBSERVATIONS ON THE MANAGEMENT OF CHICLEROS AT RIO BRAVO.

Once the full harvesting programme is underway an important aspect of management of the operation will be to ensure the optimum deployment of chicleros over the current year's harvest area. One of the most successful aspects of the pilot study was the way in which Mr Cowo worked with the strictures of the study to produce the target quantity (1200 lbs) before the end of the season. This provides good baseline data on personnel management of the operation which can be used for future planning.

To achieve the following figures Mr Cowo worked the standard chiclero working week: 6 days harvesting (Monday to Saturday) with processing and other peripheral work on Sunday.

11.1. Productivity of each chiclero.

Mr Cowo produced an average of 84 lbs of dry chicle per week with a high of 107 lbs and a low of 57 (see table 6.1.) He cut an average of 8 trees per day or 48 per week. A good day saw 11 trees cut while a bad one in which a full days work (see below) was achieved was 7.

Chicle productivity is something which can vary quite considerably between different chicleros depending on their skill and experience and is something which should be monitored in the future for different chicleros. Having worked as a chiclero for some 40 years, Mr Cowo is very experienced and his productivity should be viewed in this light.

The figure should also be viewed in the context of it being a pilot study. As such, Mr Cowo's work was at times disturbed by the research programme or appearances for film and radio crews. This will undoubtedly have slowed his progress and be reflected in this figure. It is probable that weekly production, under normal circumstances, would be higher than this, a contention which is supported by the fact that he averaged 103 lbs per week for the last four weeks compared to 69 lbs in the first four. It was early on in the work that most disturbance was caused.

A figure often quoted for chicle operations is 100 lbs per chiclero per week. Some, it is said may produce only 50, others 150. This is certainly of the correct order for Rio Bravo, however the figure should be used with caution in this management system where the smaller size classes are being excluded from the harvest.

11.2. The time taken to cover defined areas: the 'Area Rate'.

Harvesting operations are to take place in the RBCMA in a block rotation system where a defined area will be harvested each year. As the season is also limited it is important to know the area a chiclero will cover in a given time period to optimise the deployment of men in order to cover the allowable harvest area within the season. This is the 'area rate' of chicleros.

During the pilot study the chiclero covered approximately 300 hectares in 15 weeks, an average area rate of 20 Ha per week (the area is difficult to accurately state because the size of working blocks is variable). As discussed in section 9, once harvesting is underway, 2,166 Ha will be available for harvesting annually. An area rate of 20 Ha means that this will take 109 chiclero weeks to harvest.

11.3. Optimising the deployment of chicleros,

If we assume a harvesting season of 6 months - August to January inclusive - there are 27 weeks available during the season. 109 chiclero weeks are required to cover the area which means that the minimum number of chicleros required each year will be four who would finish the work in exactly 27 weeks. Table 11.1. shows the time that different size groups of chicleros would take to complete the harvest based on this area rate of 20 Ha.

Table 11.1. The time taken for varying sized groups of chicleros to complete the annual harvest of 2,166 Ha of the RBCMA, based on an area rate of 20 Ha.

Number of chicleros	Weeks to complete harvest.
25	5
20	6
15	8
10	11
8	14
6	18
5	22
4	27

Under standard chicle harvesting conditions a chiclero camp consists of up to 25 chicleros. This table shows that such a group could complete the RBCMA harvest very quickly: in under 5 weeks. As stated PFB could, if it chooses, work with only 4 chicleros to complete the work and thus can choose the optimum number for its own purposes.

Early research (Karling 1948) showed that wet cool conditions induce higher yields of chicle. This was a real increase and not just an increase in water content. This is important because rainfall varies across the harvesting season and therefore yields per tree may also vary. Harvesting should thus be concentrated around the period of greatest rainfall: during September to maximise yields and increase profits (although harvesting can be impeded by too much rain). PFB could use 25 chicleros to complete the work in 5 weeks at this time of year. This would decrease unit management costs but increase the cost of supplying equipment to the men. A larger number also increases the risk of management problems. Somewhere between using 4 and 25 chicleros is an optimum number which should be used in this way to maximise yield and minimise costs.

Research is required to find the time period for harvesting during which yield is maximal.

12. CONCLUSIONS AND RECOMMENDATIONS.

12.1 Achievements of the pilot harvest.

At the bottom line, this pilot study has proven inconclusive. It does not seem possible to use the results confidently to extrapolate yields over a wider area until further work is carried out to investigate the apparently lower level of the resource outside of the pilot study area. It appears probable that the pilot harvest has taken place in a resource abundant area and that, if extrapolated elsewhere, would overestimate productivity in Rio Bravo.

The pilot study has shown that the productive potential is not a reliable predictor of actual production so that this is ruled out as a means of yield projection. This means that yield projections must be based solely on the results of the pilot harvest. As this is seen to be optimistic further pilot harvests are required to get a better view on potential productivity from different areas.

Although these results appear, at first sight, to be negative ones, it must be emphasised that to find out such things is an essential part of the pilot study and associated resource assessment. It is essential that any risks are highlighted now and appropriate action taken, rather than having a management plan implemented on the basis of inaccurate results and unwise investment made in the whole operation.

There are also a number of other positive aspects to the pilot work. It has shown that the sapodilla population at Rio Bravo is generally in good health and recovering from heavy harvesting in the past, which includes the last harvest around 9 or 10 years ago. Regeneration is good and the yields from forest areas can be expected to increase as time goes on so long as the 30 cm limit is strictly adhered to. The yield per tree of 1.76 lbs is higher than the 1 lb expected. This is probably due to the prolonged period of rest which these trees have received and augers well for the future.

Working with the chiclero, Tivo Cowo, has been very successful. Despite temptation otherwise he has worked very closely with the various regulations imposed on his operation and co-operated wholeheartedly with the research aspects of the work. He has shown that it is possible to work the operation on the basis of mutual trust. In other chicle harvesting operations there is great distrust between the respective parties. In Mr Cowo's case there is no doubting his commitment to the goals of PFB, the successful completion of the contract and the additional income which he is receiving! He has shown that it will be possible to gather together a group of chicleros with equal commitment and pride and thus have a successful harvesting team working in the area. Prior to this work this would have been one of the major risks to the operation.

Although it has not been discussed in this report the pilot work has also established a system of permanent plots which can be used to monitor the population following this and subsequent harvests. They have been designed with the maximum of flexibility so that they can be used as the basis for other experimental work where harvesting effects require to be separated from the population's natural development. They also have the potential to be incorporated with any further inventory work which is carried out whether on chicle or the wider forest community.

12.2 Recommendations from the pilot study.

Although inconclusive it is considered that the pilot harvest produces enough information for PFB to now produce a coherent strategy for their chicle operations. At first this may be to continue pilot work for some time longer so that the decision on the profitability and workability of the operation can be assessed in more detail. If the work is to begin, however, then the information provided is as good as it will ever be.

From the pilot work the following recommendation appear to pertinent.

1. Overall approach.

Nothing has changed the provisional approach to chicle harvesting which has been to establish an area rotation system. This would be based on the need for areas of forest to be rested sufficiently between harvests. Received wisdom is that 5-7 years is adequate recovery for the population between harvests and therefore 6 working areas (or a number divisible by 6) should initially be established. One aspect of research will be to establish the optimum recovery period (see below).

Whatever the economic analysis there is no doubt that, at least in the early years, chicle harvesting will be economically marginal for PFB. At every possible juncture therefore it is proposed that the operation should be low-input. The operation is resource limited: there are no identifiable investments which would actually increase productivity dramatically from the area. The only way to increase profit reliably, therefore, is to keep costs low and so a system should be established which needs the minimum of resources to manage once it is running.

Every investment should be considered wisely. Remember that the reason natural latex lost its place in the market was because the price was difficult to control.

It is my opinion that the current 'suck-and-see' approach of PFB is wise and that great investment should not be made in advanced inventory.

2. Demarcation of working areas.

Demarcation of the working areas should precede the commencement of full harvesting operations as 'up-front' investment. The number established must be divisible by six. It would be wise to establish a larger number such as 24 compartments which then gives more flexibility once the operation is underway. The rotation could then be changed to 8 or 12 years if research suggests that it is necessary, (although this changes the investment scenario as well), or operations could be moved in a given year if some unforeseen circumstance (e.g. an incursion by rogue chicleros) took place. The actual number depends largely on the initial investment available.

These should be clearly defined as far as possible by permanent geographical features such as hills, rivers, dry river valleys, logging tracks etc. This may make the compartments of variable size however it would not be as costly to set up and they will then not need the same level of maintenance, and thus cost burden on the harvesting programme, once established. Only where absolutely necessary should these be augmented by cut lines etc. which are costly to establish and maintain.

Other factors should be considered in their establishment. Water sources for chicleros within the blocks and access routes for the movement of chicle are essential components of each individual, or group of, compartments. With their wider remit of forest protection PFB may wish to consider, in the establishment of the blocks, the interactions of other objectives, such as ranger patrolling etc., with those of chicle harvesting.

3. Building a detailed knowledge base of each compartment.

The aim of the area rotation system is that, in time, each compartment has a detailed resource profile for the harvesting of chicle. This would be built up continuously as harvesting takes place to make a responsive and efficient management system. Such information is essential for planning, and reduces the risk of unwise contractual or other investment decisions. Only with such information can management control be achieved.

Having established each compartment certain of these details must be established initially. Each one should be mapped in as much detail as possible including access routes, water courses and potential campsites. If possible the exact area of each should be known. This will assist in more accurate planning once more detailed yield data is available.

Information such as yield data, resource distribution, management history, and general observations on harvesting would then be gathered over time and linked to formal resource monitoring to make a well informed management system. With information readily available management costs are, again, minimised. Most importantly it gives the management control to PFB.

4. Harvesting.

It is my opinion that if the forest in Rio Bravo were allowed to rest in some way, the yields from each compartment would rise. For this reason it is proposed that the 30 cm limit should be maintained because it allows those trees below this size class to rest and enter the harvestable population untapped. Enforcing such a regulation is a key aspect of management control. It must be realised that in no other part of the chicle producing region (Belize, Guatemala and S. Mexico) do chicleros adhere to the legal limits, and therefore those coming into Rio Bravo would be doing something unusual if working trees above 30 cm only.

It may be that, in the future, research will show that a lower limit is adequate for sustainability.

5. Building up a relationship with the chicleros.

The whole operation must eventually be based on a mutual trust between all parties involved. It will succeed or fail on the relationship between PFB and their harvesters and therefore a strong relationship should be established early on. In the long term this may be to the extent of the chicleros having their own group representation and thus input on management. The relationship should work at all times of the year and not just during the harvest.

There is no doubt that everybody associated with PFB has a very strong sense of purpose. There is great enthusiasm for the organisation and its goals. It appeared to me that, during the pilot harvest, Mr Cowo felt this sense of purpose and it was this which meant that he worked very well with the regulations imposed and made the harvest a success. It will be more difficult to engender this feeling with a larger number of chicleros who are in the bush for longer periods however, this must be the target.

PFB should not underestimate the task of selecting chicleros. It should be viewed as seriously as if taking on new employees. The relationship should be considered a long term commitment by both parties. Once the relationship is established then regulations, such as the 30 cm limit, or any other adjustment which research suggests should take place, can be implemented with less difficulty.

6. Monitoring the resource.

Because of the management philosophy of PFB resource monitoring is an essential part of the operation and therefore should be considered as a necessary investment against the profit of the operation. As has been shown in the pilot study, it provides both immediate resource data and monitoring of long term changes in the resource in harvest areas.

7. Formal research.

Other research on aspects of sustainability which may be performed include: optimum rotation times, impact of harvesting on fruiting, and optimum tree size for harvest. These should not necessarily be costed against the harvest budget. Research is something which has application beyond Rio Bravo and PFB would, if performing such research, be doing a service for the wider community for which it should be paid. It is something which can be considered to have a separate source of funding, namely forest research or development funding agents and is thus a potential source of revenue rather than an extra cost burden on harvesting.

These are preliminary recommendations based on preliminary results. It should be remembered that this does not represent a full inventory of the sapodilla resource.

Peter Oliver, April 1994

GLOSSARY OF KEY TERMS

Area rate

The area rate in this context is a working figure for the area of forest that a chiclero works for chicle production in a given time period. It is an important component in the planning of chicle operations and the efficient deployment of personnel within an area rotation system of management.

Dry weight

In the context of chicle production, the dry weight is the weight of chicle following processing by the chiclero. It is not the standard scientific concept of bone dry weight: in this case the product would have a water content of 30-40%.

Harvestable population

Laws throughout the chicle producing area state that only trees of greater than 30 cm diameter at breast height should be harvested for chicle. PFB are adhering closely to this stipulation which means that only this portion of the population is available for chicle production. This is the harvestable population and will be naturally consistent for a given forest type in its climax state.

Productive population

At any time, for a number of reasons, only certain trees within the harvestable population will be producing chicle. This is the productive population. Factors such as over harvesting, genetic quality of the trees and even weather can effect the productive population.

Productive potential

A concept which gives the maximum potential productivity for a given area of forest. It is simply a multiplication of the productive population by the mean yield per tree found from experience.

Reliable minimum estimate (RME)

For a given parameter such as dbh, the mean figure is applied with certain confidence limits with, in this study, 95% probability. What this means is that 95 times out of 100 a similar sample will produce a mean within the stated confidence range (i.e. the mean plus or minus a certain figure). The RME is the figure at the lower end of the confidence range: i.e. the mean minus the confidence interval. It provides a conservative estimate of any parameter which should be used for prudent development of management plans.

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APPENDIX A

Field data sheet: Chicle Monitoring work.

Date...	Working Block..................................
Plot No...	Treatment..
Stand Basal Area....................................	Site Description ....
	....
	....
	....

Tree number Quadrat number D B H (>10 cm) Live crown Quality Ecological position. Tapping Height Productive? No. of taps Dead bark. Class. Comments:	