LAND UTILISATION IN A LIMITED AREA OF THE NORTHERN RANGE.
(MARACAS AND TIERRA NUEVA ESTATES).

by

IAN WILL, B.Sc. (Agric.)

Submitted in part requirement for the Diploma in Tropical Agriculture.
Imperial College of Tropical Agriculture,
Trinidad, B.W.I. JUNE, 1952.

accepted by Academic Board.
In Trinidad the scarcity of suitable agricultural land on the plains has forced quite a number of people to cultivate the steep slopes of the Northern Range. Losses through theft are also responsible for the cultivation of these rather inaccessible places. On the slopes the more usual form of cropping is on a shifting basis where the land is cleared of bush and the vegetation is burnt prior to planting the crops. Crops are grown on the same plots till the yield becomes too low to warrant further cultivation, after which the plots are abandoned. The other extreme of hill farming is to cover the land with permanent tree crops.

It has been stated by various authorities that hill cultivations have led to a great increase in the run-off of water after rain, and is seen in the increased flooding of the Caroni River. This is true to a certain extent but it should not be forgotten that much building has been carried out recently all along the Eastern Main Road. The roofs of these houses cause immediate run-off, which is led by drains and ditches directly to the rivers before it has a chance to percolate into the soil, which must result in a rapid rise in the rivers during and after rainfall.

The hill surveys were carried out this year under the supervision of Dr. G. ap Griffith. The main purpose of these surveys is to familiarise the students concerned with the technique of survey and to provide more detailed information than has been collected hitherto as a basis for any agricultural extension work the College or the Department of Agriculture may be in a position to carry out at a later date. The survey also gives an opportunity to study the different methods employed by the small scale gardener and the quite large estate owners. Much was gained simply by talking to these people and listening to their views. Identification of the various crops was interesting and is a very useful part of the survey.

Three areas were chosen this year, namely:

1. A hill garden area at Floradale, La Baja Road;
2. Peasant gardens and small estates in the Mount St. Benedit area.
area; and

3. Permanent tree crop cultivation on the Maracas and Tierra Nueva Estates on the Maracas Riverside Road.

To get an overall picture of hill agriculture all the areas were visited during the first term and after that one student concentrated on one of the areas. This report is on the third area but references are made to the other two from time to time. Area 1 was surveyed by J.S. Ure and Area 2 by R.A. Sands.

The estate area has not been surveyed before with the result that this report is mainly a general description of the area with background information and its effect on the present agricultural situation.

On the estates and also in the other areas there is no correlation between land utilisation and degree of slope. The extent of soil erosion does vary with the crop grown. Most of the erosion takes place under cocoa, with its shade, and on the exposed hill gardens.

The appendices contain the results of the soil analysis, a table of crop yields for Tierra Nueva estate, rainfall figures and a map of the area.
NATURAL RESOURCES

LAND:

Area - The total area under consideration is in the region of 1200 acres, but only 480 acres are under cultivation by tree crops. Most of the uncultivated land is on the Maracas estate and consists of secondary bush and natural rain forest.

Location - (map) The area is situated on either side of the Maracas Riverside Road four miles from the village of Curepe. It extends in the form of two valleys from the road to the mountain ridges, and is flanked by spurs running from those mountains. Morne D'Or is on the west with Mt. Tabor on the east.

Topography - The topography is that common in many of the valleys in the Northern Range, namely, a valley floor rising steeply, almost precipitously in some places, to form the slopes on either side. On the estates the elevation is 200 feet on the valley floor rising to a total height of 1500 feet with the limit of cultivation at present at 1200 feet on the Tierra Nueva estate.

Soils - The parent rock of most of the Northern Range is a metamorphic schist containing mica and quartz particles of various sizes. Scattered through the parent rock are outcrops of calcium carbonate, the presence of which causes great local variation in the pH value.

With the hot wet climate the rock weathers rapidly into soil forming material. The structure of the Range is immature and even on well wooded slopes landslips of the catastrophic type occur. After clearing and burning, in spite of the high sand content, the soil seems more resistant to erosion in these areas than would be expected under such conditions. However erosion symptoms may be masked to some extent by the rapid weathering of the soil forming material. Soil erosion is taking place however, as seen in the non-formation of a soil profile even in forest conditions.

Soil Samples - Soil samples were taken from all three areas and analysed by the Soil Science & Chemistry Department. The results are given in Appendix I. Areas 1 and 2 have been sampled in previous years. From these results and from those obtained this year the following is the general picture of the soil:

Texture -
Texture determinations show a high proportion of gravel and sand, consisting mainly of quartz and unweathered schist. The reaction (pH) is very variable, ranging from below 5 (very acid) to above 8 (very alkaline), depending on the presence or absence of the limestone outcrops.

The C/N ratio varied from between 6.3 and 11.6. 6.3 is a low value and suggests truncation, i.e., the erosion of the humic layer from the soil surface.

The available phosphate status ranged from 5 - 6.9 (very low) and the available potash from 41 - 61 (low). (These values are from previous samples as P₂O₅ and K₂O were not determined this year. The values apply to areas 1 and 2 but are likely to be fairly accurate for area 3).

In spite of the low nutrient status and the general absence of manuring, the crops grown are reasonably healthy and vigorous. On the estates the yields equal the average for Trinidad.

Peasants can grow good crops of vegetables on the hills where the rapid weathering of the parent material yields up its small supply of nutrients quickly. However erosion is such that the land must be rested in bush fallow for three or four years before another series of crops can be grown profitably.

CLIMATE:

Rainfall - There are no rain gauges on the actual area itself. The nearest rain gauges are at Mount St. Benedict, Ortinola Estate and at the Imperial College of Tropical Agriculture. The figures since 1948 are given in Appendix III. Prior to 1935 records were taken at the Maracas Government School where the average rainfall for the 13 years previous to 1935 was 68.57 inches. (Rainfall for Trinidad - Met. Office Pub.) The rainfall in the area is somewhere between 65 and 90 inches, but at all the stations there are big year to year variations. Most of the rain falls in the nine months - May to January, with a short break, the Petit Careme, in September/October. This seasonal effect regulates the planting and harvesting of crops. In spite of the heavy downpours of rain, run-off is not so considerable as would be expected, due to the porous nature of the soil.
Temperature - The extreme range of shade temperature is from 60°F. to 95°F. The average daily temperature is 84°F., and the average night temperature is 74°F. Humidity is 100% during the night and decreases during the day.

Natural Vegetation: (T.A. XVI 1939 p.230)

The original vegetation on the hills is likely to have been tropical evergreen rainforest with a proportion of deciduous and semi-deciduous trees such as - Cedar (Cedrella mexicana), Cypre (Cordia alliodora) and Poui (Tabebuia serratifolia). Balata (Mimosops balata var. Cruegeri) was probably more common in the area than it is today. During the period of Spanish ownership the forest in the valley bottoms was cut down and replanted with cacao trees. After the arrival of the French refugees at the time of the French Revolution, and later with the arrival of English colonists when Trinidad became part of the British Empire, more of the forest on the slopes of the hills was replaced by cacao. Some of the cultivations on the slopes were as high as 2000 feet and there are at present some of these old plantations at such heights. However large areas were later abandoned and the cacao trees died out, to be replaced by secondary bush of the following nature: -

- Cocorite palm (Maximilia regia)
- Gru-gru palm (Acrocomia aculeata)
- Trash palm (Scheelea osmantha)
- Bloodwood (Croton gossypifolius)
- Balsa (Ochroma pyramidale)
- Saltfishwood (Machaerium robinifolium)
- Gommier (Tapira guianensis)
- Kiskidee (Vismia falcata)

Intermingled with these trees are shrubs, vines and razor grass, which in many places form a dense mat that becomes very dry and is a great fire hazard.

Water Supply:

On both estates there are two perennial springs providing an abundant supply of first-class water for human consumption. These springs -
springs are quite high in the hills and the streams from these flow quite
a way before disappearing underground in the dry season. With the rains
these streams persist and flow into the Maracas River, which drains all of
this area.

HUMAN FACTORS :

The people - Both the estates are owned by Creoles who are
mainly of French extraction. The workers on the estates are basically
Negroid. The owners live on the estates as do one or two of the workers.

The farm house on the Tierra Nueva estate is constructed of wood,
with a roof of corrugated iron. The outhouses are made of wood. On the
Maracas estate the main house was once a barracks for the estate workers,
but was converted into a dwelling house, by the present occupier. The
house is made from stone with corrugated iron roofing. All the outhouses
are made of stone, which was obtained from one or both of the two quarries
on the estate. The majority of the workers live in the Maracas village or
in nearby houses consisting of wood or mud walls with roofing of iron or
more commonly, timite leaves. The estate buildings are in quite sound
condition, but a coat of paint would greatly improve their appearance.

Both estates are well placed for external communications, as the
Maracas Riverside Road passes between them. Internal communications on
the estates consist of narrow traces and bridle paths, limiting transport
to pack mules and donkeys, except in limited areas where carts may be used.

AGRICULTURE :

Land tenure - The land now comprising the estates was sold
prior to 1902 and is therefore held under the old Spanish Grant by which
the land, the river and any minerals, including oil, that may be found on
the estate belong to the present owners. Since 1902 the Government has
retained all mineral rights on land sold to private owners.

Estate History - Tierra Nueva :

Tierra Nueva is on the east side of the area and stretches from
the Maracas River to the first hill crests. The area is roughly heart
shaped, with natural rainforest at the higher elevations and tonka bean
plantations -
plantations on either side and on the central spur. This spur divides the area into two small valleys, well sheltered by the tonka beans. Beside the river the land is fairly flat, but once the hills are reached, the land rises quite steeply. Most of the land is now in cultivation up to the 1200 foot mark. The area is adequately provided with traces and paths.

In the early days, as already mentioned, this area was planted with cacao trees by the Spaniards who settled in the valley. This estate in the 1890's was bought by the Leotaud family and has been retained ever since. The estate is managed for the family by one of the sons.

The early improvements consisted of replacing old cacao by the three areas of tonka beans which were in bearing by 1920. Inter-planted with the tonka beans were cashew trees. These yielded quite well for a time, but have now almost entirely died out, leaving a few isolated trees here and there. Both tonka beans and cashew trees need sunshine at flowering time to obtain a good set of fruit. This qualification leads to very erratic yields which may be non-existent in some years, e.g. 1950-51, or so low as to make harvesting uneconomic. With the production of synthetic coumarin the value of tonka beans has fallen and as the future of this crop is financially doubtful, the owners have started replacing certain areas with citrus and cacao.

Since 1920 the main income has been from cacao, coffee and tonka beans (Appendix II). The cacao yields for 1920 and 1952 are approximately the same (28000 lbs), despite the fact that 22 acres, i.e. about one-fifth of the 1920 acreage is now growing citrus instead of cacao. The yield has increased by replanting with clonal cacao from La Pastora and regular inspection of the trees when moss, piphytes, and dead branches are removed.

Sodium hypophosphate has been applied with an increase in yield on another estate owned by the Leotaud family. This fertiliser was applied recently on Tierra Nueva and may explain the rise in cacao yields for 1952. Changing economic conditions and the risks of having to depend on one or two crops have led to the planting of citrus on the estate to quite a large extent. In 1940, 2115 orange trees were planted. The produce is sold to the Trinidad & Tobago Citrus Growers Association to be processed for juice manufacture. At that time 215 grapefruit trees were planted. In this
case the actual fruit is exported. When fruit is for export, it has to
be cut off the tree; if for juice, it can be pulled off. In 1947 a
further 500 grapefruit trees were planted along with 600 trees of Avocado
Pears. The Avocado Pears have just started to bear fruit. At present the
areas in crop are:

- **Cacao and Coffee**: 82 acres
- **Tonka Beans**: 173 acres
- **Citrus**: 22½ acres
- **Pasture**: 14½ acres.

The buildings occupy five acres, while thirty-three are not under cultivation, being natural forest on the ridges. This gives a total acreage of 330 acres.

The livestock consist of one donkey and two mules for transport. There is one mare used for breeding mules, and on which the Manager rides round the estate. There is a small herd of cattle of various crosses between Zebu and Holstein. The bull is a grade Holstein. The cows usually suckle their own calves, but one or two of the cows are kept for milk production for use on the estate.

The buildings consist of two drying floors, a house for fermenting the cacao beans, a store shed and a few odd sheds for livestock. All the buildings are made from cedar grown on the estate.

The labour needed to keep the estate going is 30 - 40 full time workers plus twenty task workers at rush periods.

The agricultural system for the future is to maintain the crops already in production at an economic level and then to replace them by new stocks of the same, or what is more likely, different crops, when the yields are unprofitable. The tonka bean trees are being thinned to give a final stand of trees 40 feet apart. The thinning is carried out by charcoal burners who fell the necessary trees and produce the charcoal. Charcoal is sold at $1.12 per bag of 60-lbs. Mr. Leotaud takes 20 cents a bag and by the time transport has been paid for, the burners are left with about 60 cents per bag. On the estate three men were producing 60 bags every 14 days, which is giving each burner an income of $6.00 per week.
At present a large block of cacao has just been replanted at 1100 - 1200 feet. Here the old cacao trees have been cut down along with any secondary bush and all is burnt. The cacao was replanted under the customary shade of tarinias and bananas. A few tall shade trees have been left standing. At this height and on a slope of 38° there are no anti-erosion measures. The soil is very sandy and tends to trickle downhill if disturbed when dry. The soil in spite of this is 6 inches deep.) This is definitely harmful and some anti-erosion barriers at least should be constructed. Citrus usually planted on cleared land too, but as the distance apart is greater, the ground cover soon becomes established and if grasses are encouraged erosion appears to be reduced considerably. However despite these maltreatments the estate has shown a profit for most of the years since 1917 when detailed bookkeeping was started.

Varacaz Estate:

This estate is owned by Mrs. Anderson who took over from her husband who died in 1937. As in the other estate at the end of the 19th century this area was under cacao. About 1910 this area consisted of a number of small properties that had been left abandoned by their owners. At that time a planter bought these small properties and formed one estate. The owner improved the estate and was successful for a number of years, but by 1928 the area was again abandoned. In 1929 the husband of the present owner bought the estate and really improved it. Large areas of neglected cacao were replanted with tonka beans and limes, 70 miles of roads and traces were made, drains dug at an angle across the contour instead of straight down the slopes, pen manure was applied to the cacao and a gang of small boys were trained to clear the cacao trees of moss and epiphytes. All this naturally cost money and the weekly paysheet was $1000.00. A water supply was piped down from the stream for 3 - 4 miles from a height of about 1000 feet. This water is very pure and is used in six houses in the neighbourhood. This supply has never failed. (In passing - it might be possible to use this head of water in an irrigation area near the homestead for the production of vegetables by using a sprinkler system.)
The limes yielded very well with a maximum production of 74,000 lbs. in 1932. By 1943 the yield was down to 30,000 lbs. after which the yield rapidly decreased and the limes died out as happened in all the orchards in Trinidad. These limes were about the last in Trinidad to be killed off. It is still not agreed upon as to what was the cause of death. Since then this area has been abandoned except for a small hill planted in 1949 with King Oranges. The remainder is now covered with secondary bush.

In 1937 Mr. Anderson died and Mrs. Anderson took over the management. The estate was mortgaged and only a maintenance staff of eight to ten workers was retained from the 200 workers. The staff is paid at present $1.50 - $1.80 per day. When the cacao prices were very low Mrs. Anderson was advised to replace the old Spanish cacao by new clonal cacao. Taking this advice, vast areas were cut down and are now under secondary bush as only a limited area can be replanted each year. This wholesale destruction has resulted in a financial loss as these old trees were still yielding quite a lot of cacao. It would have been better to cut down only as much as could be replanted. The land to be replanted is first rented to gardeners for one year for growing vegetables. They clear the land and burn in the usual Trinidad way. Among the vegetables they have to plant bananas and tannias to shade the cacao which is to be planted one year later. Since 1949 about 2000 plants have been planted out each year. This is a yearly programme to expand the cultivated area which at present is about 150 acres, most of which is in the valley floor, but there is still more land in the floor before the slopes will have to be tackled. There is one area of old cacao that survived the felling, on a slope of 35°. On this slope erosion is taking place at quite a rate. As on the Leotaud estate areas of tonka beans are being thinned to give a spacing of 40 feet between trees. On this estate coffee is being interplanted among the tonka bean trees which after thinning have an etiolated appearance due to close planting. On both estates coffee was confined to the sides of traces and not in definite blocks. Thinning of tonka beans is again done by charcoal burners, but in this case one-third of the coals produced is claimed by Mrs. Anderson.
The main crops now growing are: cacao, coffee, citrus, tonka beans and avocado pear, but no acreage figures are available. Papaws and vegetables are grown for domestic use, but are sold if in excess.

Livestock consists of one mule and two calves. Until last year 5 - 6 cows were kept for milk production. All the pen manure was applied to the cacao trees.

The mortgage was paid off in 1940 due to the good prices for tonka beans, but again during the war low prices caused the estate to be mortgaged. By expanding the area of cultivation and not concentrating on one or two crops this mortgage could be paid off again in a few years.

PESTS:

Squirrels do much damage especially on the Tierra Nueva estate at the higher elevations near the forest. Squirrels eat the beans from two pods daily and also damage others. The damage is recognised by the numerous empty pods with a hole two inches in diameter on the side. Shotting is the only control.

Ant damage can be considerable to the trees, especially on young citrus where the young leaves are destroyed. Spraying with chlordane provides an effective control.

DISEASES:

Both estates are free from serious diseases apart from gummosis, which is not common. It is controlled by paring off the infected bark and painting the wound with a fungicide.

FIRES:

Fires are common in the dry season and can be serious, due to the amount of dry vegetation left lying on the surface after cutlassing, especially under citrus. Fires also occur in the secondary bush and large areas can be burnt. After these fires the soil is left exposed to the action of heavy rains in May-June.

MANURES AND FERTILISERS:

Pen manure when available is used extensively on the Maracas estate -
estate when replanting. It is forked into the soil before the cacao is planted. The effect of it is seen in the healthy and vigorous young cacao plants. If more were available it would be applied to the older cacao trees as well. Sulphate of ammonia is the only fertilizer used on the Maracas estate. This is applied round the trees and is lightly forked into the soil. The amount that can be bought is limited, but as much as is available is applied to the cacao and citrus.

Mr. Leotaud applies sodium hypophosphate to the cacao and citrus as already mentioned. This is broadcast round the trees, but is not forked in and is thus liable to be lost if the intensity of the rainfall is such to produce run-off.

**SLOPE AND SOIL EROSION**

In general the greater the slope the greater the erosion. This is true for all crops but the seriousness of the erosion varies with the type of crop grown. On the slopes on both estates the signs of soil erosion are not so obvious as one would imagine with the exception of cacao grown on a slope of 36°. Here the exposed roots of the trees and the rocks and stones lying on the surface indicate serious erosion at a glance. The cacao is quite thickly planted and through it are trees of orange, breadfruit and the shade immortelles. So intense is the shade that only a few ferns cover the soil between the trees. Prior to harvesting not these ferns are cut so as to hide, which is doubtful, any fallen pods, and also to allow a breeze to blow amongst the trees. These were the reasons given by an old fellow who was brushing away steadily on one of our visits.

Now on going to the other extreme where citrus was planted 2 - 3 years ago, on a 30° - 35° slope the soil has a dense covering of grasses and flowering plants. Here there was much less soil erosion as seen by the, admittedly thin, layer of black humic soil at the surface and indicated by the high $C/N$ ratio in the soil analysis. On this area the vegetation is cut twice or more times per year and left to decompose on the soil. The dry grass is placed as a mulch round the base of the young trees at the beginning of the dry season to prevent excess evaporation of soil moisture. This dead dry vegetation is a great fire hazard in the dry season and if burnt the soil would be left completely bare and at the
mercy of the heavy rains.

In the future with the increasing growth of the citrus there is the possibility that shade may be produced to an extent sufficient to reduce the growth of ground cover but not enough to be really serious, as seen in already existing citrus orchards.

Between these two extremes therefore, sufficient ground cover can be produced to reduce soil erosion to a minimum. This can easily be produced in the case of citrus but in cacao if the shade were reduced by thinning the trees then reductions in yield are liable to follow. The greatest amount of soil erosion is likely to follow clearing and burning at planting time. Large areas of surface organic matter are also buried in the process. This burning gives an initial boost to fertility due to the potash in the ash, but is definitely harmful in the long run. As these are family estates the long term effects are the more important.

Under forest conditions and under tonka beans with quite a shrubby undergrowth there is little surface run-off as proved by the good condition of the traces, the sides of which cut at places 6 feet deep in the soil have neither slipped down nor have they had gulley's formed in them. All slopes up to 45° are cultivated, but it would be better to have about 30° slopes as the maximum. Slopes greater than 30° should be left in forest.

**SUGGESTIONS AND RECOMMENDATIONS:**

**Anti-erosion** - From observations on the estates and in the Mount St. Benedict area the presence of a good ground cover seems to reduce run-off and hence erosion, to a minimum. Production of ground cover is natural in citrus areas but under cacao ground cover is very sparse. Even when the cacao is young the tannias and bananas, most often used as initial shade, discourage the growth of other plants by their habit of growth. Therefore to prevent loss of soil the cacao should be planted on the less steep slopes. Unfortunately the citrus occupies this position on most estates due to ease in replanting when cacao prices were low. These lesser slopes tend to be the lower slopes as well, and if the positions of the cacao and citrus were reversed the transport costs would increase, owing to the more bulky nature of the citrus. This however should not be a limiting factor -
factor. Due to the nature of the land, narrow traces are all that can be made and are only suitable for mules with baskets for transporting the produce. Mechanisation will never be applied to any extent in such areas. Once the cacao was established on the lower slopes cutlassing should be reduced to a minimum, i.e., just prior to harvesting. This would encourage the growth of ferns and other plants, the roots of which would help to bind the soil together and the aerial vegetative parts of which in the raw state after cutlassing would mechanically impede surface run-off and in the decomposed state become incorporated in the soil and improve the percolation rate and water holding capacity of the soil.

On existing areas all extra and useless trees could be killed out by ring-barking the trunk and applying sodium arsenite. This chemical causes the tree to die and decay. On decomposition the tree falls down in small pieces at a time, and as a result little damage is done to the cacao underneath.

As already stated, much erosion takes place at planting time when the soil is left with no surface cover. Would it not be possible to cut the trees and leave them lying evenly across the slope and plant the tannias, bananas and cacao through them as is done in the teak plantations at Brickfield? This method was used by the Spaniards when they planted the area. Difficulties in walking over the area to plant would arise, and weeding would also be difficult, but this method is worth trying again. Where citrus is to be planted this method would be quite easy as the planting distances are greater. Cacao is planted 9 x 9 feet with no shade or up to 14 feet with shade. This close planting must produce soil erosion if planted on slopes. Grapefruit are planted 25 x 25 feet; oranges 17 to 22 feet apart and limes and lemons 15 - 20 feet apart. The trees may be planted to form squares or triangles.

Everything possible should be done to reduce the surface run-off. When cutlassing grass etc. the swaths should run across the hill. Felling useless trees across the slope where they will form soil barriers. By having the swaths of grass in the same position every year and by adding any surface stones and branches to the swaths a terracing effect will be produced.
produced in the course of time. This is preferred to mechanical terrace formation as no raw infertile subsoil will be brought to the surface, where it has to be weathered before being productive. An example of mechanical terracing can be seen at La Pastora where after quite a length of time the subsoil is still not fertile enough even to grow weeds. All terraces would have to be dug out by hand as most of the slopes are too steep for tractors. Drains and ditches should be dug as near to the contour as possible and never running straight down the slope.

Agriculture - The break away in specialising in one or two crops should be maintained, but not of course, to any great extent, for marketing difficulties will arise and storage sheds and space are limited on the estates.

It seems a great waste of a potential source of income to allow the bananas to mature and bear fruit and then to hack them up and leave them on the soil. The Mysore Fig most commonly grown is not even favoured by pigs as a food. Bearing in mind the chances of Panama Disease which is more prevalent in heavy clay wet areas and this does not describe the soil under consideration, a type of banana suitable for human consumption, and maybe export, could be grown for a cash return in the same place where these purely shade stools are growing.

Where land has been planted out with citrus there will be several years before there are cash returns. As these trees are small, some of the more highly priced vegetables might be grown throughout the area, such as peppers and okra and other bushy plants which could grow if the grass was kept short and irrigation available.

On both estates with their never failing water supply, there are the possibilities of small scale sprinkler irrigation for crops like tomatoes and lettuce in the dry season. This could easily be applied on the Maracas estate as the pipeline is of a sufficient diameter and the head of water about 800 feet.

Livestock keeping on the slopes should not be taken seriously, as animal tracks too often become gullies with little provocation. Any pen manure should be made full use of by applying round the base of trees and young plants especially where the soil is shallow.
A little experimentation would be beneficial in finding out what fertilisers need be applied. Both phosphate and potash seem to be in short supply according to the soil analysis. Only phosphate is applied on the Tierra Nueva estate and neither is applied on the Maracas estate. Nevertheless there cannot be much wrong with a system of agriculture that shows an increasing production after fifty years of continuous use as on the Tierra Nueva estate.

GENERAL CONCLUSIONS AND SUGGESTIONS

From the preceding pages it is shown that there is a place for permanent tree crop production in the hills of the Northern Range. This however is based purely on visual observations. From such observations made this year and by studying previous theses, there will be little addition to the information already known with regards to soil erosion in the hills due to agriculture. For more information, detailed work will have to be done, such as recording rainfall and its intensity and the varying amounts of run-off, and mechanical and chemical analysis of the water to find exactly what is being lost from the hills. To obtain these details three areas would be needed. Suitable areas are:

1. The water supply area for the La Pastora Land Settlement. This area is under natural forest and has not been interfered with by man. A dam is already there and measurement of the water flow would be quite easy. This area would give the value for the normal geological erosion taking place.

2. The more southerly valley on the Leotaud estate could be used. This area has been under a permanent tree crop (cacao) for a long time and the readings when compared with 1 will show the losses caused by man, but in an area that has not been disturbed lately.

3. The Floradale valley could be used to find the losses due to hill gardens.

Since citrus is being advocated in this report, a citrus area might be included as well. A scheme such as this would at least give actual figures to compare and one would not have to depend, as at present,
on visual symptoms which may be misleading.

Work would also need to be done to find the maximum slope on which the various crops with their varying ground covers could be grown without causing excessive soil losses. After finding the upper limit, the steeper areas should be left in natural forest and if necessary enforced by law. The main difficulty in all these surveys is the lack of time. The nine months Colonial Office Probationers stay in Trinidad is not long enough to get detailed and reliable results. Therefore to get results a staff member would need to take this matter seriously and recruit sufficient students each year to keep the records, and to do the actual work; the member of the staff seeing that the same thing is done each year in the same way. Records for several years are needed to account for climatic variation.

Various anti-erosion measures could be installed later and the reduction in soil loss due to them can be measured. A knowledge of the loss due to soil erosion is important, not only with regard to Trinidad, but also to the African territories where large areas are similar to the Northern Range. Any results for Trinidad will be applicable to Africa, with slight variations to meet the varying conditions.
ACKNOWLEDGMENTS

The writer wishes to give thanks to Dr. G. ap Griffith for the help and advice so willingly given during the course of this survey. To the Soil Science and Chemistry Department for analysing the soil samples. To Mr. Wackkind and his staff in the Works and Hydraulics Department in Port-of-Spain for providing rainfall data.

Lastly, but by no means the least, to Mrs. Anderson and Mr. Leotaud for spending much of their time in answering questions and searching through their records for crop yields, and to Mrs. Anderson's grandson - Dwight, who was official guide during visits to Maracas Estate.
<table>
<thead>
<tr>
<th>Description</th>
<th>Places</th>
<th>Slope</th>
<th>Depth (ins.)</th>
<th>MPS</th>
<th>Coarse (%)</th>
<th>Med. Fine (%)</th>
<th>I.T. (%)</th>
<th>Reaction</th>
<th>Norm exch</th>
<th>OM (%)</th>
<th>Total N (%)</th>
<th>C/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>CULTIVATED - Peasant cult. S/cane, Bananas, Tannia</td>
<td>Mt. St. Benedict</td>
<td>22</td>
<td>6</td>
<td>41.6</td>
<td>4</td>
<td>10</td>
<td>22</td>
<td>34</td>
<td>5.4</td>
<td>4.4</td>
<td>3.4</td>
<td>0.29</td>
</tr>
<tr>
<td>Old cultivated garden. Vegetables</td>
<td>-do-</td>
<td>nil</td>
<td>6</td>
<td>22.7</td>
<td>6</td>
<td>16</td>
<td>44</td>
<td>10</td>
<td>6.2</td>
<td>5.8</td>
<td>2.3</td>
<td>0.13</td>
</tr>
<tr>
<td>Top of garden. 2 yrs. cult. Peasant crops</td>
<td>Floradale</td>
<td>36</td>
<td>6</td>
<td>28.7</td>
<td>3</td>
<td>13</td>
<td>26</td>
<td>20</td>
<td>6.3</td>
<td>6.0</td>
<td>3.2</td>
<td>0.20</td>
</tr>
<tr>
<td>Foot of the above garden.</td>
<td>-do-</td>
<td>45</td>
<td>6</td>
<td>29.4</td>
<td>1</td>
<td>14</td>
<td>27</td>
<td>21</td>
<td>7.6</td>
<td>6.8</td>
<td>2.8</td>
<td>0.19</td>
</tr>
<tr>
<td>Newly cleared, burned &amp; planted.</td>
<td>-do-</td>
<td>32</td>
<td>6</td>
<td>26.3</td>
<td>1</td>
<td>13</td>
<td>42</td>
<td>15</td>
<td>6.6</td>
<td>6.1</td>
<td>2.9</td>
<td>0.17</td>
</tr>
<tr>
<td>UNCLEARED - Secondary bush</td>
<td>Floradale</td>
<td>32</td>
<td>6</td>
<td>25.7</td>
<td>5</td>
<td>12</td>
<td>47</td>
<td>13</td>
<td>6.1</td>
<td>5.2</td>
<td>3.2</td>
<td>0.16</td>
</tr>
<tr>
<td>RECENTLY ABANDONED peasant garden</td>
<td>Mt. St. Benedict</td>
<td>22</td>
<td>6</td>
<td>48.1</td>
<td>0</td>
<td>5</td>
<td>21</td>
<td>43</td>
<td>5.9</td>
<td>5.2</td>
<td>4.7</td>
<td>0.28</td>
</tr>
<tr>
<td>PLANTATION - Coconuts, Mangoes, Citrus - obvious erosion</td>
<td>-do-</td>
<td>15</td>
<td>6</td>
<td>35.5</td>
<td>1</td>
<td>5</td>
<td>19</td>
<td>31</td>
<td>5.6</td>
<td>5.1</td>
<td>3.0</td>
<td>0.28</td>
</tr>
<tr>
<td>Citrus. Valley bottom flat</td>
<td>-do-</td>
<td>nil</td>
<td>6</td>
<td>43.3</td>
<td>0</td>
<td>6</td>
<td>33</td>
<td>36</td>
<td>6.8</td>
<td>6.2</td>
<td>4.0</td>
<td>0.30</td>
</tr>
<tr>
<td>Citrus. Good ground cover. Mulch</td>
<td>Maracas</td>
<td>35</td>
<td>6</td>
<td>27.7</td>
<td>1</td>
<td>12</td>
<td>52</td>
<td>15</td>
<td>4.6</td>
<td>4.1</td>
<td>2.8</td>
<td>0.15</td>
</tr>
<tr>
<td>Citrus. Good ground cover. Mulch</td>
<td>-do-</td>
<td>15</td>
<td>6</td>
<td>27.3</td>
<td>2</td>
<td>11</td>
<td>56</td>
<td>14</td>
<td>4.5</td>
<td>3.9</td>
<td>3.0</td>
<td>0.15</td>
</tr>
<tr>
<td>Citrus. Good ground cover. Mulch</td>
<td>-do-</td>
<td>15</td>
<td>6</td>
<td>30.3</td>
<td>2</td>
<td>9</td>
<td>50</td>
<td>18</td>
<td>5.1</td>
<td>4.3</td>
<td>3.1</td>
<td>0.16</td>
</tr>
<tr>
<td>Cocoa. Undergrowth sparse - top of slope</td>
<td>-do-</td>
<td>38</td>
<td>6</td>
<td>26.1</td>
<td>1</td>
<td>14</td>
<td>42</td>
<td>15</td>
<td>8.3</td>
<td>7.9</td>
<td>1.7</td>
<td>0.15</td>
</tr>
<tr>
<td>Cocoa. Undergrowth sparse - foot of slope</td>
<td>-do-</td>
<td>38</td>
<td>6</td>
<td>29.4</td>
<td>1</td>
<td>3</td>
<td>40</td>
<td>19</td>
<td>8.0</td>
<td>7.5</td>
<td>2.3</td>
<td>0.15</td>
</tr>
</tbody>
</table>

+ pH value high due to presence CaCO₃ outcrop.
### APPENDIX II

Crop yields - Tierra Nueva Estate.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cacao</th>
<th>Coffee</th>
<th>Tonka beans</th>
</tr>
</thead>
<tbody>
<tr>
<td>1917</td>
<td>39,600</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1920</td>
<td>28,960</td>
<td>2,286</td>
<td>920</td>
</tr>
<tr>
<td>1925</td>
<td>25,570</td>
<td>2,814</td>
<td>431</td>
</tr>
<tr>
<td>1930</td>
<td>23,752</td>
<td>2,977</td>
<td>396</td>
</tr>
<tr>
<td>1935</td>
<td>23,919</td>
<td>1,608</td>
<td>5,940</td>
</tr>
<tr>
<td>1940</td>
<td>27,827</td>
<td>4,019</td>
<td>7,750</td>
</tr>
<tr>
<td>1945</td>
<td>18,006</td>
<td>2,154</td>
<td>5,637</td>
</tr>
<tr>
<td>1950</td>
<td>18,424</td>
<td>1,501</td>
<td>916</td>
</tr>
<tr>
<td>1951</td>
<td>17,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1952</td>
<td>28,000</td>
<td>300</td>
<td>-</td>
</tr>
</tbody>
</table>
### APPENDIX III - RAINFALL (Works & Hydraulics Department)

#### TABLE

<table>
<thead>
<tr>
<th>Year</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948</td>
<td>2.16</td>
<td>0.48</td>
<td>1.00</td>
<td>2.18</td>
<td>2.39</td>
<td>12.61</td>
<td>10.70</td>
<td>7.94</td>
<td>7.82</td>
<td>9.79</td>
<td>7.13</td>
<td>1.22</td>
<td>64.22</td>
</tr>
<tr>
<td></td>
<td>1.56</td>
<td>0.33</td>
<td>1.11</td>
<td>0.83</td>
<td>2.51</td>
<td>11.50</td>
<td>7.90</td>
<td>8.44</td>
<td>6.91</td>
<td>6.91</td>
<td>6.17</td>
<td>1.57</td>
<td>57.44</td>
</tr>
<tr>
<td>1949</td>
<td>0.65</td>
<td>1.98</td>
<td>0.45</td>
<td>0.34</td>
<td>2.85</td>
<td>11.52</td>
<td>8.94</td>
<td>12.50</td>
<td>8.12</td>
<td>7.90</td>
<td>7.45</td>
<td>7.82</td>
<td>70.52</td>
</tr>
<tr>
<td></td>
<td>0.30</td>
<td>1.05</td>
<td>0.81</td>
<td>0.08</td>
<td>1.48</td>
<td>9.24</td>
<td>6.31</td>
<td>8.53</td>
<td>3.98</td>
<td>6.81</td>
<td>8.38</td>
<td>8.21</td>
<td>55.28</td>
</tr>
<tr>
<td></td>
<td>0.45</td>
<td>0.56</td>
<td>2.32</td>
<td>7.67</td>
<td>10.49</td>
<td>4.87</td>
<td>5.53</td>
<td>5.88</td>
<td>11.30</td>
<td>64.16</td>
<td>10 mths.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950</td>
<td>6.14</td>
<td>4.53</td>
<td>1.60</td>
<td>2.28</td>
<td>2.70</td>
<td>11.05</td>
<td>9.09</td>
<td>13.32</td>
<td>5.71</td>
<td>9.20</td>
<td>4.64</td>
<td>6.71</td>
<td>76.97</td>
</tr>
<tr>
<td></td>
<td>7.08</td>
<td>5.78</td>
<td>1.14</td>
<td>2.09</td>
<td>3.49</td>
<td>10.54</td>
<td>7.00</td>
<td>13.02</td>
<td>4.93</td>
<td>8.72</td>
<td>7.10</td>
<td>5.94</td>
<td>76.83</td>
</tr>
<tr>
<td></td>
<td>15.47</td>
<td>7.30</td>
<td>3.50</td>
<td>2.28</td>
<td>2.75</td>
<td>13.64</td>
<td>8.80</td>
<td>13.47</td>
<td>6.08</td>
<td>6.43</td>
<td>10.12</td>
<td>3.55</td>
<td>93.39</td>
</tr>
<tr>
<td>1951</td>
<td>5.86</td>
<td>11.48</td>
<td>2.85</td>
<td>3.15</td>
<td>8.71</td>
<td>14.05</td>
<td>11.94</td>
<td>10.56</td>
<td>11.45</td>
<td>4.31</td>
<td>7.39</td>
<td>3.35</td>
<td>95.10</td>
</tr>
<tr>
<td></td>
<td>5.95</td>
<td>9.60</td>
<td>3.09</td>
<td>0.72</td>
<td>7.82</td>
<td>12.87</td>
<td>9.49</td>
<td>10.97</td>
<td>5.26</td>
<td>5.08</td>
<td>7.12</td>
<td>2.96</td>
<td>80.93</td>
</tr>
<tr>
<td></td>
<td>6.85</td>
<td>15.60</td>
<td>10.41</td>
<td>2.14</td>
<td>9.09</td>
<td>10.70</td>
<td>7.90</td>
<td>8.37</td>
<td>8.08</td>
<td>4.27</td>
<td>9.33</td>
<td>3.82</td>
<td>96.56</td>
</tr>
<tr>
<td>1952</td>
<td>0.98</td>
<td>1.34</td>
<td>1.07</td>
<td>2.26</td>
<td>0.98</td>
<td>1.28</td>
<td>1.37</td>
<td>0.53</td>
<td>2.06</td>
<td>1.19</td>
<td>1.03</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Maracas - Ortinola Estate)

(continued...