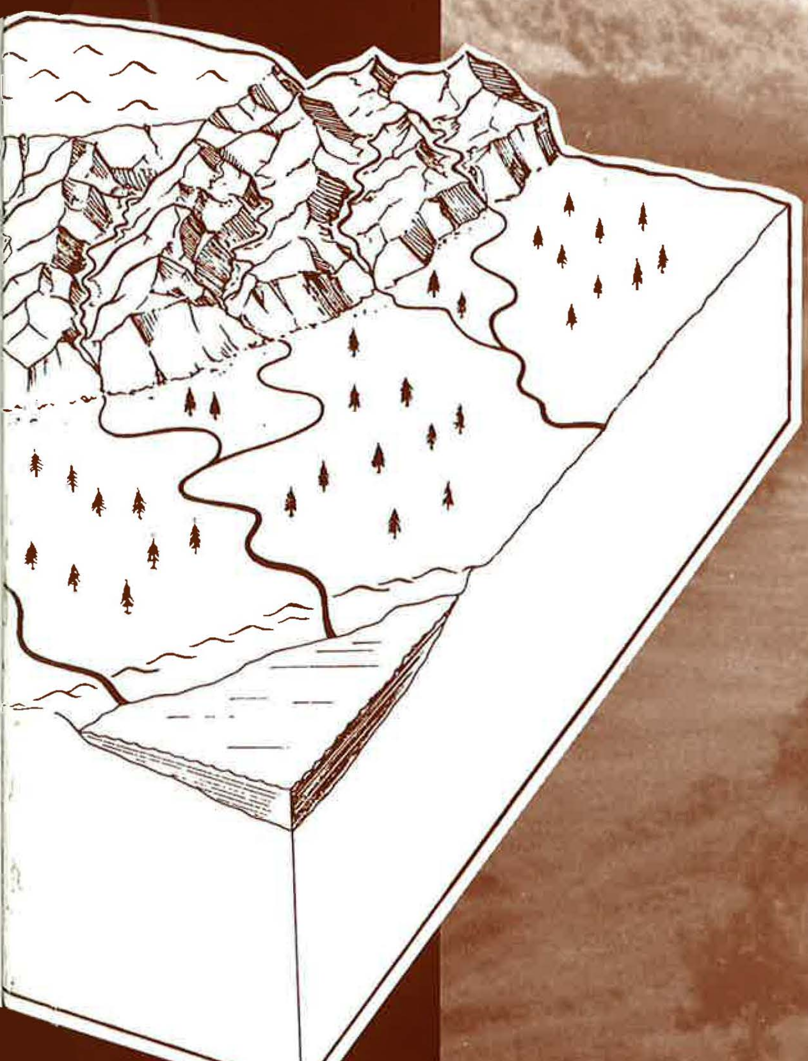
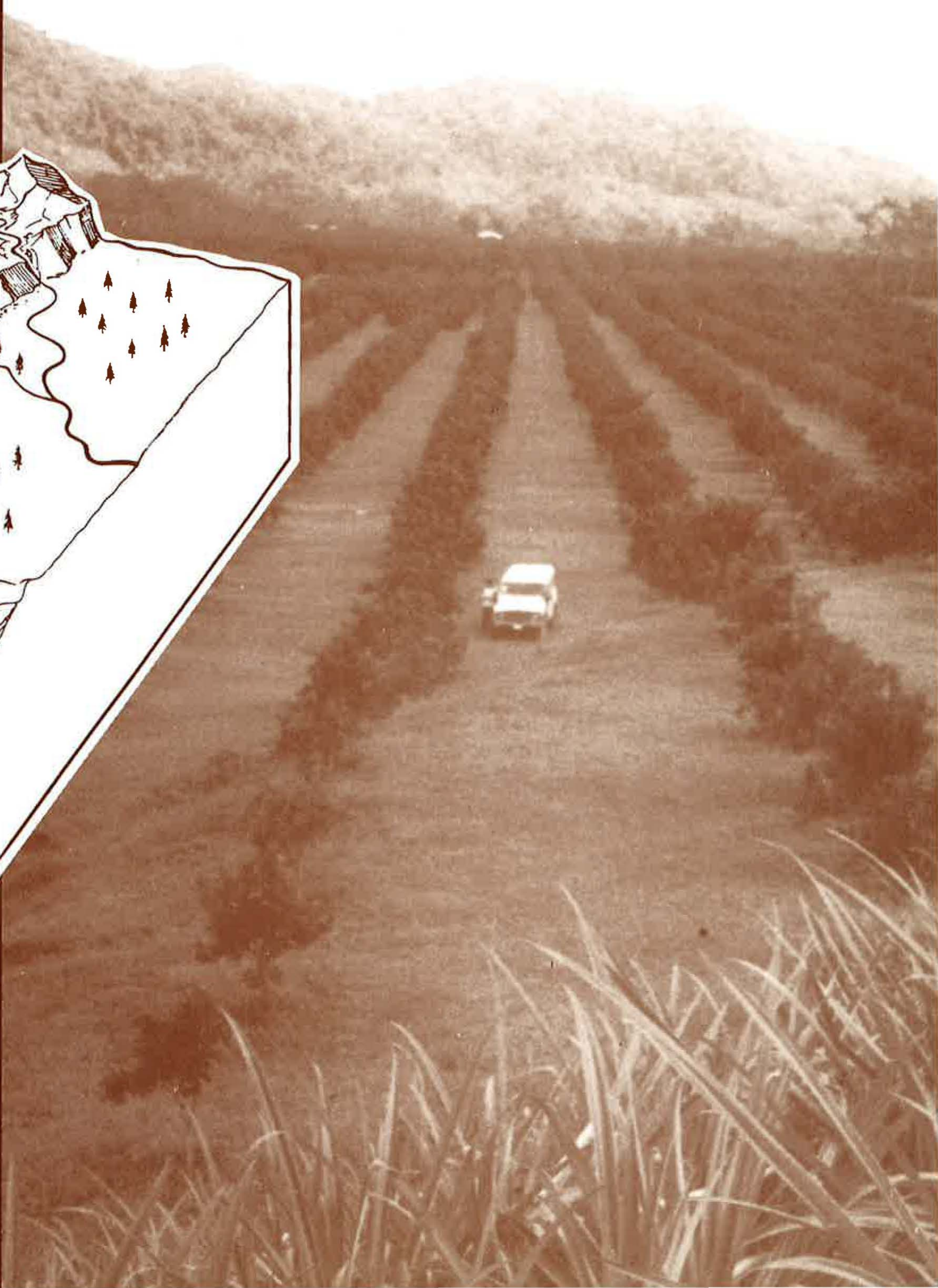
Agricultural development prospects in Belize (NRI Bulletin 48)

Natural Resources Institute

Bulletin 48

AGRICULTURAL DEVELOPMENT PROSPECTS IN BELIZE





Overseas
Development
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AGRICULTURAL DEVELOPMENT PROSPECTS IN BELIZE

R. B. King, J. H. Pratt, M. P. Warner and S. A. Zisman

Bulletin 48

Natural Resources Institute

The scientific arm of the
Overseas Development Administration

The Natural Resources Institute (NRI) is an internationally recognized centre of expertise on the natural resources sector in developing countries. It forms an integral part of the British Government's overseas aid programme. Its principal aim is to alleviate poverty and hardship in developing countries by increasing the productivity of their renewable natural resources. NRI's main fields of expertise are resource assessment and farming systems, integrated pest management, food science and crop utilization.

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Mr Barry Bowen very kindly gave us accommodation during the Programme for Belize meeting in May (1991).

Abbreviations

AMCL	Agricultural and Management Consultants Ltd
BABCO	Belize Agribusiness Company
BBC	Belize Beef Corporation
BCB	Banana Control Board
BCES	Belize Center for Environmental Studies
BFP	Belize Food Products
BGA	Banana Growers' Association
BLDP	Belize Livestock Development Project
BMB	Belize Marketing Board
BSI	Belize Sugar Industries Ltd
BTB	Belize Tourist Board
BTIA	Belize Tourism Industry Association
CARE	Cooperative for American Relief Everywhere
CCB	Citrus Company of Belize
CDB	Caribbean Development Bank
CEC	cation exchange capacity
CGA	Belize Citrus Growers' Association
COD	chemical oxygen demand
CSO	Central Statistical Office
DFC	Development Finance Corporation
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization
FD	Forestry Department
FOB	freight on board
g	gram
GIS	Geographical Information System
GNP	gross national product
GOB	Government of Belize
h	hour
ha	hectare
HHL	Hummingbird Hershey Ltd
ICBP	International Council for Bird Protection
IFAD	International Fund for Agricultural Development
IRR	internal rate of return
IUCD	International Union for the Conservation of Nature
km	kilometre
kg	kilogram
l	litre
lb	pound
LIC	Land Information Centre
LIS	Lands Information Service
LMBSF	Laguna Madre Belize Shrimp Farm Ltd
LRD	Land Resources Department
LSS	Land Suitability Survey
m	metre
MCCC	Maya Community Cultural Council .
me	milliequivalents
MED	Ministry of Economic Development
NGOs	Non Governmental Organizations

NRI	Natural Resources Institute
ODA	Overseas Development Administration
PAC	Protected Area Commission
PACA	Proyecto Ambiental Para Centro America
PCB	Pesticide Control Board
ppm	parts per million
SWOT	Strengths - weaknesses - opportunities - threats
t	tonne
TAMP	Toledo Agricultural Marketing Project United
UNDP	United Nations Development Programme
TEA	Toledo Ecotourism Association
TFAP	Tropical Forestry Action Plan
USDA	United States Department of Agriculture
WASA	Water and Sewage Authority
WWF	World Wildlife Fund

Note

Imperial units are regularly used in Belize and in this Bulletin metric conversions are given in brackets. For land areas, metric units were generally used in the original text but, for consistency, imperial conversions are given with the metric unit in brackets. Conversions are not given where the difference between the metric and imperial is minimal or insignificant, where conversion is not appropriate, for original data in tables and figures and, in some cases, where other information is already given in brackets.

Summaries

SUMMARY

This report is one of three documents completing the land resource assessment of Belize undertaken by the Natural Resources Institute (NRI) from 1986-90. The other documents are:

(i) a revised national soil classification (Baillie *et al.*, 1993)

(ii) an update on 'Land in British Honduras' (Wright *et al.*, 1959), which will present *inter alia* much of the NRI land resource assessment findings in a more easily readable format (Wright *et al.*, 1993).

The documents were compiled in Belize over the period 23 April to 23 July 1991 by the following team:

R. B. King	Land resources specialist (team leader)
I. C. Baillie	Soil surveyor
A. C. S. Wright	Soils adviser 1
S. A. Zisman	Environmental consultant
M. A. Holder	Soils adviser 2
J. H. Pratt	Economist
E. A. FitzPatrick	Soil classification specialist
M. P. Warner	Student

The aim of this report is to assess the entire agricultural resources of the country, present an assessment of how they can be used to best effect, both in the short (economically) and long terms (by protecting the environment), and present a 1:500 000 scale map indicating the preferred use for each part of the country (Map 1). Map 1 does not take into account current ownership, except in the case of Programme for Belize, where it is assumed that organization will continue to manage the Rio Bravo Conservation Management Area. This report also includes advice on how a Geographical Information System (GIS) can be used to update the NRI surveys and provide additional data so that the suitability of new crops and the effect of changed economic circumstances can be determined from the land resource assessment database.

Part 2

1. Development recommendations for each land system are given. Appendix 1 gives an alphabetical listing of land systems, indicating under which section in Part 2 they are described.

Part 3

2. Part 3 investigates the economic potential of each crop, mainly concluding that citrus appears to have the best long-term opportunity for small farmers. The cattle industry should not be intensified until suitable export market industries have been identified and developed; and the banana industry should not be expanded until it can be proved that the industry can sustain the set-backs of winter chill and disease. The sugar-cane market is saturated, although sugar-cane provides a high internal rate of return for current farmers. Cacao production is currently uneconomic, but it might be a worthwhile gamble as there are signs that the world price is bottoming out after its 15-year fall. Shrimp mariculture is

beginning to look encouraging. Export markets for intensive fruit production under irrigation have now been determined.

Part 4

3. The extent of current environmental damage is small.

4. The intention to protect most of the Maya Mountains and 'Rio Bravo' will ensure a fifth of the country's land area is under forest.

5. Recommended limits to cultivation for different geological materials and slopes are indicated. (For ease of reference, those land systems associated with the different parent materials are listed.)

6. Environmental assessments for the major agricultural industries are given; and recommendations to ensure least environmental damage by development of infrastructure are provided.

7. Enforcement of environmental protection is more crucial than environmental legislation. Enforcement is likely to be successful only if there is local acceptance of the need for environmental protection.

8. The possibility of integrating plantation forestry with livestock intensification should be investigated as part of the Tropical Forestry Action Plan (TFAP).

9. The proposal to set aside a plantation forest to provide a constant firewood supply for the white lime industry needs urgent investigation, to prevent the industry contributing to further deforestation. The investigation should be compared with the alternative option of obtaining lime from a quarry and applying it straight to the citrus plantations to provide a slower but more continuous supply of lime. This investigation should also be part of the TFAP.

10. The disregard for protection of riparian forest during land clearance for agriculture is a major cause of environmental concern.

11. Investigations into ecotourism development have revealed some resentment among local populations. Methods of working more closely with local populations are suggested.

12. An environmental specialist with experience of the effects of agricultural pollution on subtropical brackish lagoons and nearshore environments (with special reference to manatees), should be commissioned as soon as possible.

13. Criteria for the selection of protected areas are described and considered.

Part 6

14. The agricultural potential of the country is assessed: 990 km^2 (4% of the total land area of the country) is class 1 (high income potential); 2790 km^2 (12% of the country), class 2 (good chance of financial success); 4480 km^2 (20% of the country), class 3 (success subject to skilled management); 4670 km^2 (20% of the country), class 4 (marginal even with skilled management); and 10 040 km^2 (44% of the country), class 5 (mainly steep slopes).

15. Classes 1 and 2 are recommended for agriculture, class 3 for forest management and production but made available to smallholders as the need arises, class 4 for forest management and production, and class 5 for protection forest.

16. The potential land use for each district is assessed.

RESUMEN

Este reporte es uno de tres documentos que acompleta un estudio de recursos terrenales tomado por el Instituto de Recursos Naturales (NRI) durante los anos 1986-90. Los otros documentos son:

(i) una clasificación de suelos de la nación (Baillie *et al*, 1993);

(ii) un reporte sobre 'Tierra en Honduras Britanica' (Wright *et al.*, 1959), cual presentara entre otros, información sobre estudios de recursos terrenales facíl de leer (Wright *et al.*, 1993).

Los documentos fuerón compilados en Belice durante el periodo 23 Abril a 23 Julio 1991 por el siguiente grupo:

R. B. King	Especialista en recursos terrenales
I. C. Baillie	Agrimensor de suelos
A. C. I. Waight	Consejero de suelos 1
S. A. Zisman	Consultante sobre el medio ambiente
M. A. Holder	Consejera de suelos 2
J. H. Pratt	Economista
E. A. FitzPatrick	Especialista en classificacion de suelos
M. P. Warner	Estidiante

El objective de èste reporte es estudiar los recursos agricolas del país, hacer una presentación de como hacer mejor uso, tanto a corto (economicamente) como en largo plazo (protegiendo el medio ambiente) y presentar un mapa a escale 1:500 000 indicando el mejor uso para cada sección del país (Map 1). Mapa 1 no toma en cuenta al proprietario actual, excepto en el caso del Programa para Belice, donde se supone que esta organización continuara dirigiendo el manejo de conservación del area del Rio Bravo. Este reporte tambièn, contiene información de como hacer uso del Sistema de Información Geografica (GIS) para informar el estudio NRI y proveer información adicional para poder determinar la conveniencia de nuevas cosechas y el efecto de cambios economicos por medio de tranitación automatica hecho por el estudio de recursos terrenales.

Parte 2

1. Recommendaciones desarrolladas so dadas para cada sistema de terrenos. Apendice 1 muestra una lista de sistemas de tierra alfabeticamente, indicando debajo deque seccion en Parte 2 estan descritas.

Parte 3

2. Parte 3 investiga el potencial economico de cada cosecha, principalment concluyendo que el citrico parece dar la más grande oportunidad al labrador. La industria ganadera no debe ser intensificada hasta no identificar y desarollar un mercado adecuado de Industria exportadora; y la industria bananera no debe ser expandida hasta que se pueda probar que la industria es capaz de sostener atrasos de fríos invernales y enfermedades. El mercado azucarero esta saturado; aunque aun la caña provee a los actuales un alto porcentaje de ganancias. La producción de cacao actualmente es factible, pero podría ser un juego que valga la pena ya que hay señales que el precio mundial esta aumentando despuès de su caída hace quience años. La crianza de camarones comienza a verse alentadors. Mercados exportadores para la producción frutal intensiva de irrigación ya han sido determinados.

Parte 4

3. La cantidad de daño corriente del medio ambiente es minima.

4. El intentar protejer la mayor parte de las Montañas Mayas u 'Rio Bravo' asegurara que un quinto de la tierra del apís sea forestal.

5. Recommendaciones limitadas para el cultivo de diferentes materiales geologicos y encuestas estan indicados. (Para referencia, esos sistemas de terrenos con las diferentes fuentes materiales estan en lista.

6. Se estan dando estudios sobre el medio ambiente para las industrias especializadas en agricultura; y recomendaciones garantizando menor daño al medio ambiente por el desarrollo de la infrastructura proveída.

7. Ejecución de protección del medio ambiente es mas penoso que la legislación del medio ambeinte. Ejecución es probable de lograr solamente si hay aceptación local para la necesidad de protección del medio ambiente.

8. La posibilidad de integrar plantación forestal intensificade con ganadería debe ser investigado como parte del Plan de Acción de Bosque Tropical (TFAP).

9. La propuesta de poner a un lado una plantación forestal para proveer constante leña para la industria de cal necesita investigación urgente, para impedir que la industria contribuya mas deforestación. La investigación debe compararse con la opción alternativa de obtener cal de una pedrera y aplicarlo directamente a las plantaciones citricas para proveer mas despacio per continuamente la demanda de cal. Esta investigación tambièn debe ser parte del TFAP.

10. La desatención para la protección del bosque desgarrado durante aclaración de tierra para agricultura es una de las razones principales de mucha preocupación sobre el medio ambiente.

11. Investigaciones sobre el desarrollo de ecoturismo han revelado un poco de resentimiento entre ciudadanos locales. Metodos para trabajar mas cerca con ciudadanos locales son sugeridos.

12. Un especialista en el medio ambiente con experiencia en los efectos de contaminación en agricultura en lagunas salubricas subtropicales (con referencia especial a manatis), debe ser oficiado lo mas pronto posible.

13. Criterio para la selección de areas protejidas son descritas y consideradas.

Parte 6

14. El potencial agricola del país es estudiada: 990 km^2 (el 4% del area total de terrenos del país) es de clase 1 (alto ingreso potencial); 2790 km^2 (el 12% del pais), clase 2 (buena oportunidad para exito financiero); 4480 km^2 (el 20% del pais), clase 3 (exito es sujeto a dirección de expertos); 4670 km^2 (el 20% del país), clase 4 (es marginal aun con la dirección de expertos); y 10 040 km^2 (el 44% del país), clase 5 (pendiente excesiva).

15. Clase 1 y 2 recomendadas para agricultura, clase 3 para menejo forestal y producción pero èsta puesta a la disposición de pequeños agricultores cuando haya la necesidad, clase 4 para la producción y el manejo forestal, y clase 5 para protección forestal.

Part 1

Introduction

THE COUNTRY

Belize has a land area of 8860 mile^2 (22 963 km^2) (Hartshorn *et al.*, 1984). It borders Mexico in the north, Guatemala in the west and south and the Caribbean Sea in the east (Figure 1). The country is divided into six districts: Corozal and Orange Walk in the north, Cayo in the west, and Belize, Stann Creek and Toledo progressing southwards down the eastern side of the country. It has a seasonal tropical rainy climate with annual rainfall of over 150 inches (4000 mm) in the south descending to 55 inches (1400 mm) in the north. The natural vegetation is mostly broadleaf forest with pine savanna on the poorer soils.

The south-western part of the country is dominated by the Maya Mountains (reaching a maximum height of 3688 ft (1124 m)) consisting of Carboniferous to Permian metasediments with granitic intrusions. The mountains are surrounded by mainly Cretaceous limestone karst foothills. The rest of the country consists of Tertiary to recent limestone and alluvium.

The total population is only 190 792 (Central Statistical Office (CSO) provisional population figure from the 1991 census). The main agricultural activities are growing sugar-cane in the north, citrus in the centre, and bananas and subsistence 'milpa' slash-and-burn agriculture in the south.

Much of the mahogany (*Swietenia macrophylla* King) has been logged and "the bulk of the available resource is in secondary hardwoods" (ODA, 1989). The low population density 21 people/mile^2 (eight/km^2) has ensured most of the forest is still intact, although disturbed, but the widespread interest in growing citrus, and the expansion of the Mennonite communities are leading to the destruction of large areas of forest. Nevertheless the intention to protect most of the Maya Mountains and the private estates in the north-west of the country (under Programme for Belize) should ensure protection of a fifth of the country's land area, so that with this protection alone, the country would be making a greater contribution to environmental conservation than most countries.

PROJECT BACKGROUND AND DESCRIPTION

Since 1986 the Natural Resources Institute (NRI) has undertaken a series of surveys and assessments of the renewable natural resources of Belize; with associated land systems and land-use maps at a scale of 1:100 000. Each survey - Toledo, Stann Creek and northern Belize - was planned, executed and reported separately (King *et al.*, 1986, 1989, 1993 respectively). The northern Belize report also incorporated the semi-detailed survey of the Belize Valley (Jenkin *et al.*, 1976) into the land system framework (see Part 2 for review of land system terminology), so that the whole of Belize is now mapped according to the land system and Food and Agriculture Organization (FAO) land suitability (FAO, 1976) frameworks. Altogether there are seven land systems maps: four for northern Belize, one for Stann Creek District, and two for Toledo District.

This report considers the agricultural development prospects of the country as a whole, as well as paying attention to environmental protection, which was only cursorily considered in the previous surveys. In addition, every subunit has been classified according to a range of agriculturally important variables, so that all crop suitabilities can be considered, other than those considered in the

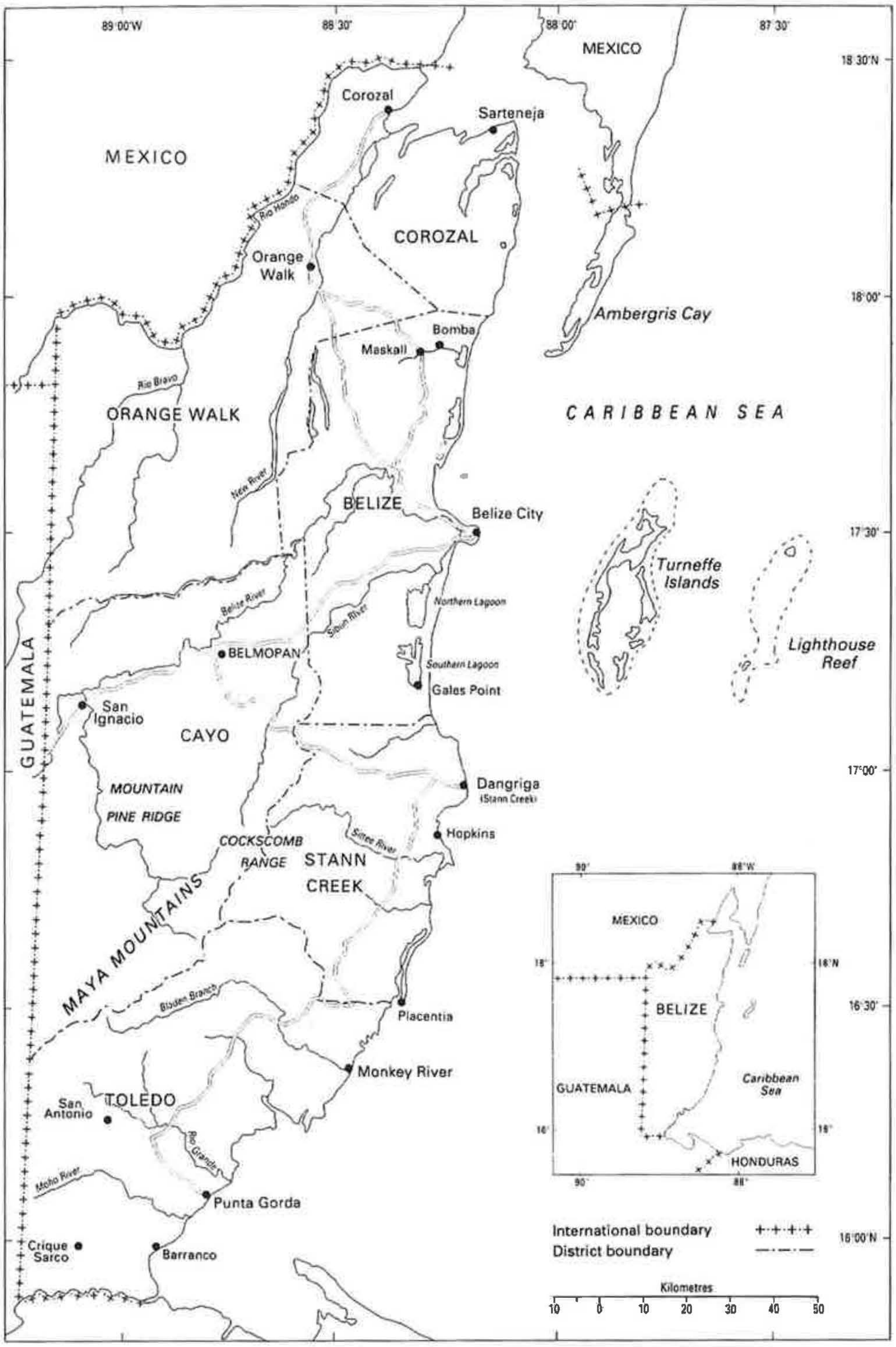


Figure 1 Map of Belize

individual reports. The report concludes with a review of how we think the various parts of the country should be developed or protected, based almost entirely on physical criteria.

Concomitant with this report, Mr Charles Wright is producing a crisp update on his 'Land in British Honduras' (Wright *et al.*, 1959), whose main purpose is to present the information gathered in the NRI surveys into a more easily readable format (Wright *et al.*, 1993). It is aimed at sixth-form level, and will be entitled 'Land of Belize'.

By re-examining all the soils information collected in the NRI surveys, the Belize Valley report (Jenkin *et al.*, 1976) and the original 'Land in British Honduras', a definitive national soil classification has been produced, and will appear as a separate report (Baillie *et al.*, 1993).

TERMS OF REFERENCE

1. To provide a profile of national agricultural and environmental potential whereby different regions and localities have different development and environment requirements.
2. To assess the general agricultural, environmental and other potential productive value for each land unit mapped by the NRI surveys, including the Belize Valley.
3. To produce a definitive national soil classification.
4. To provide advice on the range of slopes and soils which need protection.

Part 2

Physical environment

REVIEW OF LAND SYSTEM TERMINOLOGY

The NRI team used the land system method of mapping for its land resource assessments (King *et al.*, 1986, 1989, 1993) because it was considered the most suitable method of mapping in the humid tropics at 1:100 000 scale. A land system is defined as "an area with a recurring pattern of topography, soils and vegetation" (Christian and Stewart, 1953); so that a land system consists, for example, of a recurring pattern of limestone landforms under broadleaf forest, whereas another might consist of deep soils on an undulating plain under pine and oak savanna (Figure 2).

Land systems can be grouped according to similar characteristics regardless of their location, called here and in the northern Belize report, 'land system types'; or physiographically according to similar characteristics but forming a continuous landscape, which in the land system methodology (Brink *et al.*, 1966) is called a land region. The following land regions have been demarcated in Belize (Figure 3):

Maya Mountains

Bravo Hills
Central Foothills
Western Uplands
Eastern Foothills
Toledo Foothills (called 'Southern Foothills' in Wright *et al.* (1993)

Northern Coastal Plain
Central Coastal Plain
Southern Coastal Plain

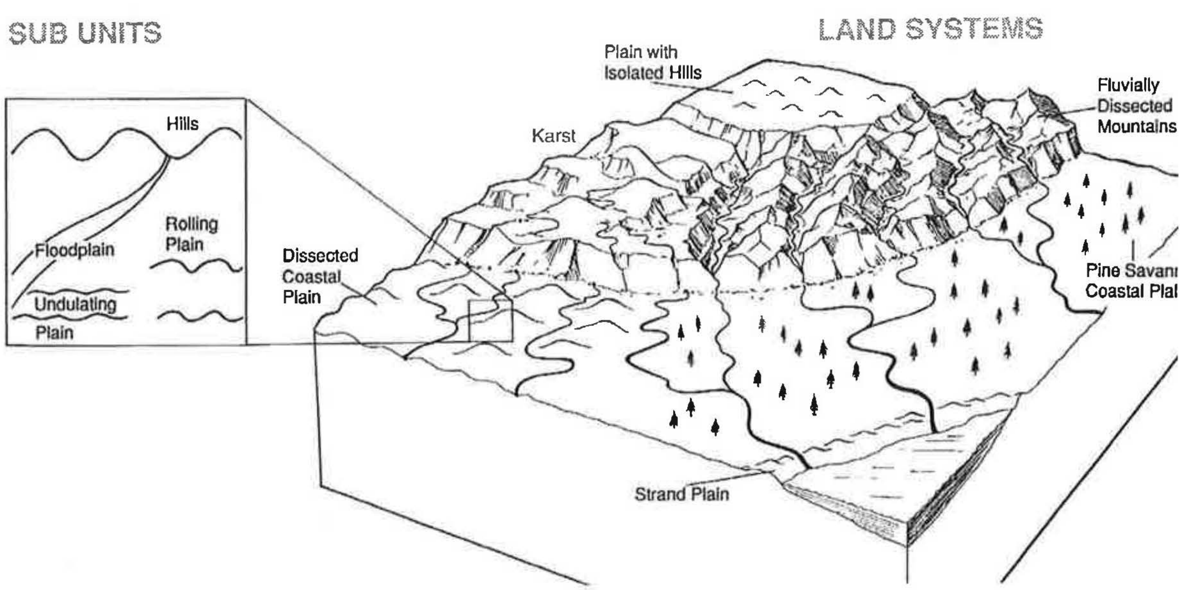


Figure 2 Land system examples

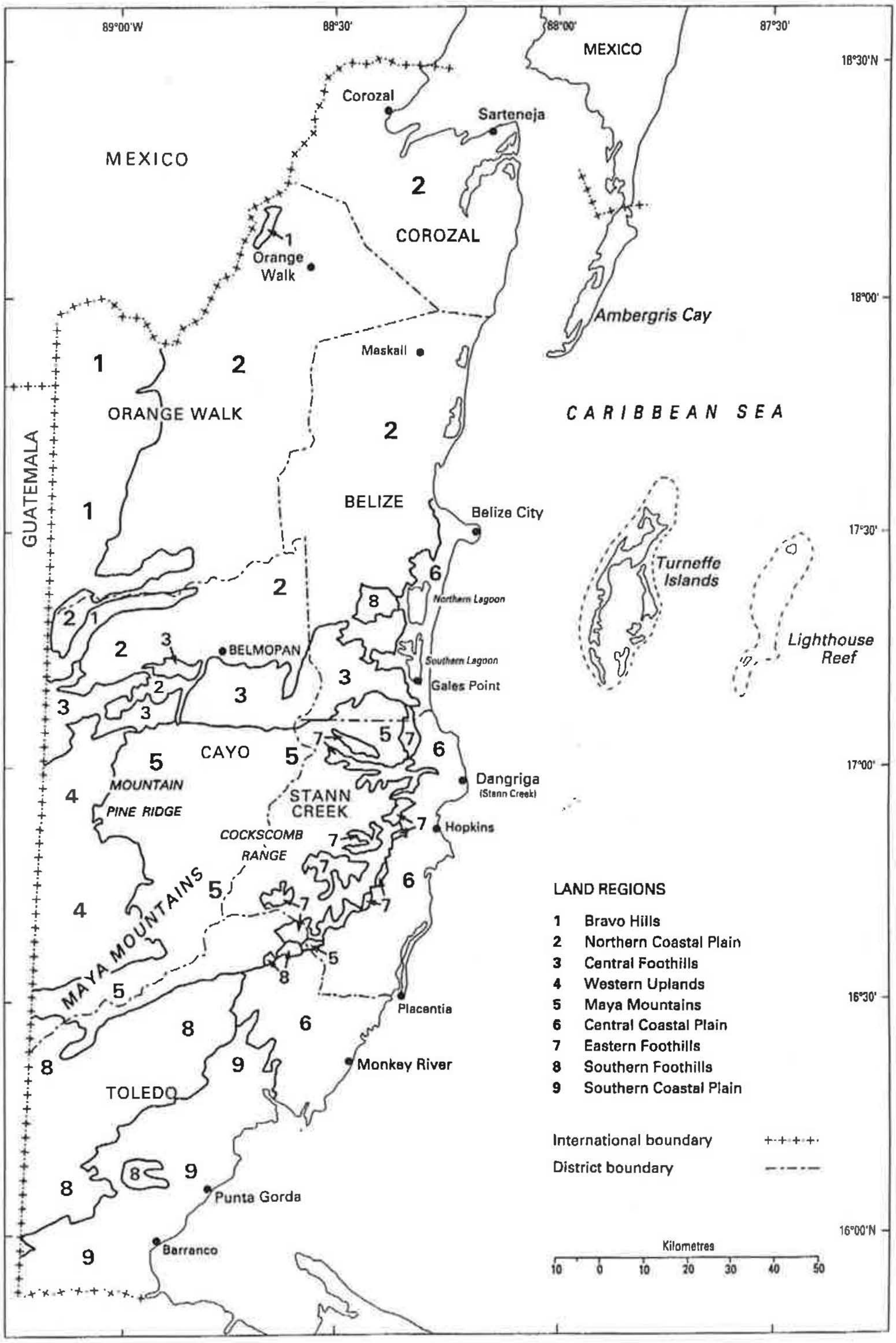


Figure 3 Land regions of Belize

According to the agreed land-system terminology of Brink *et al.* (1966), land systems are subdivided into land facets, each of which have uniform or near uniform agricultural potential, but they are not mapped at the recommended land system mapping scale of 1:250 000 to 1:1 000 000. Land facets have been mapped at 1:50 000 scale in drier environments than Belize (e.g. Murdoch *et al.*, 1976), but the high drainage density of the Belizean environment prevents land facet mapping at 1:100 000 scale. Instead a 'subunit' level of mapping was chosen, representing:

(i) land facets where they are large enough to be mapped, e.g. along the main lowland river valleys

(ii) areas within the land system with distinctive angle of slope or land relief, e.g. rolling from undulating plain, low from high karst

(iii) areas with a dominating soil type.

Each land system is named after its main soil type (e.g. Xaibe Plain), or after a local district or place name (e.g. Stann Creek Coastal Floodplains or Round Hole Plain). Some land systems are found over a wide area outside the district from which they originally took their name, e.g. Richardson Peak Mountains.

Each land system is represented by a two-letter symbol, which is used to indicate the land system on the maps. The first letter usually refers to the district or nearest local centre where the land system was first recognized. The second letter signifies the land system type. Some land systems are given a different name in each of the three surveys because of their equal local significance, e.g. TY is called Toledo Saline Swamps in Toledo District, Stann Creek Saline Swamps in Stann Creek District and Belize Saline Swamps in Belize District. The constant two-letter symbol signifies there is no significant difference between their occurrences in different districts.

LAND SYSTEM TYPES

The concept of land system type was foreseen in the Toledo report and used in the Stann Creek report to indicate 'local variations' of a land system, mainly on the basis of soil type - the land system variant concept in Brink *et al.* (1966). In the much larger area of northern Belize, however, the concept was necessarily extended wider, to symbolize the greater variety of land systems found there. In the northern Belize report, it was used as a convenient method of classifying land systems. Although the necessarily *extempore* method of mapping has produced some inconsistencies, the land system type concept does indicate the type of terrain that can be expected. Land system types are mainly associated with local relief, and because agricultural potential is generally greater on lower relief, there are only a few land system types associated with the Maya Mountains, more with the five hilly land regions, but most are on the coastal plains. Appendix 1 gives an alphabetical listing of land systems indicating under which of the following sections they are described.

MAYA MOUNTAINS

Rugged land system type (R)

The Richardson Peak Mountains (TR) land system represents three-quarters of the Maya Mountains land region. As the name and first symbol suggest, it was first recognized in Toledo District, although it is mostly found in Stann Creek District, where it occupies half the district. Its slopes are steep, its soils are shallow, and its best use is forest protection.

The Copetilla Mountains (CR) have similar slopes to the Richardson Peak Mountains but have older more leached soils. The Chiquibul Valleys (TC) land system was demarcated in the Toledo report along the northern border of Toledo District because, although its slopes are as steep as those in the Richardson Peak Mountains, the local relief is lower and it was thought it might have some agricultural potential in the more gentle slopes in Cayo District to the north; but during the northern Belize survey, it was decided to incorporate it into the Richardson Peak Mountains because, by then, the angle of slope had been decided as the distinguishing criterion for the Richardson Peak Mountains (rather than local relief), and the area of gentle slopes was allocated to other relevant land systems.

Plateau land systems

There are three plateau land systems within the Maya Mountains land region, two of which - the Palmasito (TL) and Chapayal (VL) occur in remote areas and have shallow soils. The other, the Mountain Pine Plateau (MP), occupies a larger area and is covered in pine forest.

Mountain Pine Plateau (MP)

The soils of the Mountain Pine Plateau are very leached causing acidity and nutrient deficiencies and imbalances. Subsoils are either compact (Pinol Subsuite over granite) or rather shallow and droughty (Cooma and Baldy Subsuites over metasediments). The plateau is considered moderately to marginally suitable for pasture, and the Cooma soils possibly marginally suitable for citrus and vegetables, but it should best remain under forest management with recreational and tourist facilities. It should be noted the soils are very erodible (Francek, 1988), and the plateau is a major source of water for most of central Belize.

Valley land systems

In the bottom of several valleys, the slopes are occasionally gentle enough to form landscapes more typical of the Ossory Plain with Hills (SO) land system, discussed under the 'Hills land regions' section. More importantly, the valley bottoms are sometimes wide enough for the accumulation of bouldery alluvium. These areas are demarcated as the Maya Mountains Floodplains (MF). Some have good agricultural potential and are used for growing citrus in the Sittee River valley, but most of them are too remote as are the occurrences of the Ossory Plain with Hills land system within this land region.

HILLS LAND REGIONS

Where slopes are less steep so that they can be used for agriculture, the soil type dominates development prospects. Geology governs the soil type in the young landscapes of the Hills land regions. Geological information on Belize can be found in Geology and Petroleum Office (1986) for the most recent national assessment, which accompanies the most recent provisional geological map of Cornec (1986). Other geological references are Baldwin (1986), Dixon (1956) ,Flores (1952) and Bateson and Hall (1977). Brief geological chapters are also in the NRI reports and Wright *et al.* (1959). The main geological formations are:

Recent alluvium
Tertiary (?) to Pleistocene alluvium
Cenozoic limestone
Early Tertiary Toledo Beds
Cretaceous limestone
Late Paleozoic Santa Rosa Group metasediments
Granite

Land systems on limestone

The Maya Mountains are surrounded by four hilly land regions which, except for the dispersed Eastern Foothills, are mostly composed of hard Cretaceous limestone. The Bravo Hills is another limestone hills land region in the north-west of the country. The most common land system type is karst, covering 80%

of the Hills land regions. The characteristics of the individual karst land systems, together with the similar OD, OA and OQ land systems, are indicated in Table 1. Karst and steep slopes should be left under protective forest. Gentler slopes are mostly suitable for smallholder agriculture and pasture.

Two other limestone land systems occur in the north of the Bravo Hills: Neustadt (NK) and Blue Creek (NH) plains, characterized by flinty Jolja soils which restrict rooting and contribute to moisture deficiency. The land is mainly used for pasture. Another two land systems on limestone occur near San Ignacio in the Central Foothills land region: Ramonal Hills (IK) and Hermitage Plain (IZ). They both have undulating and rolling plains as their main subunits and shallow Yalbac soils as their main soil type. The Hermitage Plain was originally demarcated as the area covering the plateau south-west of San Ignacio with Ramonal Hills as the surrounding hills but, in retrospect, the two land systems should perhaps be merged into one. They are both under widespread cultivation and are probably best suited to pasture, maize and beans.

Toledo Uplands (TU)

The Toledo Uplands is the only land system on the Toledo Beds in the Hills land regions. They cover 104 mile^2 (269 km^2) and are inherently some of the most fertile and physically workable soils in the country, but have been overused by the 'milpa' slash-and-burn cultivation system, so that there is pressure to use the surrounding steep, less fertile and shallow limestone slopes, and/or shorten the fallow period, thus reducing soil productivity.

Various organizations have investigated ways of trying to increase sustainable productivity. The Toledo Research and Development Project achieved the greatest success, not with their lowland mechanized rice projects, but with their uplands agronomy programme, which extended the 'matahambre' dry season crop, traditionally restricted to limited areas of moist fertile soils (e.g. footslopes and river levèes) to a wider range of landforms by introducing new mulch crops, inorganic fertilizers and herbicides (Brown and Johnson, unpublished). Recently the International Fund for Agricultural Development and the Toledo Agricultural Marketing Project (TAMP) have tried introducing erosion preventative measures, cash crops and fertilizer programmes.

Contour terracing has generally not been successful because it can impede drainage. Contour hedgerows appear to have had more success (Gibson *et al.*, 1991). TAMP concentrated on cacao as a cash crop, which has not been taken up much, because the price is so low, although there is some evidence that the price may have bottomed out of its 15-year fall. Citrus or annatto would have been more acceptable to farmers. Fertilizer applied in the wet season tends to be washed away in the Toledo Uplands, but the main problem with these development programmes appears to be lack of communication with the farmer: too much instructing farmers about the virtues of modern agricultural methods, and not enough listening to their problems, and working with them to solve them. The extension of the matahambre dry season crop and the introduction of profitable cash crops do seem to offer the most promising farm models (Brown, 1986; King *et al.*, 1986).

Land systems on granite (S)

Land systems on granite cover 70 mile^2 (181 km^2) within the Hills land regions, mostly (94%) in the Eastern Foothills.

Stopper Plain with Hills (SS)

The characteristic granite land system is called Stopper Plain with Hills (SS) after the Stopper Suite of granitic soils. It accounts for 77% of the land systems on granite in the Hills land regions, and mainly consists of undulating (52%) and rolling (45%) plains. The soils are suited to a range of crops, including citrus, but the undulating plain should be used rather than the rolling plain, because the

Table 1 Karst land system type

Land system	Area (km²)	Land region	Slope proportion (%)* N	U	R	S	K	Main soil types	Recommendations
TX Xpicilha Hills with Plains[1]	2823	Toledo Foothills Western Uplands Central Foothills Maya Mountains	1	29	7	7	57	Chacalte	Forest protection on K and S. Smallholder agriculture on U and R
OX Gallon Jug Plain with Hills	1051	Bravo Hills	5	61	29	1	3	Yalbac	Marginal to unsuitable for citrus. Moderately to highly suitable for maize and pasture. As most of the land system falls under Programme for Belize management, conservation is the main recommendation
CX Vaca Hills	431	Western Uplands	4[2]	12	7	0	77	Cuxu	Shallow soils and nutrient imbalances suggest pasture on N, U and R. K should be left under protection forest
BX Hummingbird Plain with Hills	345	Central Foothills	41	11	0	0	48	Chacalte Quamina	A tendency to soil capping suggests N best suited to perennial tree crops. K should be left under protection forest
HX Wamil Plain with Hills	78	Northern Coastal Plain	0	57	21	0	22	Yalbac Chacluum	Droughtiness and nutrient imbalance limitations. Smallholder agriculture on U and R. Citrus can be grown on some Chacluum soils. K should be kept under protection forest
LX Pilar Camp Hills	57	Bravo Hills	0	30	54	15	1	Shallow Yalbac	Left under current cultivation, but care should be taken to prevent erosion on R. S should not be used
0Q Yalbac Dissected Cuesta	45	Bravo Hills	0	30	50	20	0	Shallow Yalbac	Forest management and protection
OA Albion Island Plain with Hills	23	Bravo Hills	8	62	23	7	0	Yalbac	Sugar cultivation should be concentrated on U rather than R
OD Neuendorf Escarpment	10	Bravo Hills	10	0	5	85	0	Shallow Yalbac	Forest protection

* N = plain with less than 1° slopes
U = undulating plain with 1-5° slopes
R = rolling plain or valleys with 5-25° slopes
S = 25-35° steep slopes
K = karst slopes, often with slopes greater than 35°

(1) Called Xpicilha Hills in Toledo and Stann Creek surveys
(2) Valley bottom subunit

soils are easily eroded. Pasture and mechanized agriculture in particular should be restricted to the undulating plain. The greatest pasture risk is erosion along cattle paths. Tree crops can be grown on slopes up to 10°, but agriculture should be discouraged on slopes steeper than 10°.

The land system occurs either as dispersed valleys within the Maya Mountains or peripherally along their eastern escarpment. Most of the land is either already designated or has difficult access. The Cockscomb Basin covers the largest area, but contains the Jaguar Preserve Wildlife Sanctuary, and the Stann Creek report suggested the whole Cockscomb Basin Forest Reserve should be protected if the wildlife sanctuary is to remain viable. Hopefully tourist income will be greater than could be achieved by growing citrus. Another valley basin along the Left Hand Branch of the Swasey Branch south-west of the Cockscomb Basin has difficult access, and is probably best left under forest protection. The undulating plain and footslopes between Red Bank and Alabama and east to Silver Creek are currently under smallholder agriculture. The farmers there should be and are being encouraged to grow tree crops. Further north, much of the land along the Old Mullins River Road (17°N, 88°20'W) is already under citrus, but there is still some unutilized land. There is pressure to release land between Mayflower and Melinda, some of which has already been released. It would seem sensible to release the land on the SS, SO and SP land systems, but the forest plantations on the Stann Creek Coastal Floodplains (SF) should remain, as this is about the only good land retained by the Forestry Department and includes teak plantations.

The only other localities of the Stopper Plain with Hills land system currently not used are the Upper Mullins River Valley (17°2'N, 88°26'W) and along the Eastern Branch in the Western Uplands. The landform in the Upper Mullins River Valley is rolling plain which means there is a risk of erosion, as well as the expense of a new road. This area should probably be developed for citrus only if there is a prospect of a further increase in prices, which does not seem likely at the time of writing. The land along the Eastern Branch will be mostly affected by the proposed hydroelectric scheme.

Middle Swasey Basin (TS)

The only land system on granite recognized in Toledo District was 11 mile^2 (28 km^2) on the border with Stann Creek District: the Stopper Escarpment with Plain (TS). Illness during the Toledo survey prevented a field visit by the land resource specialist. Only when the Stann Creek survey was undertaken, was the nature and full extent of the granite outcrops realized. If it was possible to remap Toledo District (as could be done on the Geographical Information System), the steep slopes of TS would become an 'S' subunit of the Richardson Peak Mountains land system (TR). The flat (FT) and undulating (UT) terrace subunits are equivalent to the floodplain (F) and terrace (T) subunits respectively in the bordering Middle Swasey Basin land system in Stann Creek District.

The land system has considerable importance, because it can be used by the smallholders currently using the steep granite slopes of the nearby Richardson Peak Mountains land system. This land should be reserved for the neighbouring smallholders, and they should be helped and advised on the planting of tree crops there.

Land systems on recent alluvium

There are five land systems on recent alluvium in the Hills land regions, one for each land region, covering a total area of 58 mile^2 (150 km^2) (Table 2).

Cayo Floodplains (CF)

Cayo Floodplains is the largest land system on recent alluvium in the Hills land regions, formed by the northwards flowing rivers of Barton Creek, Caves Branch, Sibun and St Margaret's Creek, each of which have steep longitudinal profiles (thalwegs) in the Maya Mountains descending from some of the highest parts of

Table 2 Land systems on recent alluvium in the Hills land regions

Land system	Area (km²)	Land region	Dominant subunits*	Main soil types	Recommendations
CF Cayo Floodplains	127	Northern Coastal Plain	Calcareous high floodplain bench(ch) Central Foothills High floodplain bench (h) Low floodplain bench (l) Terrace (T)	Melinda Bladen	Mainly good soils suited to citrus, cacao, pasture etc. Bladen soils under pine should be avoided
NW Neustadt Swamps	48	Bravo Hills Northern Coastal Plain	Open savanna plain (l) Low marsh forest plain (m)	Chucum Sibal	Wetness, nutrients, workability and root room limitations preclude development. Marginally suitable for rice
SV Stann Creek Valley	42	Eastern Foothills Terrace (T) Dissected terrace (dT) Deep hillwash footslope (oP)	Floodplain (F) Stopper Ossory	Melinda	Mainly good soils suited to citrus, cacao, pasture etc. Citrus should not be grown on slopes steeper than 10°
TE Pesoro Plain	13	Toledo Foothills	None	Gravelly Curasow	Not considered suitable for agriculture because of reputedly gravelly nature of the soil. Not visited by NRI survey teams
VF Chiquibul Terraces	9	Western Uplands Alluvial wash (W)	Dissected terrace (dT) Melinda	Chacalte	Remoteness, limited extent, and tourism potential (Puente Natural) indicates forest management and tourism

* Occupying >10% of the land system

the country in deep gorges. They have thus eroded much metasedimentary material, cut through the limestones of the Central Foothills and deposited mainly good agricultural soils. Some calcareous material has also been included, and parts of the terrace and high floodplain bench have been exposed sufficiently long to have deteriorated into the agriculturally poor Puletan soils (see land systems on old alluvium section).

Neustadt Swamps (NW)

The very limited drainage across the Bravo Hills originates from within the land region. Since limestone drainage is mainly internal, the only alluvium found is in large solution basins in the north (Neustadt Swamps). They are not suited to agriculture, except possibly rice.

Stann Creek Valley (SV)

The eastern drainage of the Maya Mountains has a more gentle longitudinal profile than the northern drainage, and tends to follow the easily erodible granitic intrusions. The Stann Creek Valley is one such valley. The easily erodible granite has resulted in large alluvial deposition, providing good agricultural soils. Agriculture should however be discouraged on slopes greater than 10°.

Pesoro Plain (TE)

The capture by the north-eastward flowing Bladen River (along a geological fault line) of most of the drainage off the Maya Mountains has prevented alluvial deposition among the Toledo Foothills. Only shallow gravelly hillwash has drained on to the Pesoro Plain off the steep hillslopes of the Little Quartz Ridge and mountains to the north.

Chiquibul Terraces (VF)

Although the Western Uplands is traversed by the Eastern Branch, the river is still eroding down into the granite and has not yet started forming a valley flat, presumably because of the geologically recent activity along the Northern Boundary Fault.

The steep rise up to the Maya Mountains along the southern regional boundary had produced some isolated occurrences of the Maya Mountains Floodplains (MF) (see 'Maya Mountains' section earlier) and the very limited alluvium of the Chiquibul Terraces. The remoteness, limited extent and tourist potential of the natural limestone arch of the Puenta Natural suggest these areas should be left to forest management and tourism.

Ossory Plain with Hills (SO)

The metasedimentary rocks are the most resistant rocks to natural erosion in the country, which is why they form the Maya Mountains. They are rarely eroded down to gentle slopes, so that the Ossory Plain with Hills land system, consisting of gently sloping footslopes and undulating and rolling plain, only occupies a total area of 30 mile^2 (77 km^2) within the Hills land regions - all in the Eastern Foothills. As indicated in the Maya Mountains section, another 13 mile^2 (34 km^2) of isolated occurrences are also found in the valley bottoms within the Maya Mountains. Of the Hills land regions, they are only found in the Eastern Foothills, because this is the only Hills land region where the Cretaceous limestone seems to be downfaulted and overlain by Tertiary to recent sediments, so that the metasediments themselves (and the granites) border the coastal plain, instead of limestone.

As the name implies, the Ossory Suite is the main soil type. The soils are fairly porous, permeable and freely drained, but are leached, acid and have low exchangeable base status. They will therefore mostly require liming and fertilization. Slopes above 15° should be left under forest but tree crops could be grown on most of the soils below 10°, milpa cultivation and pasture up to 12°, and mechanized agriculture up to 6°.

Along the base of much of the coast-facing escarpment, hillwash soils with thick layers of ferruginous gravel or continuous ferricrete have been deposited. They form the 'Borrowpit' soil subsuite and occupy 22% of the land system. Their agricultural potential is clearly limited by rooting depth, and they are best left as road building material.

COASTAL PLAINS

Geological influence is still important on the coastal plains. The land systems can be classified into:

(i) land systems on the Toledo Beds (TM and TT) and forming the Southern Coastal Plain

(ii) land systems on limestone - the mainly Tertiary (K and Z) land system types and the Jobo Plain (BJ), and the shallow Pleistocene to recent limestone land system type (I)

(iii) land systems on Tertiary to Pleistocene alluvium (P)

(iv) land systems on recent alluvium (F, TG and B)

(v) waterlogged land systems (W and Y)

(vi) coastal intergrades - Glady (H) and Backshore (N) land system types.

Land systems on Toledo Beds (Southern Coastal Plain)

There are two land systems on the Toledo Beds in the Southern Coastal Plain distinguished by drainage: Temash Plain (TT) with imperfect or poor drainage, and the better drained Machaca Plain (TM).

Temash Plain (TT)

Philips *et al.* (1986) considered most of the Temash Plain (the poorly drained subunit 'o') to be too poorly drained, acid and infertile for most crops. It should be moderately suitable for pasture in the better drained subunit (t), but still only marginal for maize, beans and tree crops. Smallholder agriculture should continue on this latter subunit, but the poorly drained subunit should be left to management of the indigenous forest or forest plantations.

Machaca Plain (TM)

The Machaca Plain contains three main subunits: undulating plain (U) covering 51% of the land system, broken pine plain (N) covering 32% of the land system, and rolling plain (R) covering 16% of the land system. The undulating plain has mostly imperfect drainage, and the Toledo survey considered it generally unsuitable for tree crops. A subsequent more detailed survey (Baillie and Wright, 1988) considered parts of the undulating plain might be suitable for tree crops. Since then, much of the undulating plain has been cleared and planted for citrus. Doubts however remain whether tree crops can withstand the poor drainage in much of this subunit, and most of it is better suited to management of indigenous forest or forest plantation.

The rolling plain has better drainage although the soils are shallower. Much of this subunit is highly suitable for tree crops, but there will still be drainage problems in some of it. This subunit and the small hill subunit are best suited for smallholder agriculture with tree crops, which is its main current use.

The soils on the broken pine plain tend to be compact and have poor drainage. It should be left under forests or planted with pine. The pine plantation at Machaca Forest Reserve indicates how well pine can grow, even with little management.

Land systems on limestone

Yalbac land system type (K)

The Yalbac land system type was invented to distinguish land systems within an area that had less relief than the karst (X) type, but more relief than the plain (Z) type. Because it was designated within particular areas or districts, inconsistencies develop when the type is considered as a group for the whole country. Its characteristic landform is undulating plain. There are four land systems of the Yalbac type on the coastal plain (Table 3), mainly distinguished by soil type.

Plain land system type (Z)

The Plain land system type contains land systems with low relief. They are mostly on undulating terrain and contain the main areas of sugar-cane cultivation. Five land systems are recognized and distinguished by soil type (Table 4).

Jobo Plain (BJ)

The Jobo Plain is a flat plain covering most of northern Belize District (279 mile^2 (723 km^2)). It is characterized by the Altun Ha soil suite, and is named after its most common subsuite. The soils contain many flints which limit cultivation. Pasture, pineapples, coconuts and sugar-cane could be grown on the better drained Jobo soils. These crops are more marginal on the more droughty Rockstone Subsuite soils. The land system seems to be only agriculturally suited to limited smallholder cultivation.

Xaibe land system type (I)

The Xaibe land system type contains shallow soils over recent coral limestone. The individual land systems are distinguished by soil type (Table 5).

Land systems on old alluvium (Pine land system type (P))

The land systems on old alluvium were originally deposited as acid riverine alluvium derived from early erosion of the Maya Mountains. Some of the alluvium has subsequently been reworked by marine processes. Its age is uncertain, but could date back to the Tertiary Period. In any event, any nutrients it originally had, have almost been completely leached out. The soils consist of a coarse textured, friable upper horizon overlying a finer textured, firm and compact subsoil, which is impermeable to water and impenetrable to roots. It is a severe limitation to crops, because elaborate drainage is needed to prevent waterlogging in the wet season, and irrigation is needed to prevent moisture deficiency when there is a long dry season. Pinus (*Pinus caribaea*) and oaks (*Quercus oleoides*) are about the only trees that will grow on these soils, and even they do not grow well. Agricultural activity should be avoided on most of these soils.

Table 6 shows the Pine land systems on the coastal plain distinguished mainly on the basis of soil type. Except for the Crooked Tree land system which is suitable for cashew, pineapples and pasture, and the undulating plain in the Stann Creek Coastal Plain which is suitable for cashew and pineapples, pine management and possibly shrimp mariculture along the coast are the only sensible use for most of the land system type, which occupies 921 mile^2 (2386 km^2) - a fifth of the entire area of the Belizean coastal plain.

Land systems on recent alluvium

Two land system types occur in recent alluvium: those on riverine alluvium (the Floodplains (F) land system type), and those on marine alluvium (the Strand Plain (B) land system type).

Table 3 Yalbac land system type

Land system	Area (km²)	Dominant subunits*	Main soil types	Recommendations
OK Shipyard Plain	622	Flat plain (N) Lower slope (W) Undulating plain (U)	Yalbac	Nutrient imbalance, dry season moisture deficiency in shallow soils and moisture excess on lower slope, render most of the land marginal for tree crops. Generally suitable for arable, pasture and sugar-cane
BK Beaver Dam Plain	336	Flat plain (N) Undulating plain (U)	Beaver Dam	Imperfect drainage renders most of the land system only suitable for pasture. Arable is recommended for the undulating plain
LK Spanish Lookout Plain	208	Undulating plain (U)	Spanish Lookout Beaver Dam	Generally suitable for pasture, maize and beans. Only pasture on the Beaver Dam soils. Valley heads should be avoided, as indicated by the gullies at Spanish Lookout
CK Belmopan Plain	171	Undulating plain (U)	Cuxu	Nutrient imbalance is likely to affect citrus. Pasture and smallholder agriculture seem the most suitable use

* Occupying >10% of the land system

Table 4 Plain land system type

Land system	Area (km²)	Dominant subunits*	Main soil types	Recommendations
HZ Hill Bank Plain	603	Flat plain (N) Undulating plain (U) Lower slope (W)	Chacluum Chucum	Droughtiness and nutrient imbalance limitations. Smallholder agriculture recommended. Citrus can be grown on some Chacluum soils. Rice could be grown on some lower slopes
OZ Lazaro Plain	514	Undulating plain (U) Lower slope (W)	Guinea Grass	Moisture, drainage and nutrients generally available. Some deeper soils are droughty. Sugar-cane, vegetables, tree crops, pasture recommended. Lower slope should be avoided
ZZ Louisville Plain	335	Undulating plain (U) Lower slope (W)	Louisville	Sugar-cane, maize, vegetables recommended. Lower slopes should be avoided. Lime chlorosis and droughtiness will limit citrus growth
CZ Round Hole Plain	68	Undulating Plain (U) Chorro Tambos	Piedregal	Shallow soils. Most suited to pasture, maize and beans.
BZ Belize River Plain	15	None	Butcher Burns	Drainage, nutrient and flooding limitations. Could possibly be suitable for rice

* Occupying >10% of the land system

Table 5 Xaibe land system type

Land system	Area (km²)	Dominant subunits*	Main soil types	Recommendations
ZI Xaibe Plain	691	Flat plain (N) Lower slope (W)	Xaibe Remate	Droughtiness, shallow profile and phosphate fixation limitations, but can be moderately-marginally suitable for a range of crops. Wet lower slopes and the shallow and stony Remate soils should be avoided
JI Consejo Plain	50	None	Consejo	Shallow soils give low agricultural potential. Not recommended for tourism
AI North Ambergris Plain	14	None	Shipstern	Very shallow soils and hard underlying coral preclude any agricultural development. Recommended for conservation

* Occupying >10% of the land system

Table 6 Pine land system type

Land system	Area (km²)	Land region	Dominant subunits*	Main soil types	Recommendations
TP Puletan Plain	814	Northern Coastal Plain Central Coastal Plain	Flat plain (N) Valley (D)	Puletan	Worst soils in the country. Recommended for pine management
BP Belize Plain	449	Northern Coastal Plain Central Coastal Plain	Pitted plain (b) Low plain (l) Redeposited old alluvial wash (pw) High plain (h) Undulating plain (u)	Puletan	Some cashew could be grown on the deeper sand, pasture on some of the high plain, undulating plain, and in the alluvial wash, which would also be suitable for rice. But most of the land system is unsuitable for agriculture
QP Tok Plain	268	Northern Coastal Plain	Flat plain (N)	Tok>Puletan	Tok soils are slightly more alkaline but do have the impermeable subsoil of the Puletan soils. They are generally agriculturally unsuitable
OP August Pine Plain	258	Northern Coastal Plain	Undulating plain (U) Redeposited old alluvial wash (pW)	Puletan>Tok	See TP and QP above. Some cashew can be grown on the deeper sands
FP San Felipe Plain	228	Northern Coastal Plain	Undulating plain (U) Redeposited old alluvial wash (pW)	Felipe> (Puletan + Tok)	Felipe soils are less physically constraining and are more alkaline than Puletan soils, but are still only marginally suitable for coconuts, pasture and pineapple
SP Stann Creek Coastal Plain	212	Central Coastal Plain	Slightly undulating plain (SU) Flat plain (N) Undulating plain (U) Granitic floodplain (sF)	Puletan Silkgrass	Soils generally better drained and less compact than the above land systems. The Silkgrass soils on U are moderately suitable for cashew and pineapples, and some of the less sandy soils are suitable for citrus
KP Crooked Tree Plain	157	Northern Coastal Plain	Undulating plain (u) Redeposited old alluvial wash (pw) Low marine terrace (l)	Crooked Tree > (Boom + Bladen + Haciapina)	The Crooked Tree soils have a deep sandy topsoil suitable for cashew, pasture and pineapples

* Occupying >10% of the land system

Floodplains land system type (F)

The Floodplains land system type has a characteristic range of subunits classified according to flooding frequency and age of soils, which are inversely related. The low floodplain bench (l), 1-4 m above the river is flooded annually or every few years. The high floodplain bench (h), which is 3-6 m above the low floodplain bench, or 5-10 m above the river, is flooded after exceptional storms, which happen about every 20 years. The higher terrace (T) (and dissected terrace (dT)) is flooded only after exceptional climatic events that occur with a frequency of about a thousand years. Alluvial wash (W) is deposited during some of these exceptional climatic events as floodplain splays usually on top of the older alluvium of the Pine land system type. (The soil so formed is defined as belonging to the Sennis Subsuite.)

Some terraces, and even some parts of the high floodplain bench, have been exposed so long, they have developed Pine land system type characteristics: with Puletan soils and pine or 'broken pine' vegetation. Where clearly distinguishable on the aerial photographs or satellite imagery, they have been designated on the northern Belize map as 'p' or 'pt'. Subunits prefixed with a 'c' indicate a range of soils from siliceous to calcareous to the leached Puletan soils.

Where distinguishable at 1:100 000 scale, a levèe subunit is separated from the backland, or backswamp in Toledo District with its higher rainfall. The backland or backswamp usually comprises about 60% of the floodplain bench. At the time of the Toledo survey, it was not possible to distinguish subunits along most of the Swasey and Bladen branches because of the difficulty in interpreting landform beneath a forest cover on aerial photographs.

Most of the soils belong to the Melinda Suite. They have good or only slightly impeded drainage, medium textures and lack any serious rooting restriction, although they do have a tendency to capping if the surface is bared to prolonged raindrop impact or subject to excessive wheeling. The older soils on the high floodplain bench or terrace tend to be acid and of low base status, but all Melinda soils generally have sufficient clay content and cation exchange capacity for effective use of fertilizers, and have high agricultural potential. The established citrus and banana plantations are mainly on these soils, for which they are well suited. Table 7 distinguishes the various land systems, mainly according to proportion of characteristic subunits and soil type.

Governor Plain (TG)

There is another alluvial land system in the north-east of Toledo District called the Governor Plain. It consists of very coarsely dissected alluvial fans coalescing to form a flat plain. The better drained part (subunit g) has a compact subsoil preventing root penetration and limiting most agricultural development. It is possibly moderately to marginally suitable for citrus. The wetter part (subunit w) also has stony soils and only pasture is recommended.

Strand Plain land system type (B)

Southward drift of coastal sediment has produced a strand plain land system type consisting of bars and intervening swales. The bars are suitable for cashew, coconuts and tourism. Table 8 distinguishes the land systems according to the proportion of bars to swales and main soil type.

Waterlogged land system type (W)

Land systems in the Waterlogged land system types are waterlogged in the wet season, and some subunits are permanently waterlogged. It was assumed tree density indicates duration of waterlogging: 'l' (low) is herbaceous swamp that is mostly permanently waterlogged; 'h' (high) is swamp or marsh forest plain considered only seasonally waterlogged; 'm' (medium) is savanna plain, considered an intergrade between 'l' and 'h'. Both the Hondo and Belize swamps also

Table 7 Floodplains land system type

Land system	Area (km²)	Land region	Subsuite proportion (%)*							Main soil types	Recommendations
			l	h	T	W	ch	cT	p/pT		
BF Lower Belize Floodplains	502	Northern Coastal Plain	48	42	1	9	0	0	0	Melinda	There still seem to be considerable areas of high floodplain bench that could be developed
TF Toledo Floodplains	199	Central Coastal Plain Southern Coastal Plain	62	16	11	11[1]	0	0	0	Melinda Sibal	Swasey and Bladen branches still have available land for development
SF Stann Creek Coastal	180	Central Coastal Plain Floodplains	36	39	8	17	0	0	0	Melinda	Available land fast being converted to citrus plantations
CF Cayo Floodplains	127	Northern Coastal Plain Central Foothills	26	26	10	0	34	5	0	Melinda > Puletan	Unused areas need careful soil survey to distinguish the better soils from the old leached soils
IF Upper Belize Floodplains	101	Northern Coastal Plain	19	41	26	0	0	0	12	Melinda > Puletan	Very little high agricultural potential land still available for development
HF Spanish Creek Floodplains	2	Northern Coastal Plain	100	0	0	0	0	0	0	Melinda	Suitable for smallholder agricultural development but very limited area

* l = low floodplain bench
h = high floodplain bench
T = terrace
W = alluvial wash
c = calcareous high floodplain bench
c = calcareous terrace
p = old terrace
pT = gravelly old terrace

[1] The alluvial wash subunit proportion is underestimated because it was not recognized during the Toledo survey

Table 8 Strand Plain land system type

Land system	Area (km^2)	Land region	Subunit proportion (%) Bar	Swale	Main soil types	Recommendations
TB Toledo Strand Plain	38	Southern Coastal Plain (Central Coastal Plain)[1]	30	70	Barranco Hopkins Sibal	Some of the bars are moderately suitable for a range of crops; the sandier soils for pineapples, cashew and coconuts. Swales should be avoided
SM Matamore Strand Plain	18	Central Coastal Plain	90	10	Matamore	Cashew, pineapples, cassava
SB Stann Creek Strand Plain	15	Central Coastal Plain	91	9	Hopkins Sibal	Cashew, coconuts, tourism
AB Ambergris Strand Plain	8	Northern Coastal Plain	90	10	Ambergris	Tourism

[1] Very small occurrences (0.3 km^2)

have some mangrove (M). Table 9 distinguishes the land systems according to subunit proportion and soil type.

Saline Swamps land system type (Y)

There are two Saline Swamps land systems: one in the Central and Southern Coastal Plain - TY; the other in the Northern Coastal Plain - ZY. TY was first named in the Toledo survey as the Toledo Saline Swamps but, as it was found to be equally characteristic of the Stann Creek and Belize districts, it was named Stann Creek Saline Swamps in the Stann Creek survey, and Belize Saline Swamps in the survey of northern Belize. Both land systems represent the tidal flat, which in the Central and Southern coastal plains are covered with medium height red mangrove (*Rhizophora mangle*) consociations and tall black (*Avicennia germinans*) and white (*Laguncularia racemosa*) mangrove associations (TY); whereas only mainly dwarf red mangrove is found on the Northern Coastal Plain (ZY) (Gray *et al.*, 1990).

A sandier high tidal flat (h) was distinguished in the Stann Creek survey as a rare occurrence (3% of the area of the land system), and continued into the Belize Saline Swamps in the northern Belize survey. The Corozal Saline Swamps (ZY) has five subunits based on vegetation type, considered representative of hydrological or salinity conditions. It is found 40 miles (70 km) inland in part of Booth's River Lagoon. A few red mangrove have also been found in the lower slope subunit of the Gallon Jug Plain with Hills land system (OX), 2.5 miles (4 km) north-west of Gallon Jug, i.e. 50 miles (80 km) inland. Water salinity levels in these inland occurrences of the Corozal Saline Swamps land system however appear to be low.

Both land systems are unsuitable for agriculture, and the mangrove should be left both to protect the coast from erosion and keep fish spawning grounds. Some of the Corozal Saline Swamps might be suitable for shrimp mariculture, but the soils should be tested first for depth and alkalinity.

Glady (H) and Backshore (N) land system types

The low altitude of the Northern Coastal Plain combined with a variably shallow depth to bedrock has produced a mosaic of edaphic conditions, represented by the Glady and Backshore land system types. They also indicate biodiversity. The Glady land system type is dominated by broadleaf forest with savanna glades, whereas the Backshore land system type consists more of savanna (and even some mangrove) with clumps of broadleaf forest. The individual land systems of the two types are distinguished by soil type and subunit proportions in Table 10. They seem to be mainly suited to a combination of tourism, conservation and smallholder agriculture. Some of the more intermixed areas should be kept to preserve biodiversity.

Table 9 Waterlogged land system type

Land system	Area (km²)	Land region	Subunit proportion (%)*						Main soil types	Recommendations
			U/N	W	h	m	l	M		
SW Sibal Swamps[1]	709	Northern Coastal Plain Central Coastal Plain Bravo Hills	0	0	17	23	61	0	Sibal	Conservation. Rice might be possible on the swamp or marsh forest plain
TW Toledo Swamps	286	Southern Coastal Plain Central Coastal Plain[2]	0	0	70	19	11	0	Sibal	Dry season growing on some of the better drained parts. Mechanized rice does not appear to be economic. Conservation suggested
LW Cadena Creek Plain	159	Northern Coastal Plain	59	41	0	0	0	0	Beaver Dam Chucum	Pasture on the upland slopes. Rice on the lower slopes
OW Hondo Swamps	113	Northern Coastal Plain	0	0	44	5	49	1	Sibal>Pucte	Conservation
BW Belize Swamps	76	Central Coastal Plain	0	0	14	34	40	12	Sibal>Ycacos	Conservation
ZW Corozal Swamps	67	Northern Coastal Plain	60	40	0	0	0	0	Xaibe Pucte	Pasture on the upland slopes. Rice on the lower slopes

* U/N = Upland plain
W = Lower slope of upland plain
h = Swamp or marsh forest plain
m = Savanna plain
l = Herbaceous swamp
M = Mangrove

(1) Called Stann Creek Swamps in Stann Creek survey
(2) Toledo Swamps in this land region should be Sibal Swamps

Table 10 Glady and Backshore land system types

Land system	Area (km²)	Dominant subunits*	Main soil types	Recommendations
ZN Shipstern Plain	67	Glady forest plain (H) Clumped tree savanna (N)	Xaibe Ycacos Remate	Conservation
ZH Northern Bulkhead Plain	44	Flat plain (N)	Xaibe Ycacos	Smallholder pasture, pineapple, rice
AN West Ambergris Plain	25	None	Ycacos Shipstern	Conservation, tourism
BH Estevez Plain	24	None	Altun Ha Tok Puletan	Conservation
BN Maskall Plain	21	Glady forest plain (H) Clumped tree savanna (N)	Altun Ha Ycacos	Conservation

* Occupying >10% of the land system

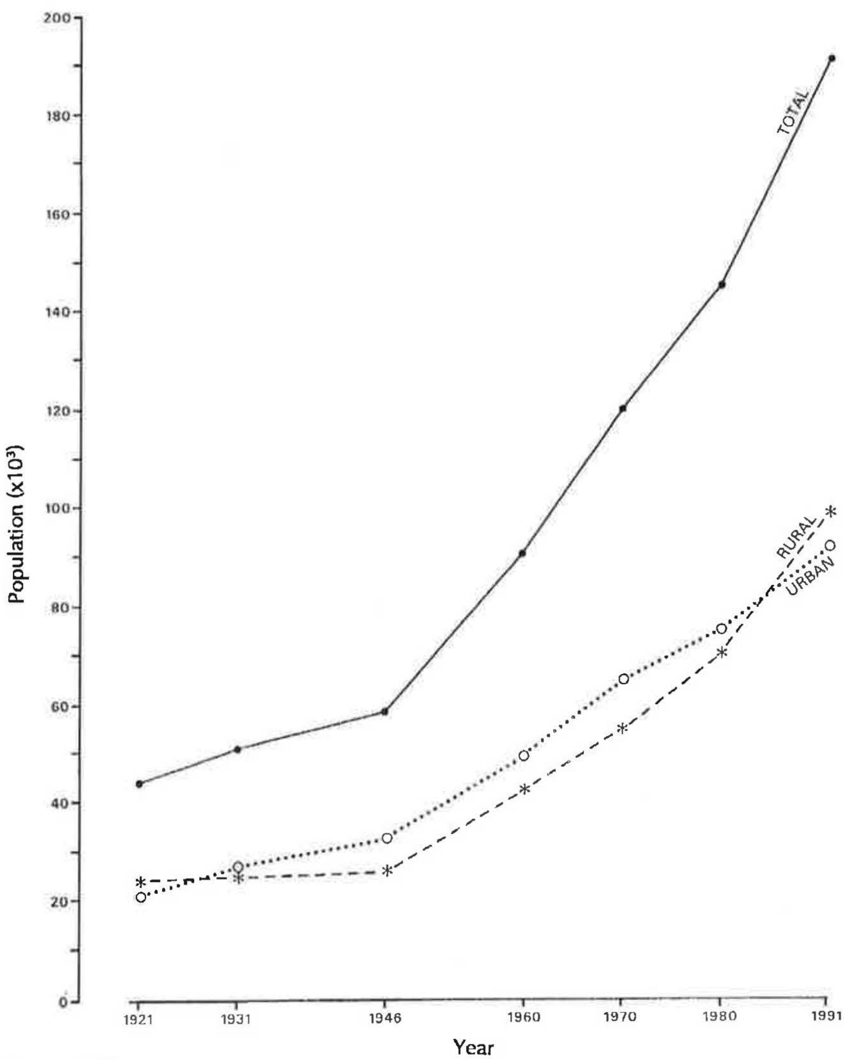
Part 3

Socio-economic environment

POPULATION

The 1991 census carried out by the Central Statistical Office (CSO) indicated a provisional total national population of 190 792 of which 91 803 (48.1%) were urban and 98 989 (51.9%) rural. In the rural areas Mestizos make up the largest proportion at some 40%, followed by Creoles at 25%, and Mopan Mayan and Kekchi communities at 18%.

Since 1921 the population has quadrupled (1921:45 297) in both urban and rural communities. Figures 4 and 5 show the population for selected years between 1921 and 1991. Figure 4 shows how the rate of growth of the national population increased after the Second World War from about 1% per year to about 2.6% per year. The faster rate of growth of the rural population compared

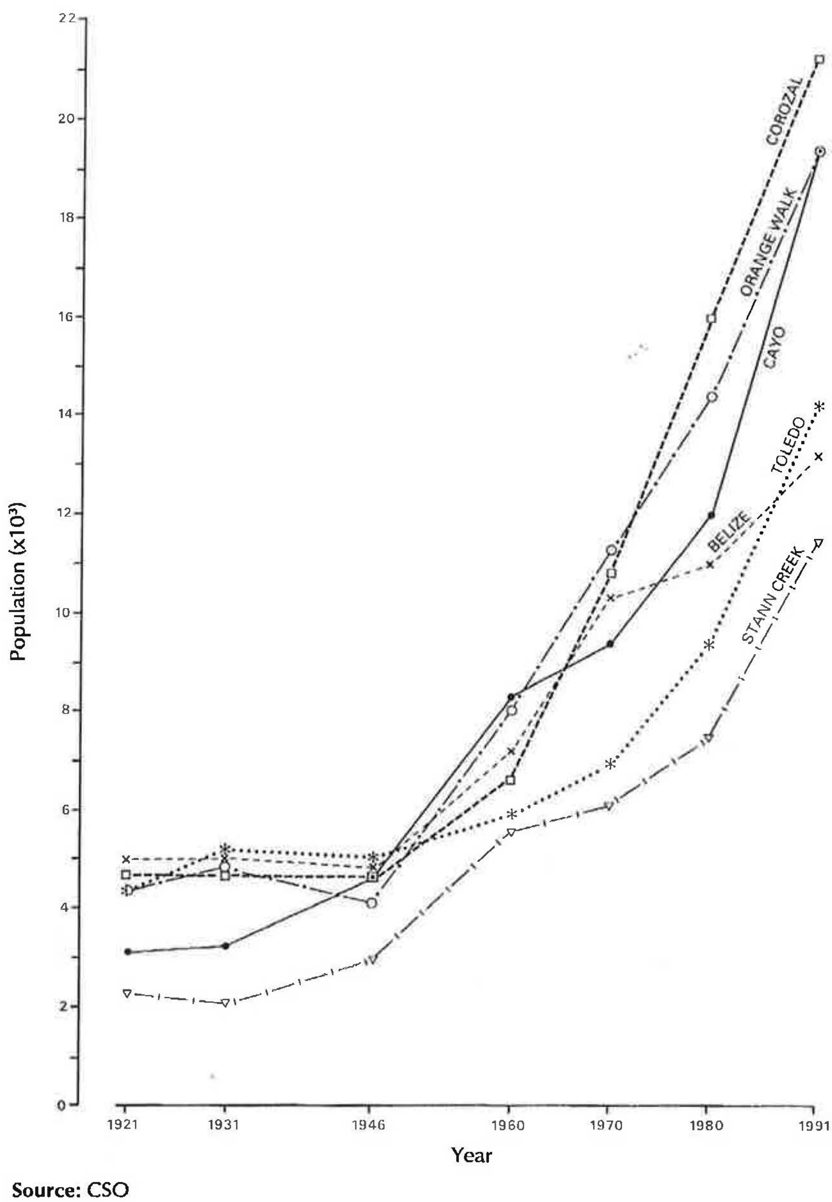


Source: CSO

Figure 4 National population at census dates to the urban population in the last ten years is probably due to the influx of immigrant farmers from neighbouring countries and the rush to buy land to grow citrus. Figure 5 shows the fastest consistent rate of growth has been in the northern districts, particularly Corozal, but the rate of growth in Cayo District is now faster. Population growth and stability in the rural areas can be attributed partly to the rise of the sugar, citrus and banana industries, but also to the need to feed the urban population - met mainly by the Mennonite communities in Cayo, Corozal and Orange Walk districts.

Table 11 identifies the ethnic composition of each district and respective urban and rural communities. While Belize is 75% Creole, Corozal and Orange Walk together are about 61% Mestizo. Corozal rural is 20% Mayan and Orange Walk rural is 21% white. The Kekchi and Maya Mopan communities make up 57% of the whole of the Toledo District population, but constitute 70% of Toledo's larger rural population.

Although Dangriga is 70% Garifuna, they constitute only 24% of Stann Creek's rural community. As a whole they make up 46% of the population of Stann Creek, followed by 33% Creole who are Stann Creek's largest rural population. Creoles and Mestizos constitute 43% and 18% of Stann Creek's rural population respectively.



Source: CSO

Figure 5 Rural populations by districts at census dates

Table 11 Percent population by race and district, 1980

District	Population	Creole	East Indian	Chinese	Mopan Maya	Kekchi	Garifuna	White	Mestizo	Other not stated
Country total	145 353	39.7	2.1	0.1	6.8	2.7	7.6	4.2	33.1	3.6
Urban	72 717	54.0	1.5	0.3	0.8	0.1	11.3	0.8	26.2	5.7
Rural	72 636	25.5	2.5	0.0	12.4	5.3	3.9	7.4	40.1	2.4
Belize	50 801	75.1	1.5	0.3	0.7	0.1	3.2	1.1	13.1	4.8
Belize City	39 771	76.0	1.5	0.4	0.3	0.1	3.5	0.9	12.2	5.1
Belize Rural	11 030	71.8	1.5	0.0	2.1	0.1	2.3	1.6	16.4	4.1
Corozal	22 902	16.9	2.9	0.1	13.8	0.3	2.3	1.7	58.4	3.6
Corozal Town	6 899	30.5	1.8	0.5	0.0	0.0	3.2	0.3	59.2	4.5
Corozal Rural	16 003	11.1	3.3	0.0	19.7	0.4	1.9	2.2	58.0	3.4
Orange Walk	22 870	11.3	0.3	0.0	6.8	0.2	2.3	13.5	64.5	1.1
Orange Walk Town	8 439	19.7	0.4	0.1	3.8	0.0	5.1	0.2	68.9	1.8
Orange Walk Rural	14 431	6.4	0.2	0.0	8.6	0.3	0.6	21.3	61.9	0.7
Cayo	22 837	31.0	1.1	0.0	4.6	0.4	1.9	8.0	49.0	3.8
San Ignacio	5 616	28.1	1.5	0.1	1.0	0.5	1.2	1.1	59.0	7.5
Cayo Rural	14 286	26.9	0.4	0.0	6.9	0.4	0.7	11.6	50.5	2.5
Belmopan	2 935	56.8	3.2	0.0	0.5	0.1	9.3	3.9	22.9	3.3
Stann Creek	14 181	32.9	2.0	0.1	5.2	0.2	45.6	0.5	10.5	2.9
Dangriga	6 661	21.6	1.4	0.3	0.3	0.0	70.0	0.4	1.8	4.2
Stann Creek Rural	7 520	43.0	2.7	0.0	9.7	0.4	23.7	0.5	18.3	1.7
Toledo	11 762	11.9	8.6	0.0	25.4	31.5	12.7	1.0	5.9	3.0
Punta Gorda	2 396	23.6	4.4	0.0	3.3	1.1	48.3	0.9	8.9	9.5
Toledo Rural	9 366	9.0	9.6	0.0	31.1	39.3	3.4	1.0	5.1	1.3

Source: Population census, 1980

In Cayo, Belmopan is 57% Creole though in the district as a whole they constitute 31% of the population; less than the Mestizo population of 49%.

The number of registered refugees has risen from 4774 in 1989 to 5395 at April, 1991. It is estimated by the Refugees Office that approximately 80% are illiterate; the male:female ratio is in the region of 2:1 (F. Gamero, 1991, personal communication). In 1988 75% of the registered refugees were resident in Cayo District (Foster, 1989), but there may be several thousand unregistered refugees living in other districts. In 1989 nationalities of refugees included 71.3% Salvadoran and 27.3% Guatemalan.

A CSO survey in 1984 identified 47 300 persons in the labour force of whom 68% were male. Rural employment accounted for 21 400 workers (45.2%) of whom 78% were male. Given recent expansion in *inter alia* the citrus and banana industries and a wave of new investment in construction, the labour force has probably already passed 50 000. The number of temporary employment permits granted by the Labour Department has continued to increase - from 2753 in 1987 to 3326 in 1989, when 2134 permits were issued for agricultural workers. Stann Creek District, where the banana and citrus industries are concentrated, absorbed 624 workers, and Corozal and Orange Walk districts together accounted for 400, the majority of whom would have been recruited for sugar-cane cultivation and harvesting. Although many Guatemalan immigrants enter Belize through Toledo District, they rarely stay more than six months, before moving north. Toledo District itself accounts for the lowest level of applications for work permits and, in 1989, of the 55 permits issued for the district, 38 were for agriculture. Notwithstanding the presence of several banana farms in northern Toledo District, the district would appear to be the most self-sufficient in terms of labour, and the least affected by migrant settlement.

Given the large numbers of unregistered refugees thought to be present in the country, several hundreds, if not thousands, are probably employed by remote or small agricultural undertakings, where registration checks would be expensive. The agricultural work-force could already be 26 000 persons, of whom

4000 (i.e. 15%) are probably migrant and refugee workers engaged in the banana, citrus and sugar-cane industries.

TRENDS IN AGRICULTURAL PRODUCTION

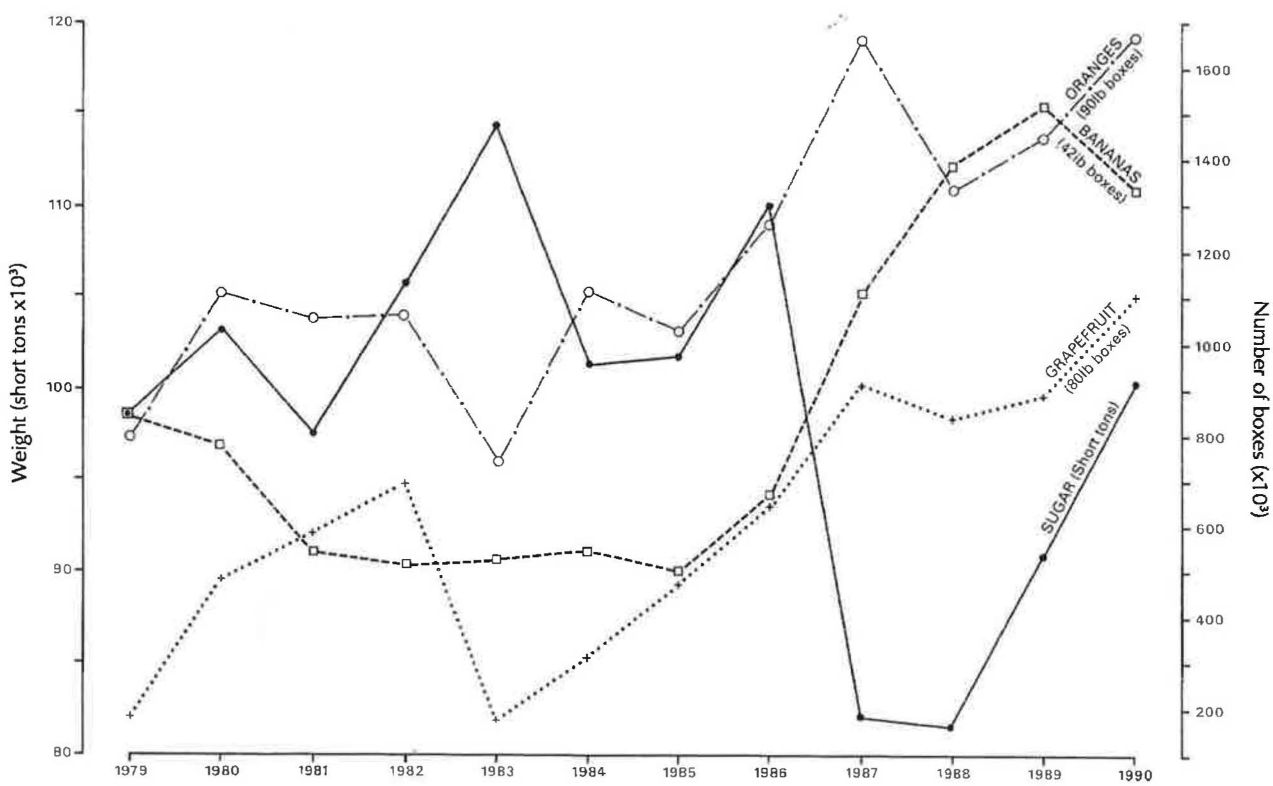
Figure 6 reproduces CSO's compilation of agricultural production statistics for the years 1979-90 for sugar-cane, oranges, grapefruit and bananas, supplemented by data from the Ministry of Agriculture.

Sugar-cane for sugar manufacture

Sugar production has stabilized within a range of 80 000 to 120 000 tons. The cane yield of about a million tons is enough to meet foreseeable sugar production requirements of Belize Sugar Industries Ltd (BSI) at Tower Hill (Orange Walk District), leaving a cane surplus available for delivery to the high test molasses factory of Petrojam Belize Ltd at Libertad (Corozal District).

Cane sales to BSI peaked at 1 196 000 long tons in 1983; then partly as a result of BSI's withdrawal from sugar manufacturing at Libertad in 1985, gradually declined to 777 000 long tons in 1988, which was an unusually wet harvesting season. Favourable weather contributed to a crop of 867 267 long tons in 1989 processed by BSI, and in 1990 the company milled 977 442 long tons. In May, 1991, with approximately one month of crop remaining, BSI anticipated processing up to 1 050 000 long tons of cane which could yield some 95 000 short tons of sugar. (One long ton is 1.12 short tons). In 1991 preferential markets accounted for quotas amounting to 64 000 short tons (European Community: 42 000; USA: 22 000), leaving the balance of production for sale on the local (some 7500 tons) and world markets.

In recent years the BSI factory has been operating at full capacity and is internationally credited with being a highly efficient facility. Sugar recovery, and hence profitability of the sugar industry, could nevertheless be improved by



Source: Ministry of Agriculture, Belize Sugar Industries Ltd, Petrojam Ltd

Figure 6 Agricultural production of sugar, oranges, grapefruits and bananas, 1979-90 better organization of cane deliveries, especially from farmers in Orange Walk District whose cane becomes stale due to trucks routinely queuing for up to 30 hours.

A feasibility study commissioned by BSI in 1988 concluded that further expansion of the Tower Hill factory beyond the 250 long tons of cane/h rated capacity was not a financially viable option for the industry. With the world sugar market weakening in early 1991, BSI did not anticipate considering the possibility of increasing production for at least five years (E. Zetina, 1991, personal communication).

For planning purposes BSI's requirements of cane for sugar manufacturing have stabilized: the annual requirement will continue to hold at, but not exceed, about 1 million long tons of cane. To meet this demand the present cane area, considered by BSI to amount to some 60 000 acres (24 000 ha), will need to yield 17 long tons/acre (43 t/ha). In Appendices 4 and 5 the gross margin analysis for sugar-cane cultivation under well-managed conditions, including the use of some chemical inputs, indicates that if a viable complementary cropping system could be devised for lands retired from cane production, there would be scope for reducing the planted area of cane while maintaining overall cane supply at the desired level.

In 1991 the total number of licences granted for the supply of cane to BSI was 5300 (1990: 5181) of which some 92% were in respect of supplying 400 long tons or less, i.e. equivalent to 23.5 acres (9.5 ha) producing cane at 17 long tons/acre (43 t/ha). Only 50 farmers held licences of over 1000 long tons.

Sugar-cane for high-test molasses manufacture

The 1987 acquisition by Petrojam Belize Ltd (Petrojam) of the Liberted sugar factory, and its modification for high-test molasses manufacture created an extra market for sugar-cane. Petrojam plans to process up to 400 000 long tons of cane annually, of which 130 000 long tons may, under an agreement with the Government of Belize (GOB), be supplied from canelands owned by the company. Some 5000 acres (2000 ha) of such lands are being established and are expected to yield in the region of 30 long tons/acre (75 t/ha) (L. Rosado, 1991, personal communication). In order to achieve the desired throughput Petrojam requires some 270 000 long tons of cane from farmers in each season, equivalent to (at 17 long tons/acre (43 t/ha)) some 16 000 acres (6000 ha) of production.

In 1989, Petrojam's first season of milling, the company milled 57 000 long tons of cane; in 1990, 121 256 long tons were milled. The total cane milled in Belize in 1990 by the two companies was therefore 1 098 698 long tons.

Petrojam's milling season begins about two months after the start of BSI's season and, like BSI, continues until rain prevents further harvesting. In 1991, out of the total of 57 723 long tons (58 647 t), about 84% (48 227 long tons (48 999 t)) was from farmers in Corozal District. By May 10 Petrojam had milled about 56 000 long tons from its own estate and purchased a further 69 000 long tons from farmers, with all the remaining supply coming from farmers (R. Marshall, 1991, personal communication). Given satisfactory weather conditions for a further month, the total throughput of Petrojam for 1991 was expected to reach 145 000 long tons. In 1991 therefore, deliveries from farmers will reach about 90 000 long tons, satisfying 33% of the 270 000 long tons of cane sought from farmers.

If carry-over mature cane for harvesting in 1992 is ignored, the amount of cane available in excess of BSI requirements and sold to Petrojam during 1991 is about 9%, which could be regarded as a safe buffer of supply to satisfy sugar manufacturing needs. To meet Petrojam's future requirements, the excess will need to be 27%, i.e. calling for extra plantings of between 6000 acres (2000 ha) (30 long tons/acre (75 t/ha)) and 10 600 acres (4300 ha) (17 long tons/acre (43 t/ha)). Extra canelands should be established as close as possible to Libertad.

Citrus for juice concentrate manufacture

Over the last five years the citrus industry has doubled in size, although the true extent of planting is uncertain. Planting has taken place on several hundred acres of soils considered only marginally suitable for citrus under traditional management.

Production of citrus concentrates and oils, for export, rose steadily over the decade up to 1990: the volume of grapefruit processed rose 88% to 1 102 999 80-lb (36-kg) boxes (634 000 gallons (2 400 000 l) of concentrate), while the volume of oranges processed rose 58% to 1 681 028 90-lb (41-kg) boxes (1 475 000 gallons (5 583 000 l) of concentrate). Much of the growth of grapefruit production is from rehabilitation of old plantations, while the increase in orange production is largely due to new plantings.

The Stann Creek District harvesting season runs for some 150 working days from mid-October until early June, i.e. most of the season coincides with sugar harvesting and hardwood logging. Unlike Stann Creek, orange harvesting in Cayo and Toledo districts does not start until April. The future planning of processing requirements needs to take this difference in seasonality into account. Calculating from piece-work pay rates, some 425 workers would have been employed in the 1990 harvest, i.e. about 42 acres (17 ha) harvested per piece-worker.

Citrus is processed by two competing companies in the Stann Creek Valley: the Citrus Company of Belize Ltd at Pomona, and Belize Food Products Ltd at Alta Vista. The national Agricultural Census of 1984-85 identified a total of 12 886 acres (5215 ha): 10 158 acres (4111 ha) (79%) planted to oranges and 2728 acres (1104 ha) (21%) of grapefruit; 69 acres (28 ha) of limes were also planted.

In a market study for the Caribbean Development Bank, Agricultural and Management Consultants Ltd (AMCL, 1990) identified an estimated total planted area of 28 625 acres (11 584 ha), of which 4600 acres (1862 ha) (16%) were grapefruit and 24 025 acres (723 ha) (84%) were orange. In September 1990, the Belize Citrus Growers' Association (CGA) estimated 25 000 acres (10 000 ha) in cultivation of which about 18 000 acres (7000 ha) were considered bearing, yielding an average of 155 boxes/acre (383/ha). The Development Finance Corporation (DFC) estimated on the basis of a rapid survey in 1991 that 28 000 acres (11 000 ha) had been brought into cultivation, of which 4000 acres 1600 ha) were grapefruit.

Given the rate of expansion of plantings by existing producers and the cultivation of plantations by many newcomers to the industry, a detailed census of plantings should be undertaken to facilitate forward planning of the processing companies. The census should take account of plantation age, land quality and management practices with a view to forecasting the yield potential of each farm, especially of the bigger growers. In 1991 hundreds of acres of oranges on the Puletan Plain land system in southern Stann Creek and northern Toledo Districts exhibited slow growth; they were also severely affected by drought.

For the purposes of this study, AMCL's area estimates are used and reproduced at Table 12. In the course of becoming productive, plantation-permanent labour requirements double: large-scale plantations requires a field work-force at the rate of 1 man/50 acres (20 ha) immature (mechanized maintenance) and 1 man/20 acres (8 ha) mature to undertake year-round upkeep (B. Faux, 1991, personal communication). For the industry as a whole this implies a permanent work-force of at least 860 workers, and some 1300 workers in aggregate, during the 1990 harvesting season (excluding processors' employees).

From Table 12 we can see a total of about 475 growers were registered members of CGA in 1990. Membership is not available until an applicant's grove is producing. Some 390 members have plantations of up to 20 acres (8 ha), estimated to amount to 3950 acres (1600 ha) in aggregate, and a further 55 have plantations of between 21 and 50 acres (8-20 ha) amounting to 1925 acres

Table 12 Estimated citrus acreage distribution

Acreage category	Number of growers (estimate)	Orange acreages (estimate)	Grapefruit acreages (estimate)	Total acreages (estimate)	% of all growers	% of all acreages	% of all orange acreage	% of all grapefruit acreage
1-5	200	775	200	975	42.1	3.4	3.2	4.3
6-10	100	700	275	975	21.1	3.4	2.9	6.0
11-20	90	1 600	400	2 000	18.9	7.0	6.7	8.7
21-30	25	525	200	725	5.3	2.5	2.2	4.3
31-40	15	400	125	525	3.2	1.8	1.7	2.7
41-50	15	525	150	675	3.2	2.4	2.2	3.3
50+	30	19 500	3 250	22 750	6.2	79.5	81.1	70.7
Total	475	24 025	4 600	28 625	100.0	100.0	100.0	100.0

Source: Agricultural and Management Consultants Ltd, 1990

(779 ha). The remainder of the planted acreage comprises 30 holdings encompassing about 22 750 acres (9207 ha), i.e. 79.5% of the industry. The citrus processors are included in the latter count and they provide 40% of processing throughput (1983:52%) and achieve field yields in the region of 200 boxes/acre (500/ha) for oranges and 300 boxes/acre (740/ha) for grapefruit. In early 1991 both processors' plantations were being expanded, with some 3000 acres (1200 ha) due to be planted.

Compared with the sugar industry the number of smallholders participating in the citrus industry is small: unlike cane, which can be cropped within 18 months of planting, citrus takes five years to come into bearing. Yield data imply extensive rather than intensive production by smallholders, i.e. exactly the same pattern as prevails in sugar-cane cultivation, but recent high prices may have spurred most growers into spending more on inputs, especially fertilizers.

Agricultural and Management Consultants Ltd report processing capacity of the two plants at 14 000 and 20 000 boxes/day, i.e. 2.8 million boxes and 4.0 million boxes/season. Capacity is therefore about 59% underutilized. Some underutilization is inevitable due to normal peaking in the fruiting cycle. The plants operate at full capacity (three 8-hour shifts/day) for about 20 days each year, and run two shifts for about 60% of the time and one shift for 30% of the time. If the estimated current planted area of 28 625 acres (11 584 ha) were to yield just 155 boxes/acre (383/ha) on average, as at present, this would provide some 4.4 million boxes/season. On a two-shift basis the processors could handle up to 4.5 million boxes/season. Given the adoption of improved field practices throughout the industry to match those of the processors, to yield an average of 200 boxes/acre (500/ha) (5.7 million boxes/season), plant utilization could reach 84%.

A grower in Cayo District is considering establishing a processing plant in the Belmopan area. If this plant is intended to purchase fruit from other growers, investment decisions should await the result of the plantation census and yield forecasts. Overcapacity would reduce profitability and damage the economies of scale of the Stann Creek plants. Yield forecasts for production on Puletan soils are substantially below the yield currently applying in the industry as a whole. Over the last four years major planting on these soils has included 900 acres (360 ha) at Mango Creek and 3300 acres (1340 ha) at Monkey River (S. Sorensen, 1991, personal communication), equivalent to about 15% of the estimated national planted area.

In 1985, 81% of citrus production, i.e. 10 421 acres (4219 ha), was located in Stann Creek District, followed by 13% (1628 acres (600 ha)) in Cayo District. At that time Toledo District had just 103 acres (42 ha), Belize District had 283 acres (115 ha), Corozal District had 300 acres (121 ha) and Orange Walk District had 152 acres (62 ha). The first commercial planting of citrus in Toledo District was in 1963; it is still bearing (O. Lewis, 1991, personal communication). Current development plans include 3000 acres (100 ha) (V. McAleer, A.

Johnston, 1991, personal communication) in the Big Falls area of Toledo District (of which 1000 acres (400 ha) were planted at the time of writing) and, since 1985, 6040 acres (2440 ha) in Cayo District (of which 1371 acres (555 ha) were planted at the time of writing).

Market projections by AMCL for Belize citrus concentrates anticipate export market volume rising from the 1990s' level of 2.11 million gallons (7.99 million litres) to 3.75 million gallons (14.2 million litres)/year in the year 2000. At an assumed yield of 0.75 gallons (2.8 l)/box, AMCL forecasts fruit requirement for processing rising to 5 million boxes by the year 2000. The forecast anticipates the gradual elimination of imbalance between world supply and demand, and a consequent decline in prices. The USA domestic supply of orange concentrate is expected to rise by 43% by the year 2000, causing import needs to decline by 23%. The USA orange consumption pattern is changing: chilled fresh juice consumption at 30% of total utilization in 1989/90 is expanding, while concentrate consumption has declined from 78.5% of total utilization in 1984/85 to 63.3% in 1989/90.

Belize exports concentrates to the USA free of duty under Caribbean Basin Initiative provisions. Progress with the USA's free trade initiative for the Caribbean and Latin America could lead *inter alia* to the elimination of the present import tariff on Brazilian juice concentrates, at US$ 0.34/lb (US$ 0.75/kg) solids, undermining Belize's position. In 1990, 75% of orange concentrate export volume and 77% of grapefruit concentrate export volume was sold by Belize's processors in the USA - see Figures 7 and 8. AMCL projects these sales to decline to 52% in the year 2000, and to be compensated by expanding markets in Europe and the Far East. AMCL concludes "if the international market situation stabilizes, farm prices can be expected to decline resulting in financial difficulties for some producers. The citrus industry should therefore guard against unplanned expansion based on ... short-term price movements ..."

Plans for expansion of Belize's citrus industry should accordingly be tailored to withstand recession. Marginally suitable lands should not be developed. Existing growers should consolidate their operations before contemplating further expansion. Pineapple juice concentrate manufacture is being investigated by one of the processors.

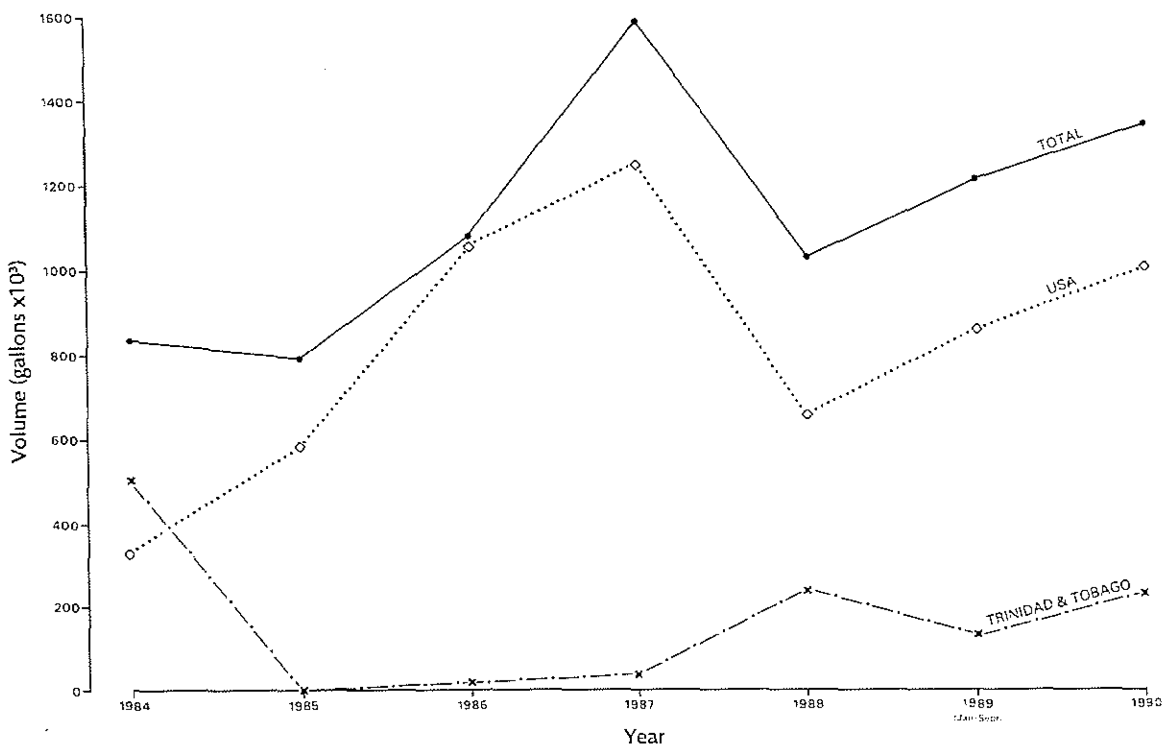
Bananas for export

Current economic considerations

The banana industry has expanded rapidly from about 2000 acres (800 ha) in 1985 to about 6000 acres (2400 ha) in 1991, of which about 5000 acres (2000 ha) are in production.

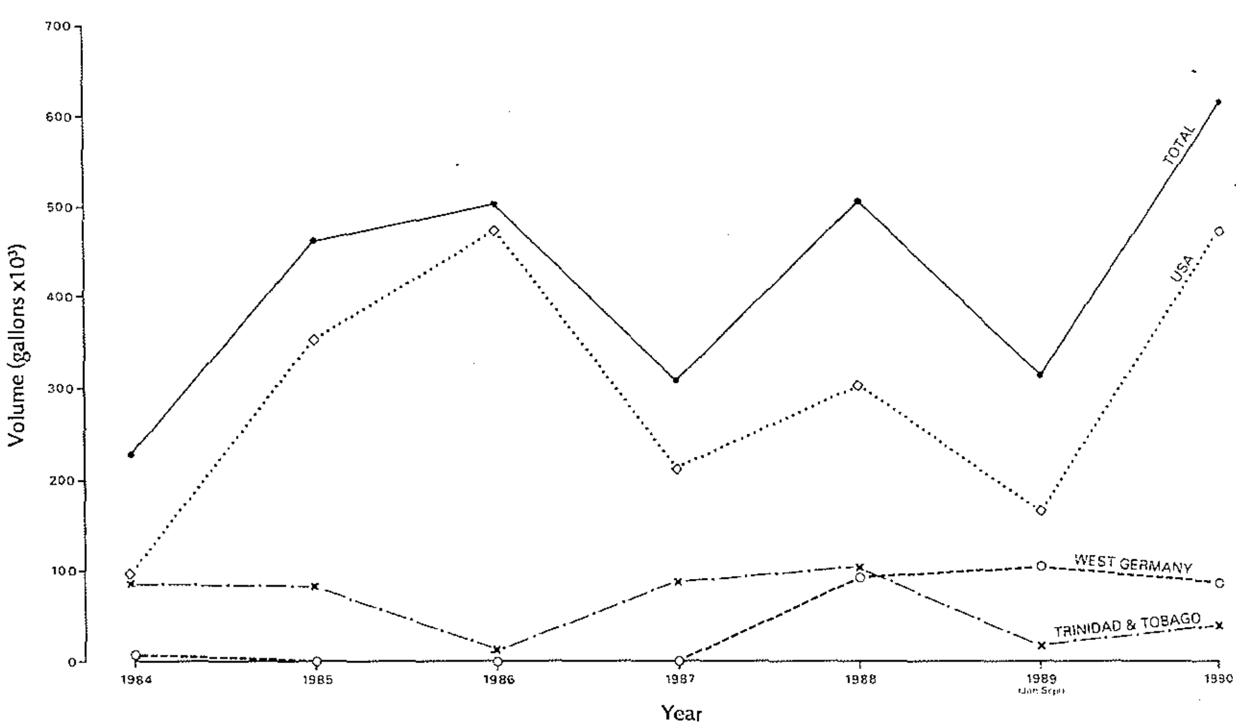
Permanent labour requirements for field maintenance are at about 6 acres (2.5 ha)/employee (Posford Duvivier *et al.*, 1988; M. Reddy, 1991, personal communication). Most field workers are Honduran single male migrants earning about BZ$ 17.00/day. Packing employs part-time workers at an average wage rate of BZ$ 24.00/day (including some overtime). These are mainly Belizeans (i.e. 90%) from Mango Creek. Packing personnel requirements work out at about 10 acres (4 ha)/worker, depending upon yield; they normally work for two days at each shipment. There are about 850 fieldworkers in the industry, and a further 500 part-time workers.

Until 1986 the industry was dominated by the 1600 acres (600 ha) of banana farms belonging to the Banana Control Board (BCB) parastatal at Cowpen, in southern Stann Creek District, with a handful of private growers providing the balance of production from farms located between South Stann Creek and Big Creek. Privatization of the Cowpen farms in 1986 and resulting yield increases (see Figure 6), accompanied by improved prices, gave farmers the confidence to expand and invest in irrigation equipment. Commercial banks willingly supported this expansion with new lending.



Source: Belize Statistical Service

Figure 7 Frozen orange juice concentrate exports



Source: Belize Statistical Service

Figure 8 Frozen grapefruit juice concentrate exports

In 1991 BCB's operations at Big Creek were wound up. Its export marketing role was taken over by the Banana Growers' Association (BGA) thus completing the privatization of the industry. In November 1990, following a BZ$ 1.5 million investment by a farmers' property company, Banana Enterprises Ltd, in port facilities at Big Creek, matched by an investment by Fyffes Group Ltd and loans from the Commonwealth Development Corporation and a commercial bank, direct shipment of fruit by ocean-going vessels to Portsmouth, UK, began, taking about 17 days. With the construction of the port at Big Creek, average shipment time was to be reduced to 12 days, eliminating a cumbersome barging and transhipment operation, and markedly reducing fruit spoilage in transit. Refrigerated vessels chartered by the UK importer Fyffes Group Ltd call at Big Creek weekly. The banana cargo capacity of each vessel is 150 000 boxes. Stowing has been manual but palletized stowing will be tried in 1991. Shipment of reefers has not yet been considered, and vessels do not have couplings for reefers. Therefore currently there is no prospect of using these vessels for shipping containerized perishables.

Big Creek is the second port of call in Central America (after Guatemala). Fruit is also collected from Honduras and the Dominican Republic on the return voyage to Belgium and the UK. Belize production, at around 30 000 boxes/week in 1990, accounts for 20% of each vessel's load. The Dominican Republic provides a further 13%, and the balance is made up of high quality fruit from Honduras and Guatemala.

One of the purposes of establishing port facilities at Big Creek for ocean-going vessels was to generate other economic development in southern Belize (Posford Duvivier *et al.*, 1988). Following experimental export of two reefers of mangoes in 1990 by a Monkey River producer, banana vessels will be shipping mangoes from the producer to Belgium by break-bulk in 1991. Mangoes are already on the banana vessels being shipped from Guatemala to Europe (M. Bwibank, 1991, personal communication).

As long as the EC banana protocol favouring traditional banana suppliers remains, or is succeeded by similar provisions after 1992, Belize, through the system of banana import licensing into the UK (which *inter alia* affords a 20% tariff protection to Belizean fruit) will be allowed to ship unlimited supplies of bananas. Current scheduling provides for shipment of up to 7.5 million boxes/year in aggregate by Fyffes from the four supplier countries.

Belize banana exports peaked at 1.5 million boxes in 1989 (see Figure 6) but would have been about 20% higher had not the crop succumbed to both winter chilling and an epidemic of sigatoka disease. In 1990 an even more severe chill was largely responsible for a decline in export sales to 1.3 million boxes. In 1991, although chilling did not take place, a protracted drought during the first five months (last experienced in 1975) will probably seriously retard output from May until September. Nevertheless production of up to 2.0 million boxes was anticipated from the 5000 acres (2000 ha) during 1991 (M. Bwibank, 1991, personal communication).

In 1988 one grower achieved a yield of 801 boxes/acre (1980/ha) without irrigation. High levels of productivity are being achieved on only three farms capable of yielding up to 900 boxes/acre (2200/ha) (A. Zabaneh, 1991, personal communication). None of the Cowpen farms is performing satisfactorily. The industry's largest farmer has experienced a decline in production from 450 boxes/acre (1100/ha) in 1988 to 300 boxes/acre (700/ha) in 1990. This performance is no better than that achieved under BCB management in the mid-1980s. Several years of uneventful weather are needed to put the existing industry back on a sound financial footing.

In February 1991, BGA and the Belize Agribusiness Company (BABCO) agreed to co-operate to look at the possibility of banana growers diversifying into *inter alia* avocados, mangoes, papayas and, especially, pineapples (A. Novelo, 1991, personal communication).

Plans for expansion of the industry

The financial justification for port investment was based solely upon forecast production, estimated in 1988 to stabilize at about 4 million boxes (of 42 1b (19 kg) equivalent) annually by 1992.

In 1991 the banana industry entered a crisis, due to cash-flow problems (brought about by the cumulative effects of disease - in 1989 only - and extreme weather conditions) which could not readily be solved by further commercial borrowing - the industry's borrowing was already highly geared. In May, three farms had suspended production, while production by two other growers had been reduced because of drought, so that out of the 1990 area of 6075 acres (2458 ha) of plantations, about 1000 acres (400 ha) were no longer being harvested. Meanwhile new planting had taken place on only 200 acres (80 ha). Operations were suspended on 800 acres (300 ha) but were considered capable of resuscitation. In 1992 therefore, discounting any plans for further planting, the acreage will remain at about 6000 acres (2400 ha).

Seven thousand acres (3000 ha) could be in production by 1994 from the development of land already acquired by farmers. This forecast excludes 600 acres (240 ha) that could be financed under a credit programme of the Development Finance Corporation (DFC) using World Bank funds. The BGA hopes to attract foreign capital to reach a productive area of 10 000 acres (4000 ha) which could be expected to provide about 4 million boxes of export-grade fruit annually.

The BGA is critical of the management practices of most of its members: only six farms (40% of the total planted area) have a fully operational irrigation system, and, having expanded in 1987-89 on the strength of anticipated cash flow, several undercapitalized producers in 1991 found themselves unable to maintain the appropriate level of inputs. The three farms in suspense are insolvent. Their under-canopy irrigation systems, sufficient for about 1500 acres (600 ha) and imported from the UK in 1989 under a group scheme for six farms (2500 acres) (1000 ha) organized by the BCB, have not yet been installed. Serious effort to resuscitate idle farms is required before the Government of Belize can consider proposals for planting new, as yet unallocated, areas to bananas.

Taking into account the facilities of Big Creek port and the probability that political lobbying will ensure some measure of market protection in the EC for traditional suppliers, the expansion of banana production to 10 000 acres (4000 ha) could be encouraged, but the continued risk of winter chilling and disease suggests limiting expansion until it can be seen whether the industry can be profitable.

Cacao for export

With support from Hummingbird Hershey Ltd (HHL) and donors, the cacao industry has steadily expanded during the 1980s to about 1200 acres (490 ha) in cultivation (1984-85 Census: 1142 acres (462 ha); 318 holdings). In southern Toledo District semi-wild cacao can be found, which may have potential as a source of germoplasm for breeding. HHL's own estate comprises 400 acres (160 ha) at Sibun in Cayo District. In 1990 HHL achieved an average yield of 800 lb dry beans/acre (900 kg/ha). Of the 340 000 lb (150 000 kg) exported that year, some 13% (45 000 lb) (20 000 kg) were supplied by outgrowers in Cayo, Stann Creek and Toledo Districts. For 1991 HHL expected to produce only 200 000 lb (90 000 kg) (500 lb/acre) (600 kg/ha) on its estate because of the severe drought.

In 1991 HHL was buying dry beans from growers at BZ$ 1.25/lb (BZ$ 2.76/kg) at its factory, equivalent to a gross revenue of BZ$ 1000/acre (BZ$ 2500/ha) on land yielding 800 lb/acre (900 kg/ha). Given the demanding level of management required by cacao, this represents a dismal return to labour and investment, especially since few small farmers manage to attain this yield. Runaway fires in 1991 wiped out several acres of smallholder cacao in Stann

Creek and Toledo Districts during 1991: leaf litter retention for mulching predisposes the crop to such a hazard.

Some commodity forecasts are beginning to suggest an end to the 15-year decline in world prices. The crop is a component of the International Fund for Agricultural Development (IFAD) and Toledo Agricultural Marketing Project (TAMP) projects in southern Toledo District, and is also the main crop of a settlement scheme established for HHL employees. It should be grown for long-term speculation. The industry is fortunate to retain the long-term support of HHL.

For land-use planning purposes, allocation for smallholder cacao should be considered only when the nature of the world market has been explained to the prospective planters. Cacao will not materially affect land-use planning; it is likely to become a significant crop only in southern Stann Creek and Toledo districts.

Shrimp mariculture for export

Shrimp mariculture started in 1982 mainly under foreign ownership. By 1988 a total of 468 acres (189 ha) of raised ponds had been built. Investment had been mainly in earthworks rather than the development of appropriate farming technology. There have been difficulties in procuring finance to continue experimental operations, causing suspension of operations by four out of the seven firms active in the industry. This has both retarded the development of the industry and discouraged the participation of new firms.

Fisheries Department's record of farmed shrimp production for 1990 was 208 810 lb (94 714 kg) and its estimate for 1991 is 1 706 000 lb (774 000 kg). Attempts to produce shrimp seed stock by captive breeding in two hatcheries in Belize during the late 1980s did not result in development of reliable methods of propagation, although some success was achieved with breeding both local and imported species. Both hatcheries are no longer operational. Of all the species tested for growth performance, *Pennaeus vannamei*, a Pacific species, has consistently given the best response (H. Hun, 1990, personal communication). Seed stock of this species is currently imported as Post Larvae from suppliers in the USA, Costa Rica and Panama. In 1990 most of the supply come from a USA hatchery. Laguna Madre Belize Shrimp Farm Ltd (LMBSF), located at Riversdale in Stann Creek District is planning to develop an experimental hatchery (L. Thornton, 1991, personal communication). This could reduce dependence upon imported seed stock, which at certain times of the year is in short supply due to domestic demand in the producer countries.

There is no set pattern of employment in the industry. In general there has been heavy reliance upon expatriate management and technical expertise in the initial development of each project, which has substantially raised overhead costs. One project is currently employing full-time pond operators (mainly Belizean) at the rate of one operator per seven acres (3 ha) of ponds. For crops of about 32 000 lb (14 500 kg) in aggregate of whole shrimp, a part-time work force of 30 harvest workers and 50 processors has been recruited from Mango Creek.

Viability of shrimp farming depends, among other things, upon the achievement of high stocking density without high mortality, satisfactory feed conversion ratios, maximal growth rates, and efficient harvesting and processing. Ice requirements at harvesting are equivalent to twice the crop weight.

In 1991 two producers were stocking at rates of between 70 and 90 shrimps/m^2 (6.5-8.4/ft^2): one stocking juvenile shrimps after growing on Post Larvae in juvenile ponds, and the other stocking Post Larvae direct. Recent yields have been between 6000 lb and 8500 lb/acre (6700-9500 kg/ha) at five months from stocking, with feed conversion ratios at about 2.4:1. Tail yield is about 64% of whole shrimp weight.

About 150 gallons of diesel/pond acre (1700 l/pond ha), i.e. 750 gallons/crop/acre (8400 l/crop/ha) are required for pumping and aeration. The cost of importing feed from the USA is BZ$ 0.04-0.06/lb (BZ$ 0.9-1.3/kg). If the industry expands, feeds should be formulated and marketed in Belize. Seed stock in the form of Post Larvae is currently sustaining operations. The NOVA shrimp farm is establishing a hatchery.

The number of applications for land for shrimp farming has shrunk over the last two years (G. Myvette, 1991, personal communication). Existing producers have already secured sufficient lands for their foreseeable needs, although one producer plans to acquire a further 2000 acres (800 ha) of contiguous lands for possible future expansion. Applications for new lands for shrimp farming are unlikely to follow until existing producers have been successful. Land near the shrimp farms should be held in reserve for future possible smallholder satellite shrimp production, benefiting from the already established processing facilities, if they prove successful. Such a scheme is contemplated by the World Bank/Development Finance Corporation credit programme. An important selection criterion for pond land is altitude, which must be more than 6 ft (2 m) above sea level in order to permit satisfactory gravitational drainage. Few coastal sites meet this requirement.

Beef cattle industry

Notwithstanding a buoyant local market for fat slaughter cattle at about BZ$ 0.90-1.10/lb (BZ$ 2.00-2.40/kg) liveweight, and some sales of live slaughter steers to Mexican importers in 1991, the cattle industry is stagnant. Local market prices, which have risen by about 5% over the last year, imply that supply is just sufficient to satisfy demand.

The closure of the United States Department of Agriculture (USDA)-approved slaughter and meat-packing operations of Belize Meats Ltd at Ladyville in early 1991 ended a 14-year effort by the Government of Belize (GOB) to develop a profitable beef export industry by means of Belize Beef Corporation (BBC), established in 1977 as a BZ$ 6.0 million joint venture between the public and private sector to undertake integrated large-scale ranching, feedlot and slaughter operations. The private sector did not take up its share of equity, leaving ownership shared between the Caribbean Development Bank (CDB) and GOB with only BZ$ 2.4 million capital raised. Undercapitalization prevented farm operations reaching full potential; the feeding of home-grown sugar-cane was never given full trial. The throughput (4000 head/year) and cold storage capacity of the slaughter and packing facility of Belize Meats Ltd proved to be greatly in excess of requirements. Some success was obtained during the late 1980s, when a USA group began a joint venture with the government to export frozen beef to Jamaica and the East Caribbean, but low throughput, from lack of availability of slaughter cattle and an uncompetitive buy-in price, prevented viability. The joint venture was dissolved in 1990. Recommendations for major refurbishment of Belize Meats Ltd have not been pursued and the plant cannot be resuscitated, especially since it is 50 miles (80 km) from each of the major ranch areas. Cayo District now has its own facilities.

During the 1970s the national total of cattle slaughtered peaked at 7276 head in 1978. There then followed a steady decline to 5820 head in 1983. Controls on slaughtering and domestic meat prices in the early 1980s (since lifted) are blamed by farmers for the reducing level of output.

In 1984, 6189 head were slaughtered, since when slaughterings have averaged about 7000 head annually. In 1990 a total of 7139 head were slaughtered, of which 3220 were slaughtered in Cayo District. With the closure of Belize Meats Ltd, Cayo slaughterings are likely to increase to about 3600 head/year. In recent years slaughterings in Orange Walk District, which has almost the same pasture area and 76% of the cattle population of Cayo District, averages 700 head/year.

Between 1978 and 1985 the national cattle herd declined by about 400 head to 48 400 animals, whereas the pasture area increased by 9300 acres (3800 ha) to 117 700 acres (47 630 ha) of which 36 500 acres (14 800 ha) (31%) were considered to be under imported, improved grass varieties - see Table 13. Since 1985, herd numbers are thought to have reduced, especially in Stann Creek District, where about 600 acres (200 ha) of pasture have been converted into citrus groves, and in Orange Walk District, where large-scale ranching has suffered from neglect and breeding herd dispersals. Between 1978 and 1985 the national pasture stocking rate declined by 8% to 2.4 acres (0.97 ha)/animal; Orange Walk District declined from 2.0 acres (0.8 ha)/animal to 2.8 acres (1.1 ha)/animal. Field observations in 1990 and 1991 indicated large areas of unmanaged pasture in Orange Walk and Cayo Districts were being recolonized by secondary bush.

The Belize Livestock Development Project (BLDP) of the Ministry of Agriculture aims, among other things, to upgrade cattle productivity throughout Belize by developing simple management systems for natural and improved pasture, accompanied by improvement of the genetic base through implementation of a *Bos indicus* artificial insemination programme. Participating farmers are thereby expected to achieve stocking rates of about 2 acres (1 ha)/cow on natural pasture, and 1 acre (0.4 ha)/heifer or steer on improved pasture. Tergas (1991) considered the project could be extended to all ranchers. Existing pasture lands could thereby carry up to 69 000 head, representing an increase of 40% in pasture-carrying capacity. Replacement of natural pasture by improved grass varieties, introduction of legume trees (*Leucaena* spp.) for dry-season feed supplementation and as live fence posts, and modest use of fertilizers were included among the possibilities he considered for raising carrying capacity. He also identified possibilities for converting marginal pasture lands, e.g. on steep, erodible slopes, into plantation forestry which, if accompanied by improved cattle ranching practices, would allow the cattle industry to expand on to the remaining pasture.

For many farmers, especially smallholders, animal husbandry is not a cash-cropping activity, rather a form of saving, i.e. cattle and pigs can be sold for cash in times of cash-flow difficulty, but are otherwise held in reserve. Notwithstanding the present very extensive system of raising cattle in Belize, cattle farmers should be encouraged to perceive their animals as a cash crop, like sugar-cane and citrus, but only if appropriate market opportunities can be created beyond the existing domestic fresh meat market.

Corned beef features highly on the import list of several Caribbean countries. In 1990 Belize imported 373 089 lb (169 229 kg) of corned beef (64% from Brazil) for a landed value of BZ$ 736 000, of which 30 746 lb (13 946 kg) were re-exported to Mexico. In 1991 a meat trader in Merida, Mexico was reported to be interested in importing whole sides of beef from Belize (J. Dyck, 1991, personal communication). The private sector could be encouraged to take the initiative in pursuing new markets and in establishing appropriate processing facilities. Since Cayo District dominates domestic meat supply, it would be

Table 13 Ratio of pasture to cattle numbers

District	Number of cattle 1978	1985	Pasture (acres) 1978	1985	Pasture/animal 1978	1985
Belize	6 922	6 665	19 472	16 500	2.8	2.5
Corozal	1 050	1 644	2 226	29 301	2.1	1.8
Orange Walk	15 501	15 328	30 885	42 313	2.0	2.8
Cayo	22 225	20 267	50 050	46 859	2.3	2.3
Stann Creek	1 526	1 678	2 847	3 314	1.9	2.0
Toledo	1523	2 781	2 961	5 820	1.9	2.1
Total	48 747	48 363	108 441	117 737*	2.2	2.4

* Improved grasses: 36 482 acres; natural pasture: 81 255 acres
Source: Ministry of Agriculture, 1978, 1987

logical to direct new abattoir and export processing development towards Orange Walk District.

The decline in stocking rates of the cattle industry between 1978 and 1985, and the lack of development of new markets for Belizean beef, indicate a moratorium on further pasture development should be declared, although this will be difficult to implement since mechanized arable cropping systems often incorporate a fallow period under grass. Nevertheless land clearing purely for ranching should be discouraged.

There are two pre-requisites to expansion of the national pasture area: new market openings must first be identified; and a commitment from investors to establish appropriate processing facilities to supply the respective markets must also be obtained.

It is essential that BLDP meanwhile devises a level of animal husbandry practice that can be realistically extended to farmers, yet provide satisfactory returns to labour and finance under present market conditions.

Maize

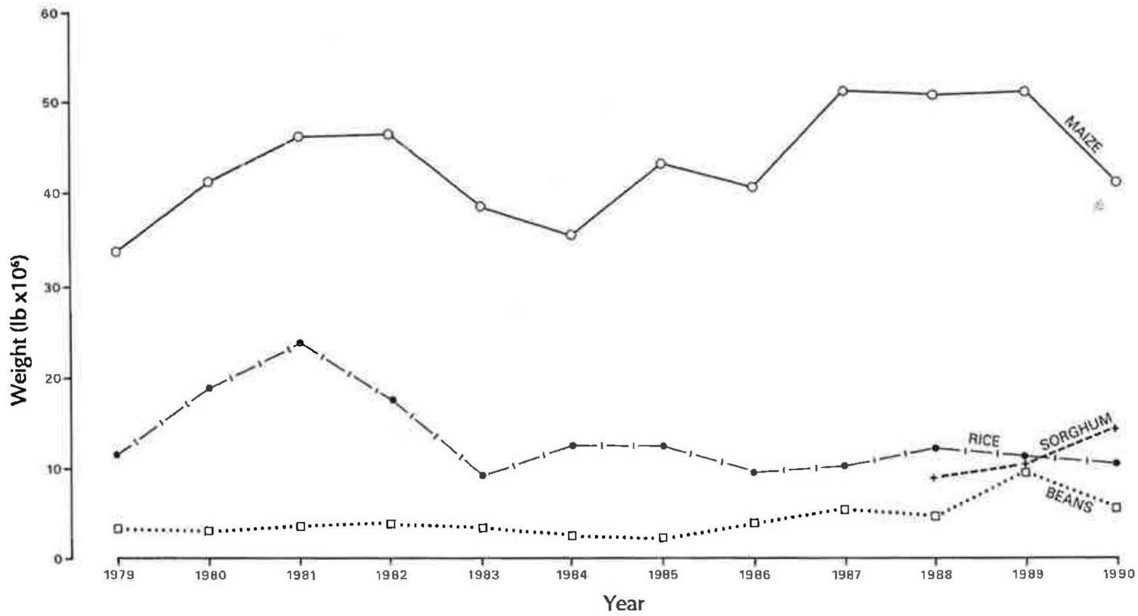
Maize is produced to meet domestic requirements both for human consumption and for blending in poultry and pig rations. The market is free, with prices in 1990 in the range of BZ$ 0.18-0.20/lb (BZ$ 0.40-0.44/kg). In 1990 a total of 41.2 million lb (18.7 million kg) were produced from 24 326 acres (9844 ha), which is about 80% of the production achieved in each of the previous three years, when the gross area cropped was about 32 000 acres (13 000 ha)/year. Maize imports in 1990 amounted to 117 713 lb (53 393 kg); maize flour imports amounted to 124 278 lb (56 371 kg) mainly from Guatemala. If contraband imports of flour are discounted, Belize is 99% self-sufficient in maize production. Table 14 sets out the 1990 production for milpa and mechanized farmers respectively in each district. Slightly more than one half of production is mechanized, mainly by Mennonite communities. A new grower in Orange Walk District is planning to plant about 1200 acres (500 ha) of high-yielding corn during 1991, which could add about 3 million lb (1.4 million kg) of production. Milpa production is especially important to communities in Toledo District where, over the last four years, between 34 and 53% of the national land area under milpa maize has been cultivated, although the percentage will probably be lower in 1991.

Over the last decade recorded maize production has fluctuated between 31 and 51 million lb (14-23 million kg) annually (Figure 9). Maize consumption is likely to rise in proportion to population, possibly accelerating through sales of pork and poultry responding to a rise in disposable incomes. If consumption of about 65 million lb (29 million kg) (about 27% higher than 1989 production) is projected for the year 2000, the increase required in the annual planted area over the 1987-89 level of about 26 000 acres (11 000 ha) net would be about 7000 acres (3000 ha). Arable farm expansion on lands at Yalbac, New River Lagoon and at Little Belize will be quite sufficient to meet such an increase.

Table 14 Maize production for 1990

District	Milpa		Mechanized		Total	Total
	Area (acres)	Yield (lb/acre)	Area (acres)	Yield (lb/acre)	area (acres)	production ('000s of lb)
Corozal	520	1 200	4 780	1 500	5 300	7 794
Orange Walk	1 500	1 500	3 000	2 560	4 500	9 750
Belize	231	1 000	0	0	231	231
Cayo	2 790	1 500	5 210	2 500	8 000	17 210
Stann Creek	295	600	0	0	295	177
Toledo	6 000	1 000	0	0	6 000	6 000
Total	11 336	1 100	12 990	2 200	24 326	41 162

Source: Ministry of Agriculture



Source: Ministry of Agriculture

Figure 9 Agricultural production of maize, rice and beans (mainly red kidney beans), 1979-90

Sorghum

Sorghum production volumes now match those of rice (see Figure 9). Pests and diseases are normally not a problem. Nearly all sorghum produced is sold to millers at about BZ$ 0.18/lb (BZ$ 0.40/kg) for blending in poultry and pig feed concentrates. Between 1988 and 1990, production rose from 8.9 million to 14.4 million lb (4.0-6.5 million kg), but the recorded area in production remained broadly unchanged at some 4400 acres (1800 ha). Shipyard farmers provide about 90% of the production. In May 1991, a new grower who planted sorghum for the first time in 1990 was seeking buyers for his crop; possibly this new supply put production in surplus. With the relocation of some Shipyard farmers south of Indian Church they should be able to meet all of Belize's foreseeable increases in demand for sorghum.

Rice

In the early 1980s, rice production was managed by the Belize Marketing Board's (BMB) fixing of prices and control of imports. Production fluctuated between 9.2 and 23.9 million lb (4.2-10.8 million kg) (see Figure 9), according to the declared price. From 1984 production stabilized between 9.7 and 12.5 million lb (4.4-5.7 million kg) annually when the price was held at BZ$ 0.24/lb (BZ$ 0.53/kg). Milled rice was sold by BMB at BZ$ 0.50/lb (BZ$ 1.10/kg) wholesale, but net recovery of dried, milled rice to whole rice was in the region of 60%, implying a direct cost of BZ$ 0.40/lb (BZ$ 0.88/kg) milled rice, to which should be added milling, drying and storage costs in the region of BZ$ 0.15/lb (BZ$ 0.33/kg), leaving BMB with a deficit.

In 1990 BMB established a whole rice floor price of BZ$ 0.25/lb (BZ$ 0.55/kg), from which deductions would be made if moisture and foreign matter content were unacceptably high. BMB has taken on the role of a price stabilization agency, allowing retail prices to creep up to a maximum of BZ$ 0.69/lb (BZ$ 1.52/kg) before intervening with sales from its stocks to cool the market. The ceiling allows for a retail price rise of up to 33% over the controlled retail price (BZ$ 0.52/lb) (BZ$ 1.15/kg) prevailing earlier in 1990. Mechanized rice farmers, with appropriate land at their disposal, and private rice millers will probably be the main beneficiaries of the price stabilization programme. The extent to which BMB will be able to accumulate stocks is not clear.

In 1990, 10.2 million lb (4.6 million kg) of rice were produced from 5089 acres (2059 ha) of which 2819 acres (1141 ha) were considered milpa. Between 1988 and 1990, production in Toledo District declined from 7.0 million lb (3 million kg), with 4173 acres (1689 ha) under milpa, to 4.0 million lb (1.8 million kg), with 2240 acres (907 ha) of milpa, constraining the ability of BMB to cover the overhead costs of its rice mill at Big Falls. Following the construction of an access road to new land, the area planted to milpa rice in Toledo District has increased. Milpa rice has been planted as a roadside crop only for the last couple of years. Meanwhile although the national area of rice plantings declined from 6802 acres (2753 ha) to 5089 acres (2059 ha), the area under mechanized cultivation increased slightly from 2045 acres (2059 ha) to 2270 acres (919 ha).

In 1991, BMB anticipated that the expansion in production necessary for Belize to achieve self-sufficiency would come from additional mechanized production, not from increased milpa production. About 1100 acres (445 ha) of mechanized rice is planned for southern Toledo District (V. Choco, 1991, personal communication), 300 acres (120 ha) of double-cropped, fully irrigated paddy at Rio Bravo (J. Dyck, 1991, personal communication), and 1700 acres (700 ha) of mechanized rice at Blue Creek in Orange Walk District. Assuming a medium yield of 2500 lb/acre (2800 kg/ha) /crop, these areas, combined with production from a 470 acre (190 ha) mechanized farm in Stann Creek District, would, at 3570 acres (1440 ha) probably provide almost 9 million lb (4 million kg) in 1991.

The 1990 imports of milled rice by BMB amounted to 5.0 million lb (2 million kg) (landed cost BZ$ 0.43/lb (BZ$ 0.95/kg)), mainly from the USA, to cover a 45% deficit in local milled rice production.

Fully appreciating the economics of BMB's rice operations at Big Falls, GOB has stated it is continuing its commitment to small-farmer production of rice in southern Toledo District, but this level of subsidy cannot be expected to last indefinitely, especially when mechanized rice production is increasing rapidly in the north of the country.

The BMB (1991) anticipates per caput consumption of milled rice to continue at 1990 levels of about 50 lb (23 kg)/person annually, and to grow with the population at about 2% per year. By the year 2000 milled rice consumption could be in the region of 11.2 million lb (5.08 million kg), equivalent to 19 million lb (9 million kg) of whole rice. If the industry were fully mechanized at that time, the area required for planting (assuming one crop/year) would be about 7600 acres (3100 ha), representing an increase of about 4000 acres (1600 ha) over the current area in mechanical cultivation. As in the case of other grain crops, it is likely that the new lands being opened up by the Mennonite communities will provide some suitable sites, such as the lower slope subunits of the Hill Bank and Xaibe Plain land systems.

Official encouragement of more mechanized rice production should be accompanied by adaptive research to assist milpa farmers in transforming their system of production out of rice. To some extent the IFAD and TAMP projects in southern Toledo District are addressing this issue.

Beans

Between 1988 and 1990 soya bean plantings increased from 49 to 223 acres (20-90 ha), principally in Cayo (126 acres (51 ha)) and Corozal (91 acres (37 ha)) Districts. In 1990 a feed-mill in Spanish Lookout was buying production at BZ$ 0.33/lb (BZ$ 0.73/kg), i.e. about BZ$ 0.05/lb (BZ$ 0.11/kg) higher than the cost of equivalent imports, to be used as a full-fat feed ingredient (O.Reimer, 1990, personal communication). Problems with obtaining use of a combine harvester at the right time have prevented production developing further. The Ministry of Agriculture and Fisheries plans development of up to 2000 acres (800 ha). Suitable land could be found within existing arable areas.

Commercial black bean production has had a turbulent start: 1.1 million lb (0.5 million kg) were produced from 1137 acres (460 ha) (890 acres (360 ha) in Cayo District) in 1990. In Toledo District, people have stopped buying black beans and farmers have stopped growing them. This is essentially a cash-cropping activity integrated into arable farming and need not be a concern of long-term land use planning.

Red kidney beans are produced for local consumption and export, mainly to Jamaica where tariff barriers favour Belize. Following a bumper crop of 9.3 million lb (4.2 million kg) in 1989, much of the 1990 crop succumbed to blight during late rains, providing a yield of only 5.7 million lb (2.6 million kg). A total of 2.8 million lb (1.3 million) were exported at an FOB value of BZ$ 3 231 000 (BZ$ 1.15/lb; BZ$ 2.54/kg).

Plantings covered 11 350 acres (4593 ha) in 1989 and 9786 acres (4439 ha) in 1990. Production is concentrated on mechanized arable farms in Corozal, Cayo and Orange Walk Districts. In 1990 the Little Belize community exported 460 000 lb (209 000 kg) and planned to export 500 000 lb (200 000 kg) in 1991 (J. Redecop, 1991, personal communication). Owing to the poor storage properties of red kidney beans produced in Belize, a high proportion are normally exported, while beans are imported from the USA to satisfy the local market during the wet season.

Red kidney bean cultivation could be doubled to about 20 000 acres (8000 ha) by arable farming communities on their existing lands, given continuation of opportunities to export to the Caribbean.

Minor crops

Vegetables, root crops and melons

Various vegetables and root crops are grown for local consumption, particularly during the closing months of the wet season, and various varieties of melons are grown during the dry season. Efforts by the Belize Agribusiness Company (BABCO) to develop dry-season cropping with irrigation are achieving some results. The Ministry of Agriculture and Fisheries identified 290 acres (120 ha) planted with vegetables in 1990, a further 381 acres (154 ha) planted with cassava, sweet potatoes and yams, and some 80 acres (30 ha) with melons. The areas required for these operations generally comprise small plots within a mixed farming system. Their doubling to some 1500 acres (600 ha) could be readily achieved on existing arable lands.

Peanuts

Peanut production reached 0.4 million lb (0.2 million kg) on 496 acres (201 ha) in 1989, but fell back to 0.2 million lb (90 000 kg) on 168 acres (68 ha) in 1990. Although 69 020 lb (31 310 kg) at an FOB value of BZ$ 79 000 (BZ$ 1.14/lb; BZ$ 2.51/kg) were exported to Barbados in 1990, it is unlikely that Belize will be able to develop a major export market for this crop: on a farmer's average selling price of BZ$ 0.95/lb (BZ 2.0/kg) in 1990, the gross margin was only 10%. Moreover the nut is small and samples lack uniformity (A. Novelo, 1991, personal communication). If market conditions change, sizeable expansion of peanut production could take place on existing farms.

Mangoes

The local mango market is supplied both from small-scale production from clusters of trees throughout the country, and from a large commercial grower of 1000 acres (500 ha) of rehabilitated 25-year-old orchards at Monkey River. The same grower established a further 350 acres (160 ha) in 1986/87 which are expected to bear in 1993. There were substantial sales of budwood to multinational plantations in Honduras in 1990.

The mango harvesting season coincides almost perfectly with the citrus off-season, and can run from May until September, but normally nearly all of the crop is taken in the period May to July, with a modest second crop in late August. There are about ten commercial varieties.

Belize mangoes are usually unfit for export as fresh fruit: flowering takes place mainly in November, i.e. during the wet season, and under wet conditions fruit set is accompanied by invasion of anthracnose. At ripening, anthracnose breaks out of dormancy and initially gives rise to black lesions on the fruit skin, which then develop into a mould. Effective methods of controlling anthracnose under Belizean conditions have not yet been developed, but when flowering has taken place under dry conditions (about once every five years), as occurred in 1990, the resulting fruit may be fit for export. This is the basis of the 1991 plan to export to Europe. Phytosanitary regulations relating to incidence of *inter alia* Mediterranean Fruit Fly prevent fresh mangoes being exported to the USA.

Mango trees have proved to be extremely hardy under Belizean conditions, being able to cope with both waterlogging and drought. The trees can grow without receiving any care; so fruit reaping in most situations is opportunistic rather than a strictly agricultural activity. Fruit yield follows a biennial pattern: 1990 was a particularly lean year, although producing export quality fruit.

The trial shipment of fresh mangoes to Belgium in 1990 amounted to 27 000 lb (12 000 kg) (declared value BZ$ 11 000). Efforts by the Monkey River producer to develop exports of frozen mango puree are continuing.

Cotton

Sea Island cotton was produced on about 800 acres (400 ha) of former sugar-cane lands near Trial Farm, Orange Walk in 1990; 79 596 lb (36 104 kg) of cotton was exported at a declared value of BZ$ 641 000. Regrowth of the crop in 1991 was hampered by drought. The success of this venture should be monitored to determine whether it may be extended to other mechanized farms.

Papayas

Following on from irrigated field trials conducted by BABCO in 1987-89, a group of investors is growing 95 acres (38 ha) of irrigated solo papaya in Corozal District, producing for the local hotel trade and for export. In 1990, 1.1 million lb (0.5 million kg) were exported to the USA (declared FOB value BZ$ 443 000). In 1989 exports were suspended for several months due to an outbreak of Mediterranean Fruit Fly.

Efforts by small farmers to participate in production for export have been assisted by BABCO. Although organizational and technical difficulties prevented operations from becoming viable at the first attempt in 1987-88, about 60 acres (24 ha) of new plantings will be grown by groups of farmers in 1991. This is an intensive crop which could be further developed in the sugar-cane farming districts.

Coconuts

The 1984-85 Agricultural Census (Ministry of Agriculture, 1987) identified 7376 acres (2985 ha) of coconuts, spread over 4761 holdings. The crop is kept for home use and for sale of whole nuts and oil in the urban areas. Producers in Hopkins sell ripe nuts at BZ$ 0.25 each at the farm and at BZ$ 0.50 in towns. Coconuts create a tropical ambience sought by visiting tourists on off-shore cays. Stands should remain intact on the cays. The cays should also be planted with hybrid material resistant to the lethal yellowing disease which has already denuded resorts in the Yucatan Peninsula, Mexico.

Spices

The spice for which Belize is best known is allspice or pimento which traditionally has been harvested from wild trees growing under the natural forest canopy. There were no recorded exports in 1990. Until the early 1980s up to 100 tonnes/year were exported to Germany, the UK and Scandinavian countries (J. Loskot, 1991, personal communication). Much of the area from which allspice was harvested has since been brought into cultivation. The world market for this spice should be monitored to determine whether the business should be reactivated in the remaining forest areas. BMB buys allspice from producers at BZ$ 0.50/lb (W. Bardalez, 1991, personal communication).

In 1991 garden stands of nutmeg could be found at Barranco and Dolores, southern Toledo District. All the trees are over 25 years old, with female trees giving consistent yields of up to 400 nuts/year without receiving any maintenance. Sun-dried nuts are sold in Punta Gorda at BZ$ 0.25-0.30 each (A. Zuniga, H. Arana, 1991, personal communication). As a garden crop nutmeg could have potential in the southern, wetter areas. World market conditions are currently weak due to the failure of a cartel established by Grenada and Indonesia. Cloves might similarly be worth trials for small-scale production, but again world market conditions are currently unfavourable due to oversupply. Black pepper trials in Toledo District were unsuccessful because of fungi.

Southern Toledo District probably provides satisfactory growing conditions for vanilla, but no work has yet been carried out with this crop. It is highly labour intensive and will have to compete with synthetic vanilla. The crop is extensively cultivated in former French overseas territories in the Indian Ocean. Prior to the oil boom, Mexico was an important producer.

Belize Agribusiness Company is co-ordinating experimental cultivation of vegetable ginger on several farms throughout the country. It is a high-yielding crop, expected to give up to 40 000 lb/acre (45 000 kg/ha). The experiment may lead to cultivation of ginger for dried spice, in which instance a Jamaican cultivar will be used. The intensive nature of ginger cultivation means, at a commercial scale, more than 500 acres (200 ha) would be required.

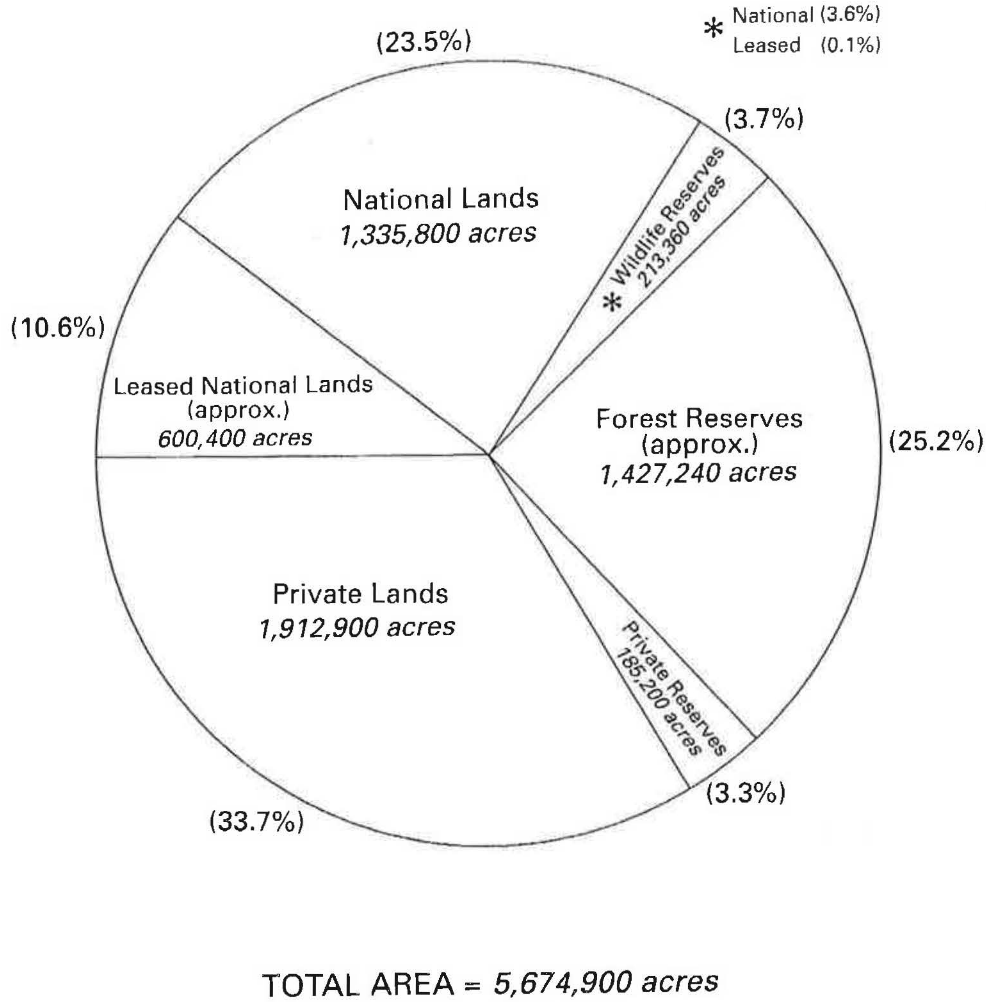
Cashew

Cashew is grown on the deep sandy Crooked Tree soils found in Crooked Tree village in Belize District. A number of families earn BZ$ 6000/year from the sale of roasted kernels in Belize City. Several attempts at establishing cashew elsewhere in the country, often on unsuitable Puletan soils, have failed. Sometimes growth is stunted by fires.

Jenkin *et al.* (1976) estimated yields from a mature tree could be 30-60 lb (14-27 kg)/year. Coles (1980) took a more conservative estimate of 22 lb (10 kg)/year. There has been little development of cashew due to the labour cost of harvesting the nuts, and the difficulty of processing them because of the corrosive oil from the shell of the cashew nut. NRI is currently testing a small-scale decorticating machine which can process 220 lb (100 kg) of cashew nuts/hour, but the capital cost is too high for a smallholder community.

DEMOGRAPHIC AND SOCIAL CHARACTER OF CURRENT LAND USE

Figure 10 shows the national apportionment of land ownership and tenure. The 1984-85 agricultural census (Ministry of Agriculture, 1987) identified 9900 rural households with land, of which 7500 had less than 50 acres (20 ha). On farms with less than 50 acres of land (small farms), 7100 persons worked full time and 6100 part time on their land. On farms with more than 50 acres (large farms) 2600 persons worked full time and 1700 part time on their land.



Source: BCES, 1991a

Figure 10 Land ownership and tenure

The small farms provided full-time employment for 1200 persons while the large farms provided full-time employment for 2700 persons. Part-time employment figures for the two categories of farms were 4000 (ignoring probable treble counting for Toledo District) and 1700 persons respectively.

According to the agricultural census therefore, in 1985, of the total farm workforce of about 27 000 persons, some 13 600 persons worked full time and 13 500 worked part time on farms. It is likely that the collection of data on part-time employment gave some double counting, but this is unlikely to be great because the citrus and sugar harvesting seasons overlap.

Of the total 120 000 acres (49 000 ha) of land in holdings less than 50 acres, 73% of the area was held by flexible forms of tenure, i.e. only 27% was freehold property.

Corozal and Orange Walk Districts together accounted for 3500 holdings of less than 50 acres - 47% of the national total of farms in this category. They provided full-time self-employment at the rate of one family member per holding. The same level of self-employment applied to small farms in Cayo District. In Belize District, the small farms provided a full-time livelihood in only half the cases. In Stann Creek District a slightly higher level of full-time self-employment is implied. In Toledo District, quite unlike the other districts, self-employment at the rate of two persons per small farm is implied. They also employed 4600 persons part time.

Corozal and Orange Walk Districts have the highest level of full-time employment on small farms; accounting in 1985 for 87% of full-time employment. Elsewhere full-time employment on small farms is unusual. Female part-time employment on small farms in Toledo District appears negligible: one for every 416 males. Elsewhere the ratio is 1:28.

Of the 2700 full-time jobs provided by farms over 50 acres (20 ha) in 1985, 1600 (59%) were in Stann Creek District, in large part presumably for citrus and banana plantations. Part-time employees for the large farms numbered 2000 where, with the exception of Stann Creek District, men outnumbered women in the ratio 17:1. In Stann Creek District, the ratio was only 1.2:1.

Farming is largely a male preserve especially in part-time employment. In Toledo District, the culture appears to discourage women undertaking farm work. If so, they might be encouraged to establish forms of cottage industry.

The foregoing data suggest smallholders in Toledo District are more dependent upon farming for their livelihood than in Belize and Stann Creek districts, where it appears to be mixed with the pursuit of complementary occupations. In Orange Walk and Corozal districts small farming, mainly of sugar-cane, is an economically important activity, providing significant employment. Similarly for many families in Cayo District, smallholding is a full-time occupation.

Large-scale farm employment is concentrated in the banana and citrus industries. While the success of both these industries depends partly upon the continuation of harmonious industrial relations, labour supply has never been a problem. In 1991 farmers in both industries reported migrant labour supply continuing to exceed requirements, dampening farm wage levels. Important changes in land tenure are taking place in southern Toledo and southern Stann Creek Districts. With encouragement from the IFAD and TAMP projects, and Help for Progress (a non-governmental organization), village communities are adapting their agricultural systems to include tree crop cultivation, which involves permanent settlement. A programme of land titling is quickening with the objective of providing all families with 30 acres (12 ha) of leasehold title, convertible to freehold title, so they can cultivate some 15 acres (6 ha) of tree crops as well as subsistence crops.

Traditional slash-and-burn agriculture (principally for maize and rice), with an ever-reducing fallow cycle, will come to be regarded as wasteful of both land use and labour effort. The titling programme is gaining acceptance, especially among the younger members of these communities. In southern Toledo District its logical consequence will be the release of the remaining reservation lands back into the national estate, substantial areas of which are unsuitable for agriculture. However, the average number of children born per female in these communities is currently in the region of six to eight so that the quantity of land required for such settlement will treble over the period to 2010.

The number of rural households in Toledo District was 1723 in 1985, of which 126 owned freehold properties exceeding five acres (2 ha). Permanent settlement of those rural households with less than five acres freehold, at the rate of 30 acres/household could therefore take up about 50 000 acres (20 000 ha), and call for the availability of another 100 000 acres (40 000 ha) over the next 20 years, unless employment opportunities outside smallholder agriculture can be found.

In the absence of development of alternative crops, the planning of employment for future generations in the sugar-cane areas is problematic, given the limit already reached in sugar manufacture. Industrialization may possibly alleviate the pressures that are foreseen.

Expansion of citrus production in Cayo and Stann Creek districts may provide employment opportunity in the future provided the citrus price remains high.

EFFICIENCIES IN THE AGRICULTURE SECTOR

Pressure on land has accelerated over the past few years due to:

(i) refugee influx

(ii) expansion of large landholdings, particularly in the citrus industry

(iii) smallholder desire to benefit from an apparently profitable citrus industry.

In Toledo District most maize cultivation by small farmers is for subsistence. Typical family consumption is about 1500 lb (680 kg)/year, equivalent to one acre (0.4 ha) wet-season cropping at about 1000 lb/acre (1100 kg/ha) supplemented by the dry-season matahambre crop from replanting (D. Chub, 1991, personal communication). Most families cultivate red kidney beans for home use. They also sell (free range) pigs and chickens to passing tradesmen at about BZ$ 65 and BZ$ 3 each respectively, which can raise up to BZ$ 300/household/year.

The slaughter of farm livestock for home consumption usually takes place only on special occasions, such as when a farmer has been assisted in his fieldwork by a gang from the community. Game meat is consumed more frequently (in one community about twice weekly). Other sources of dietary protein are pulses and eggs.

The main cash income comes from rice sold to the BMB. A total of five acres (2 ha) are usually cleared by each family for rice production and this area appears to be regarded as a standard unit for reciprocal work sharing within the respective communities. Some rice is retained for home consumption. Sales from five acres, at 1000 lb/acre (1100 kg/ha), would realize a farm gate gross revenue of about BZ$ 1000. Allowing for three weeks' paid employment at BZ$ 12-15/day (J. Cayetano, 1991, personal communication), i.e. BZ$ 203, and some BZ$ 300 of other miscellaneous sales, the annual cash income appears to be below BZ$ 2000.

A large number of Toledo District farmers are hard-pressed to meet high-school fees and book costs, which run at about BZ$ 1500/year. A significant number of eligible students therefore end their formal education at around 14 years of age.

In southern Stann Creek District small-scale farmers plant maize for sale, often up to 10 acres (5 ha)/household, providing at 1000 lb/acre (1100 kg/ha) about BZ$ 2000 of gross income. The matahambre maize crop yields about 200 lb/acre (220 kg/ha). Contract employment in the periods March-April and June-September can provide income of about BZ$ 1500 (C. Tush, 1991, personal communication). These activities, combined with small-scale production of rice and red kidney beans can generate about BZ$ 4000 of cash income/year. Several of these farmers are cultivating new plantings of citrus.

Stevedores resident in Hopkins can earn about BZ$ 2500/year from work on the citrus concentrate vessels at Commerce Bight; most of these are also subsistence farmers (R. Coleman, C. Nunez, 1991, personal communication). Women in the Garifuna communities cultivate cassava, which is sold at BZ$ 0.55/lb (BZ$ 1.21/kg), and some of them sell cassava bread at the rate of about BZ$ 40/week. Average family cash income of non-fishing smallholders in Hopkins is about BZ$ 3000/year, but one-third of them regularly receive remittances from relatives overseas, which contribute about BZ$ 1500/year of extra income.

Most small farmers in the southern districts earn a cash income of less than BZ$ 4000/household/year. While the total value of their economic activity may significantly exceed this, the cash value of their earnings is no greater than can be gained from daily, unskilled full-time employment. With the use of appropriate technology a small farmer should be able to earn more than a full-time unskilled worker.

Gross margin analysis

Gross margin analysis has been carried out for a range of crops to help determine allocative efficiencies. They are set out in Appendices 2-11.

The opportunity cost of milpa rice production in southern Toledo District appears to be high (Appendices 2 and 3). BMB's rice mill operates at a loss and farmers appear to be willing to farm rice at a return per labour day of BZ$ 10, i.e. for an effective wage of only 60% of the nationally accepted normal level (about BZ$ 16). While it should be noted that the community structure in southern Toledo District keeps these farmers from being freely mobile to gain employment elsewhere, it is reasonable to ask whether they could be guided into alternative forms of production.

According to the gross margin analysis indicated in Appendices 4 and 5, the current performance of sugar-cane producers is spectacular: on a fully costed basis the average gross margin/acre is between 53% (BZ$ 380) and 96% (BZ$ 540), according to proximity to the factory, yet establishment costs for this eight-year perennial crop are modest at about BZ$ 752/acre. About 10 acres of cane, without the use of the farmer's own labour, will on average return over BZ$ 4000/year.

Sugar-cane is outstanding in its very low cost of maintenance - equivalent to just 11% of annual sales value. Most of the expense is in reaping and transport. As may be expected, the financial internal rate of return (IRR) is high at between 55 and 81% under present conditions.

Measured in isolation, sugar-cane production for high-test molasses manufacture is uneconomic, but although the molasses business is subsidized by the sugar industry its presence assures adequate supplies of raw material.

Projections for orange production in this report assume a fall in the price of fruit at the concentrate plants to about BZ$ 10/90-lb (40-kg) box, i.e. at some 73% of the 1989/90 level. Start-up investment is high: as much as BZ$ 2800/acre (BZ$ 6900/ha) for large mechanized producers (excluding interest charges) over a period of seven years before cash flow becomes positive. Lower (milpa method) land clearing costs of small producers reduce their investment costs to BZ$ 2000/acre (BZ$ 5000/ha).

The annual cost of farm maintenance is between 15 and 17% of the value of sales (at peak production) according to the intensity of management, while harvesting costs represent between 13 and 26% according to location.

Assuming peak production of 300 boxes/acre (700/ha) for large mechanized producers and 250 boxes/acre (600/ha) for smallholders, gross margins/acre at full production range between BZ$ 1800 and BZ$ 2100 (BZ$ 4400-5200/ha) and vary, depending on location If a small farmer can prepare land with family labour, instead of incurring a cash cost, only four acres (2 ha) of grove are required to return over BZ$ 4000/year. However on a fully costed basis, owing to the high costs of land clearing, mechanized citrus cultivation gives a financial IRR of about 24% in Stann Creek and 21% in southern Toledo districts; IRRs for small farmers are better at 29 and 25% respectively. Small farmers also have the advantage of being able to subsist on home-cultivated produce in a market downturn. If orange prices fall below BZ$ 10/box, new mechanized growers may be particularly hard pressed.

At an investment cost in the region of BZ$ 10 000/acre (BZ$ 25 000/ha), banana cultivation is the most capital-intensive farm operation of all - with the exception of shrimp farming. Depending upon age of plantation (up to 10 years) maintenance costs amount to between 30 and 47% of sales value, making operations more vulnerable to weather than in the farming of sugar-cane, or citrus. Harvesting accounts for 29% of sales value. The financial IRR is not spectacular - only 22% - but gross margins/acre are considerable starting at some BZ$ 1700 (BZ$ 4200/ha) in the second year of plantation and holding at some BZ$ 4600/acre (BZ$ 11 000/ha) (69%) - weather permitting - for about three years before declining to about BZ$ 1600/acre (BZ$ 4000/ha) in year 10 when the plantation is replanted.

The banana industry employs three times as many workers/unit area as citrus, but virtually all of these workers are expatriates who to some extent will remit earnings to their families.

King *et al.* (1992) showed mechanized grain farming by the Mennonite communities as a relatively low-input, low-output production system. For maize and sorghum, while establishment costs amount to 52% of sales value of the crop, the risk is low, and on an annual investment (fully costed) of about BZ$ 170/acre (BZ$ 420/ha) gross margins of between BZ$ 55 (21%) and BZ$ 90 (32%)/acre (BZ$ 136-222/ha) are achieved. A model prepared for mechanized rice production (Appendix 11) gives a gross margin of about 50% on an outlay of BZ$ 250/acre (BZ$ 620/ha). Red kidney beans, when not affected by late rains, can give a gross margin of 60% on an investment of about BZ$ 190/acre (BZ$ 470/ha). Where land is not limiting, and the market is still open, extensive cultivation of mechanized grain crops is worthwhile but, to realize BZ$ 4000 profits/year (fully costed basis), about 45 acres (18 ha) (i.e. of maize) need to be grown.

CONCLUSIONS

1. Belizeans appear to be most successful when farming crops which can withstand a period of neglect, yet be capable of resuscitation when market conditions improve. In this way sugar-cane and citrus have served the country well.
2. Taking into account the saturated state of the sugar industry, citrus would, notwithstanding market uncertainties, appear likely to provide the best long-term opportunity for small-farmer diversification.
3. The financial requirements of banana farming dictate a long-term investment. Although gross margin/acre is higher than for any other crop, the IRR of bananas is not spectacular and the problem of winter chill and disease discourage investment.
4. The shrimp farming industry may be poised for a breakthrough and land-use planning should take account of this.
5. Export markets for intensive fruit production under irrigation have yet to be determined: BABCO's on-farm trials may develop a technology suitable for extension in the cane-growing districts.
6. Only when suitable export market opportunities have been identified, and appropriate export infrastructure organized, should cattle farming be intensified.

Part 4

Environmental protection

INTRODUCTION

Environmental impacts of current levels of development are relatively minor. Nonetheless, in an effort to reduce poverty through development (or to get rich through development, which has slightly different implications), there is a danger that permanent environmental damage will be done - as has happened in many other countries - so that time and effort have had to be expended in correcting the worst excesses of ecological mismanagement. Replanting red mangrove at a cost of BZ$ 600 an acre (BZ$ 1500/ha) is but one example.

Current development impacts on the Belizean environment are often very visible, leading to vociferous concern. In the absence of empirical data on impacts however, received wisdoms based on subjective observation are repeatedly used by conservationists.

The problem faced by planners is to respond to political demands, meet a wide range of development needs, and find practical ways of protecting the essential components of the environment without sufficient information.

To formulate an effective planning response in the face of rapid uncontrolled development and lack of data, a clear understanding of the main environmental issues is necessary. Assessments of these have been carried out by Pendleton (1991), ODA (1989) and Hartshorn *et al.* (1984). Reviewing their findings, and combining them with information from consultations with conservation, forestry, agriculture, economic and local interests, the most immediate and serious concerns have been highlighted (Tables 15 and 16). The bases for this assessment were criteria of scale, permanence of change, sensitivity of ecosystem, potential risk to public health, number of people affected, and the degree of impact on economically valuable species and ecosystem functions. The conclusions remain a consensus of opinion, however, rather than empirical findings. At a local and watershed level, the main concerns are contamination of aquatic and marine environments by polluted runoff and accelerated soil erosion from agricultural development.

Steps to integrate continuing rapid economic growth with some degree of mitigation against the more serious environmental side-effects of development are needed urgently. Discussions were held on finding workable ways forward with as wide a range of interests as possible, through a series of regional meetings with farmers and agricultural, forestry and lands staff. Awareness of environmental issues is generally high amongst developers, and this does credit to the work of environmentalists and developers in the country over preceding years.

The challenge is to translate this awareness of those actually altering the landscape into solid mitigatory action on the ground. This requires workable solutions for the agricultural, industrial, and engineering activities which are associated with the main environmental concerns, i.e. mitigation measures which minimize the most harmful side-effects of development, at an acceptable cost to the developer.

Table 15 The most immediate and serious environmental concerns threatening Belize

Local	Scale of impact	National
Physical reef damage by increased siltation, dredging, anchor drag, and diving and snorkel users	Mangrove clearance in the Belize River watershed leading to increased coastal erosion, loss of biodiversity, and magnified public safety hazard for hurricanes	The degradation of nearshore fisheries by overfishing
Biochemical reef damage from entrophication and/or toxins	Siltation of the Northern Branch and North Stann Creek from upgrading of the Hummingbird Highway	
Mangrove clearance leading to accelerated coastal erosion	Forest clearance along rivers leading to accelerated bank erosion along the Belize, Sittee and Sibun rivers, North Stann Creek, and Swasey and Bladen branches	
Suspected contamination of freshwater by agrochemical runoff		
Eutrophication of waterways by discharge of effluent from food processing plants in Stann Creek Valley	Extensive valley bottom and valley side forest clearance plus artificial drainage along new road section of Hummingbird Highway causing faster rise in floodwaters and higher risk of flooding	
Blocking of streams by bulldozed forest debris, reducing freshwater flows		
Industrial contamination of the Belize River from Ladyville downstream		
Forest clearance on erodible slopes for milpa and/or citrus		
Overhunting of game species leading to reduction in biodiversity and localized extinctions		

Table 16 Trends of main environmental concern

Local	Level of impact Watershed	National
Suspected contamination of freshwater by ——> agrochemicals	becoming more widespread in Monkey River and North Stann Creek	Risk of depletion of nearshore fisheries beyond threshold for recovery for certain key species
Population growth and inequitable land distribution forcing ——> people into marginal land	leading to severe flooding in the wet season and drying up of creeks in the North Stann Creek Valley	

FOREST COVER AND RATES OF CLEARANCE

In 1983, the estimated loss of forest was 8700 acres (3500 ha) a year (Leonard, 1987). This figure presumably referred to closed broadleaf forest, which covered a total of 3 908 100 acres (1 581 200 ha) (Hartshorn *et al.*, 1984). Consequently, deforestation accounted for approximately 0.2% reduction in closed forest a year in the early 1980s. Our assessments come to a similar rate of deforestation over the period from 1969-72 to the late 1980s (see 'Current land-use' sections of the 'Land Resource Assessment' Reports).

More recently, land clearance has escalated. A Belize Center for Environmental Studies (BCES) review of development concessions and other leases indicates approximately 243 200 acres (98 400 ha) proposed for agricultural development during 1990. Not all of this land is likely to be cleared however, and the Forestry

Department gives an approximate estimate of 15 000-30 000 acres (6000-12 000 ha) of closed forest clearance for 1990. At this rate, only steep or otherwise agriculturally unsuitable land (class 5) will be under forest in 100 to 200 years. Pressure to use class 4 land for agriculture, currently recommended for forest management and plantation, is likely to occur in about 50 to 100 years. If, however, as is strongly recommended (see Part 6), the steep slopes of the Maya Mountains and the whole of the Rio Bravo Conservation Management Area remain under forest, a fifth of the country's land area will be under forest, which will be a greater contribution to forest conservation than can be claimed by most countries. If, on the other hand, clearance of the steep slopes of the Maya Mountains is not stopped now, particularly along the Hummingbird Highway, the heart of the country will quickly become deforested, leading to flooding of the nations' most valuable agricultural land, degradation of national water resources, loss of a potentially substantial tourist income, and destruction of the environmental birthright for Belizean generations to come.

Approximate rates of forest clearance by land tenure for 1990/91 are indicated in Table 17. Land ownership and tenure are also summarized in Figure 10 (on p 48).

Table 17 Estimated rates of forest clearance (1989/90-1990/91)

Tenure type	Approximate total area, 1990 (acres)	Approximate rate of clearance (% p.a.)	Approximate area cleared (acres)
Private	1 912 900	3.8	145 000
Leased national land	640 000	5.9	75 000
National lands	1 335 800	0.5	25 000
Forest reserves	1 427 240	0.2	4 400
National wildlife reserves	213 360	0	0
Private reserves	185 200	0	0
Total	5 714 500	-	249 000

Source: BCES, 1991

Soil protection guidelines

The extent, nature and management of forests in Belize are being investigated under the Tropical Forestry Action Plan (TFAP). Slope angle and length and soil erodibility (primarily related to texture, structure and organic matter content) govern the suitability of various harvesting techniques. Clearfelling (i.e. intensive) harvesting is considered appropriate for non-granitic soils up to 15° slope angle, selective logging for slopes between 15 and 25°, and no logging (i.e. protection forest) on slopes above 25°. Clearfelling on granitic soils (Stopper Suite) should be limited to slopes up to only 4°.

AGRICULTURE

Figure 11 shows the recommended limits to cultivation for different types of land utilization on particular slopes and soils. Alluvium is not included because most of the slopes are gentle, but the bluffs of floodplain benches and terraces should be avoided, particularly the bluffs of dissected terraces (subunit dT).

Part 2 has discussed land systems according to rock type, but for ease of map reference, the land systems with erodible slopes associated with each rock type are as follows:

Toledo Beds
- TU Toledo Uplands
- TM Machaca Plain
- TT Temash Plain

Limestone

TX	Xpicilha Hills (with Plain)
BX	Hummingbird Plain with Hills
OK	Shipyard Plain
HY	Wamil Plain with Hills
HZ	Hill Bank Plain
BK	Beaver Dam Plain
CZ	Round Hole Plain
LK	Spanish Lookout Plain
CK	Belmopan Plain
OA	Albion Island Plain with Hills
NK	Neustadt Plain
OD	Neuendorf Escarpment
OX	Gallon Jug Plain with Hills
OQ	Yalbac Dissected Cuesta
LX	Pilar Camp Hills
IK	Ramonal Hills
IZ	Hermitage Plain
VX	Vaca Hills

Metasediments

TC	Chiquibul Valleys
TR	Richardson Peak Mountains: O and Q subunits
TL	Palmasito Plateau
SO	Ossory Plain with Hills
VL	Chapayal Plateau
MP	Mountain Pine Plateau: non-granitic subunits
CR	Copetilla Mountains: non-granitic subunits

Granite

TS	Stopper Escarpment with Plain/Middle Swasey Basin
SS	Stopper Plain with Hills
SV	Stann Creek Valley
TR	Richardson Peak Mountains: granitic hills (S)
MP	Mountain Pine Plateau: granitic subunits
CR	Copetilla Mountains: granitic hills (p)

Since the low karst subunit is defined as having local relief less than 25 m, milpa cultivation and pasture should not be an erosion risk on these slopes. High karst with local relief more than 75 m lowers the limit of milpa cultivation and pasture to 15°. Metasediments are a higher erosion risk than limestone, because the soils are so shallow that there is a danger that any erosion will remove the soil altogether. As indicated by Figure 11, granitic soils are the most erodible.

Citrus should be planted on contours, and only through trash on 8-12° slopes. Mechanized citrus agriculture should be restricted to slopes less than 6°. Cacao can be planted on steeper slopes because it is grown under shade. Coffee has the same limitations as cacao. The main erosion risk of pasture is cattle paths, particularly down to water-holes. Longer slopes increase the erosion risk. Hedgerow planting is considered more economic than terracing.

The expansion of agriculture raises a number of environmental issues, but of particular concern since the best soils are generally close to rivers, is the impact of clearance along rivers. Agricultural development along river-banks also necessitates mitigation against four significant environmental side-effects:

(i) the use of agrochemical inputs with the potential to pollute and therefore degrade aquatic and marine ecosystems

(ii) the much quoted 66 ft (20 m) 'requirement' for leaving a forest strip (riparian buffer) along river-banks on leased and private land is rarely followed. Consequently, river-bank clearance is causing accelerated erosion, which increases sediments in suspension, degrading hydrological systems and possibly aquatic and marine ecosystems

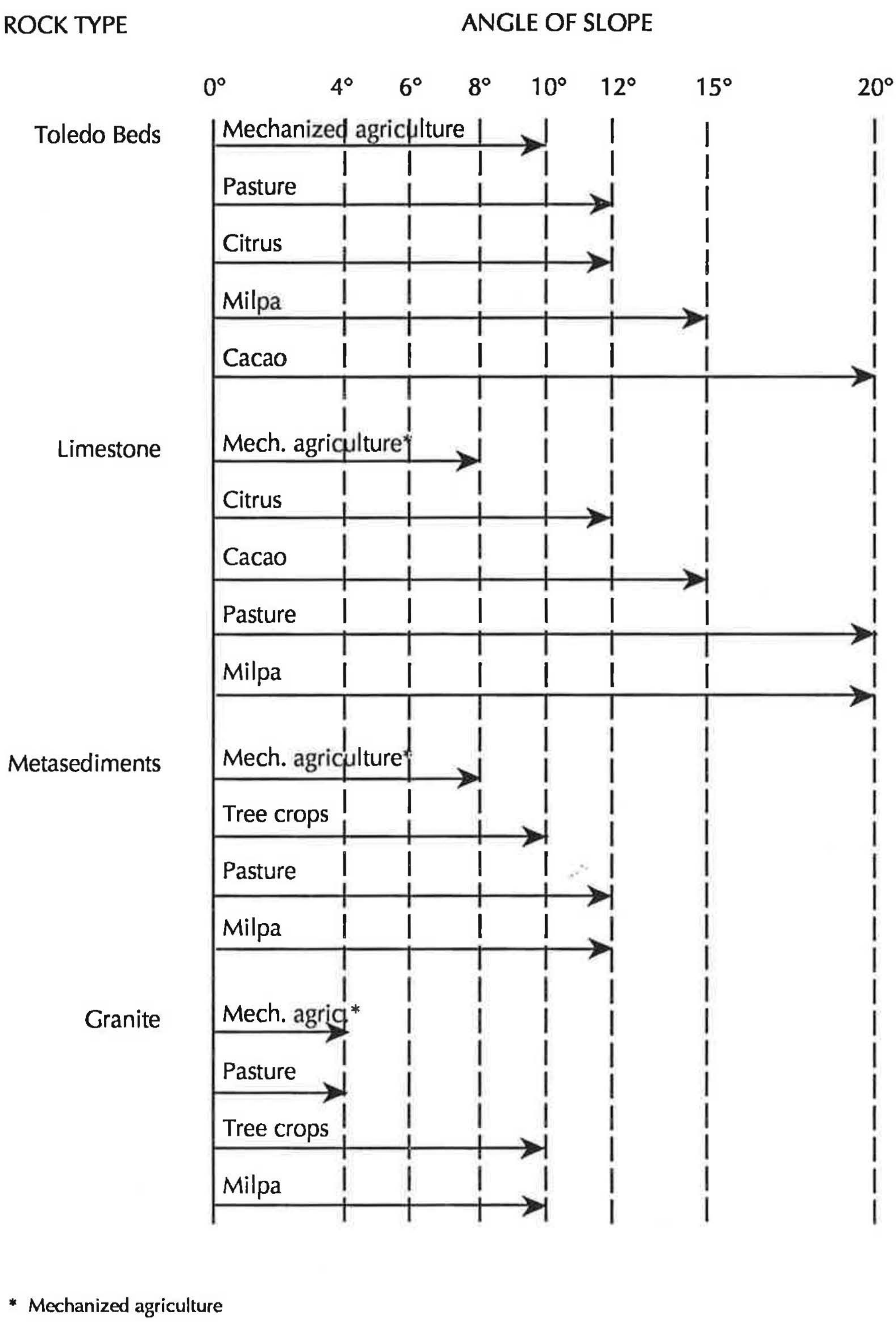


Figure 11 Recommended limits to cultivation for different geological parent materials

(iii) the loss of riparian wildlife and biodiversity

(iv) the widespread practice of bulldozing trees into drainage channels causes local disturbance of water movements and stream ecology.

The physical significance of all four areas of concern is difficult to substantiate because no monitoring of relevant parameters is carried out. For example, the often-quoted but rarely substantiated risk of damage to reefs by excess siltation depends on complex nearshore coastal processes, wind direction and strength, time of rainfall, river discharge characteristics, soil type, and proportion and location of forest clearance in the watershed. Without information on all of these, preventative action cannot be accurately targeted.

Consultations with the departments of Lands and Survey, Agriculture and Environment and the Conservation Division have highlighted four main farming systems where environmental protection issues deserve prior attention (Table 18). A preliminary environmental audit is given for each. The purpose of the environmental audit is to assess the environmental consequences of each systematically, and identify means of mitigation where desirable and feasible.

Bananas

The policy of the Banana Growers Association (BGA) is to encourage the planting of 7000 acres (3000 ha) by 1994 through the development of lands that have already been acquired. The BGA hopes to attract foreign capital to enlarge the productive area to approximately 10 000 acres (4000 ha).

Land is cleared mainly by hand with chainsaw/machete and fire in some instances. Original tree stumps are left to rot. Seeds are hand-planted between stumps. A dose of nematicide is applied in the root hole. Initially, herbicides may be applied to control weeds, but the close spacing and quick growth of the banana plants limit the need for herbicide application.

Irrigation and drainage

Bananas require abundant and continuous supplies of water to maintain optimum production. Irrigation water is currently drawn from rivers and wells. Cowpen holdings, for example, pump approximately 300 gallons/minute (20 l/second) from the adjacent Swasey River for 12 hours/day, each day of the dry season (from January to June in 1991 for example). Assuming a dry season of 150 days, Cowpen therefore uses a total of 32 400 000 gallons (147 million litres) of water for irrigation/year. Both the BGA and Fyffes are recommending irrigation for all banana plantations. So it is expected that over the coming years the entire banana area will be irrigated, amounting to an annual demand for water of approximately 50 million gallons (240 million litres), to be obtained from rivers (primarily the Swasey, Bladen, and South Stann Creek) or local wells.

More water, derived from a well at Cowpen, is also used to wash fruit - a water recirculation system may be more appropriate. The fruit is then sprayed with a mixture of Alum and Benlate to prevent crown rot during shipment. Application rates are 4 oz (100 g) Alum and 4 lb (2 kg) of Benlate in 25 gallons (110 l) of water. It is recycled through a continuous circulation system in one packing shed at Cowpen, but this may not be the case in other packing houses.

Bananas also require wet-season drainage, a network of primary, secondary and tertiary drains (approximately 6-10 ft (2-3 m), 4-6 ft (1-2 m) and 1-2 ft (30-60 cm) deep respectively). They are vegetated and therefore unlikely to

Table 18 Farming systems most in need of prior environmental protection

Crop	Farming system	Main location
Bananas	Commercial banana estates	Southern Stann Creek and northern Toledo Districts
Citrus	Commercial citrus estates	Stann Creek, Toledo and Cayo Districts
Mixed	Milpa	Hummingbird Highway
Sugar	Medium or small mixed farms	Corozal and Orange Walk Districts

contribute to long-term soil erosion, but they receive pesticide in the secondary drains of sufficient concentration in the dry season at Cowpen to kill small fish (Sosa, 1991, personal communication). The primary drains are generally not fed into major rivers because of the risk of crop loss during floods. Smaller creeks are used instead, e.g. Sennis Creek at Monkey River Estate. Some drains also lead into enclosed wetland swamps.

Fertilizer application

All farms make at least one annual application of fertilizer but major use is concentrated on five estates. Applications are typically between 100-400 lb of urea/acre (100-400 kg/ha) four times a year, plus one application of NPK 18.18.46 or 18.0.46. The use of excessive N or P fertilizer can lead to eutrophication of surface waters and groundwaters if leached out or washed into runoff, creating an ecological imbalance and deterioration in water quality.

Pest control

The principal banana pest is Black Sigatoka fungus (*Mycosphaerella fijiensis* var. *difformis*), whose propensity for developing resistance to fungicides, requires application of several different fungicides in a spray programme. The chemicals are applied aerially on all estates through a co-ordinated spray programme organized by the BGA. Water, spray oil, fungicide and emulsifier are mixed into a tank, then loaded into a plane. The BGA has two Agcat planes equipped with Micronairs. One has an AU-5000 eight-nozzle spray frame and the other an AU-3000 with six nozzles. The AU-5000 is more efficient because it can concentrate spray along the flight path.

Use of Tilt and Punch has been previously abused by spraying considerably above the recommended dosage. For three to four years, applications were made 16-18 times a year, instead of eight. With no detectable improvement in the crop, a decision was taken to implement a more controlled programme of spraying using Bravo. The effectiveness of this combination will be reviewed in 1992. One further triazole, Anvil, may also be introduced in 1992 as a systemic fungicide.

The BGA is currently recommending insecticides are not used on banana estates because of fears that the eradication of non-target species will lead to greater insect pest problems in the medium to long term.

The contact herbicide Gramaxone is most commonly used for weed suppression, applied by knapsack sprayers every two to three months depending on tree height and season. One pint of Gramaxone is applied per acre (1.5 l/ha). The systemic herbicide Round Up is also used, though less frequently, at 4-8 oz/acre (300-600 g/ha) four times a year. It has a longer control period but is more expensive. Machetes are often used for weed clearing, because wage expenditure can be spread over a longer period than the purchase of herbicide in bulk.

Plastic sacks

Plastic sacks, used to protect the fruit from disease and chill, are found along roadsides and river-banks (Figure 12). There have even been reports that sacks have been washed down the Monkey River onto the reef. Pollution by insecticide-impregnated plastic sacks, currently used on one estate only (Sagitun), is avoided by collection and incineration (T. Zabon, 1991, personal communication).

The environmental implications of plastic dumping are visual despoilation of the land and seascape and minor physical damage to flora and fauna, e.g. coral and river and roadside vegetation. The impact is long term because plastic is not biodegradable and it takes several years to decompose.

Figure 12 Plastic sacks and below-grade fruit dump

Waste

Disposal of putrescible waste attracts insects which can carry infections, and can contaminate ground and surface waters by nutrient enrichment (eutrophication). Waste fruit is even dumped near dwellings, drainage ditches and places where workers are present. Little, if any, attention seems to be paid towards eliminating this source of pollution on estates by introducing controlled waste disposal.

Environmental audit summary

There are a number of potentially serious impacts arising from banana cultivation that require urgent investigation and resolution. There are health risks through direct contact and contamination from pesticides for those applying biocides or for those caught in drift from spray planes, and from damp insanitary working conditions due to rotting fruit. Some improvements have been made by advance warning of aerial spraying after complaints of skin burning and illness by workers who were getting sprayed. There is still, however, a lack of controlled waste disposal for waste fruit and some plastics. Homes adjacent to fields receive spray drift. No health checks are carried out to investigate the significance, if any, of these environmental conditions.

Fish kills in secondary drains suggest surface runoff is carrying residues of biocides (of unknown concentrations) into streams and rivers. Infiltration also has the potential to contaminate groundwater. Many pesticides are formulated to become inactive once they reach the soil. However, this is not the case with nematicides for instance.

Contamination of surface water and groundwater, if present, presents a risk to populations using wells and rivers for drinking water, including the downstream community of Monkey River town (150 people). For the last three years, they have travelled 7.5 miles (12 km) by boat to Big Creek to collect drinking water because of fears that Monkey River itself has become contaminated. The concentration of the banana industry within the Monkey River and South Stann Creek watersheds increases the risk of significant water pollution. Some wells sunk for drinking water by immigrant workers have been contaminated by seepage of untreated sewage from nearby cesspits.

There is minimal impact on soil erosion mostly because a vegetated strip is retained along the river-bank to prevent erosion (C. Griffiths, 1990, personal communication). The three farms along the Bladen, one on the South Stann Creek and the one on the Swasey are exceptions. Bamboo on the latter farm was planted in June 1991 to prevent river-bank erosion.

The small loss of mainly riparian forest is unlikely to affect wildlife significantly because similar habitats are still abundant nearby. Reported demise of botlass fly and catfish in Monkey River needs investigation to assess the cause. There has not yet been any evidence of fish kills in local rivers, including Monkey River.

Citrus

Until the mid 1980s, 90% of citrus production was concentrated in the Stann Creek Valley where both processing companies, Belize Food Products (BFP) and the Citrus Company of Belize, are also located. Production was characterized by relatively low levels of chemical inputs, particularly during the 1970s when low citrus prices restricted the viable level of management input. Recent growth has, however, been characterized by large-scale land clearance and planting both within and outside the Stann Creek Valley, mainly elsewhere in Stann Creek District and in Cayo and Toledo Districts. Expansion has been combined with an increase of inputs especially fertilizer, lime, and on soils subject to waterlogging, surface drainage. Citrus plantations on the Puletan Plain land system require a high level of inputs to overcome poor drainage and fertility, which in turn reduce local water quality, specifically through eutrophication and biocide runoff. The significance of any contamination cannot be assessed until relevant parameters have been monitored.

Bulldozers are generally used to clear land. Very large clearings are sometimes chained which minimizes soil disturbance and the risk of erosion. Once felled, vegetation is burnt, bulldozed into windrows, and burnt again. Clearance is carried out in the dry season but, with the arrival of rains in May, June or July, accelerated erosion occurs (Figure 13) leading to downstream sedimentation. Establishment of substantial cover takes one to five seasons.

In many instances, trees have been bulldozed into streams (Figure 14) causing gross medium- to long-term interference of drainage, reducing dry-season flows, damaging stream ecology and increasing the likelihood of bank erosion and flooding. Local fishing will also be threatened.

After about 10 years, a citrus plantation generally provides good canopy cover over a grass sward, reducing soil erosion to that equivalent under forest, but wide rows and/or over-weeding can cause erosion, and may reduce soil fertility and weaken rooting conditions.

Fertilizer application

Fertilizers are used almost universally in citrus production, applied both as urea and NPK compounds (22.11.22 or 19.9.19). They are applied two to three times a year for adult trees (November/December and May/June or December/January, June/July and October/November) at a rate of approximately 100 lb of nitrogen/acre (100 kg/ha). First- and second-year trees receive three to six applications.

Figure 13 Erosion of newly established citrus plantation

Figure 14 Cut trees bulldozed into stream

The effect of a higher application frequency is countered by the smaller fertilizer dose and rapid uptake.

High nitrate levels lead to eutrophication, excessive enrichment of water bodies leading to rapid algal growth, and oxygen depletion. The potential for leaching of fertilizers is related to application rates and soil type. Heavy limestone clays generally have stronger immobilization capabilities than the Pine Ridge soils or the free draining alluvial soils (M. Holder, 1991, personal communication). The less susceptible limestone soils and smaller area of plantations in Cayo District reduces the threat of eutrophication of the Belize River. Monthly monitoring of phosphate and nitrate levels in the more endangered North Stann Creek at Dangriga gives highest monthly figures for 1990 of 0.2 mg/1 and 1.8 mg/1 respectively. Both fall well within the human tolerable levels set by the Public Health Bureau, and would suggest that from a health perspective, fertilizer runoff is not a problem.

The Citrus Growers' Association (CGA) is trying to rationalize fertilizer use by encouraging soil and leaf analysis as a means of determining appropriate rates of application, rather than routine use of standard doses.

Lime is applied to neutralize acid soils, e.g. under older groves on the Stann Creek terraces, and on the Puletan soils. On the Belize Food Products groves, burnt lime is applied once a year at 1-2 tons/acre (2-5 t/ha). Burnt lime has a faster and higher neutralizing capacity than unburnt lime and is, therefore, used at half the rate. It is more dangerous to handle and can cause skin irritations.

Pest control

The major pests for citrus in Belize are described by King *et al.* (1989) and CGA (unpublished a). The CGA has also produced a separate pamphlet on 'Agricultural Chemicals used in Belize Citrus Industry' (unpublished b) which lists insecticides, fungicides, herbicides and nematicides used, their target species, mode of action, rates of application, post-application wait before harvesting, and other practical comments.

The contact herbicide Gramaxone (Paraquat) is most commonly used for weed control; it is applied by knapsack sprayers during the wet season at 1 lb/acre (1 kg/ha) twice a year. Round Up is the most widespread systemic, applied year round by the same method, at 1 pint/acre (1.4 l/ha) twice a year. Karmex (Diuron) is used as a pre-emergent herbicide with some residual activity, again applied in a similar manner at 3 lb/acre (3.4 kg/ha) twice a year.

Reports from the Pesticide Control Board (PCB) suggest significant misuse of pesticide, both through ignorance and over-application, because of the desire for more immediate results. Both the PCB and the CGA acknowledge the need to offer extension training for farmers and applicators on handling techniques and safe interval periods before harvesting; but there is a major human resource limitation for training, with too few extension workers in the Ministry of Agriculture and Fisheries and an already stretched Research and Extension Unit in the CGA.

Bird pests, mainly species of parrots and woodpeckers, are reported to cause significant crop loss. Current methods of control are shooting, although the CGA has requested the Belize Audubon Society to look into non-lethal control possibilities.

Harvesting

Harvesting is carried out by hand, primarily by seasonal labour. Traditionally, people have been brought to Stann Creek District from Cayo District, but there is an increase in use of cheaper labour from outside Belize. The establishment of milpas by this labour force is a cause for environmental concern, assessed in more detail later.

The harvesting season runs for about 150 working days from mid-October to early June, with a corresponding increase in water demand, wastewater generation, and sewage from the seasonal labour force. There has been no report of water shortage over this period, despite it being the dry season.

The shipment of harvested oranges from the fields to the processing plants generates substantial extra traffic. BFP use some of the wastewater from processing for road spraying, to prevent dust being stirred up along the roads. Aside from the labour issue, harvesting itself seems to have no significant environmental consequences.

Rehabilitation

Uprooting of declining or dead citrus trees for new planting will cause very localized soil disturbance, but it is generally carried out on a piecemeal basis, and therefore has minimal impact.

The original series of drains excavated in the Stann Creek Valley plantations generally need renewing (N. Obando, 1991, personal communication). It would most likely be carried out during the dry season, and consequently would result only in highly localized temporary increases in suspended sediment in ditches and streams. Clearance of banks and ditches by heavy machinery should be avoided during periods of heavy rainfall. Under these circumstances, yields of suspended sediment would be greater, and could foreseeably have significant adverse temporary localized effects of stream ecology.

Abandonment

At current price levels, abandonment of citrus plantations is unlikely, even in marginal areas. Should the price fall, the uneconomic plantations on the Pine Ridge will most likely be abandoned. The land should then be left under pine.

Processing

There are currently two citrus processing plants in Belize: one at Alta Vista, belonging to Belize Food Products (BFP), and one at Pomona, belonging to the Citrus Company of Belize (CCB). Each should have a complete environmental audit, but waste skin disposal appears to be the primary concern.

The BFP skin dump is next to a tributary of the North Stann Creek. Overspill of skins into the stream was causing eutrophication and water discolouration along its lower course and its junction with the main creek. It was mainly restricted to the dry season, when flows and pollution dilution were low. Complaints arose from local people using the creek for swimming. A combination of holding dams, gravel filter, and two pools were installed in 1990 to retain effluent during the dry season. The remedial measures rely on the higher wet-season discharge flushing out the accumulated waste with sufficient dilution to prevent pollution.

Environmental audit summary

The PCB reports difficulties in ensuring field workers understand the care necessary in handling pesticides and herbicides. There is some contact and contamination, although not widespread, according to information currently available.

The Public Health Department is monitoring water quality from rural hand pumps, including nitrate and phosphate measurements. Readings are currently well within human tolerance levels. There are no reports or visual evidence of eutrophication caused by fertilizers or runoff from citrus estates. Neither has been monitored. Streams surrounded by concentrations of new citrus plantations, on leachable soils, provide a suitable starting place for water quality investigations. There should be an investigation of Quamina Creek draining

White Ridge Farm citrus plantations because water for Gales Point village is pumped from this creek, and it may be contaminated by fertilizers, pesticides or herbicides (see Figure 15)

Forest clearance for citrus is leading to permanent soil loss through sheet erosion and gullying, plus localized episodic silting of streams. Deterioration of the soil resource through topsoil loss is concentrated in the first two years of citriculture. After that, sufficient grass cover builds up to consolidate and bind the soil surface.

Long-term erosion attributable to citrus estates is likely to be more localized where forests have been cleared down to river-banks, or during periods of flooding. The potential erosive impact of the latter has been increased by the practice of bulldozing trees into drainage channels.

There is a lack of quantative data on the effects of soil erosion. Visible evidence of silted channels and drains, especially following storms, is clear; the implications for stream ecology are not. Comparative studies are therefore needed to determine environmental impacts related to different characteristics of clearing. Accounts of suspended sediment in streams inconveniencing people washing or collecting freshwater have also been given, although there is no indication available of the number of people affected.

The large scale of clearance, and its concentration along alluvial floodplains (and therefore the riparian zone), is causing significant loss of habitat. There are few examples of riparian buffer forest left intact. Forests have been cleared down

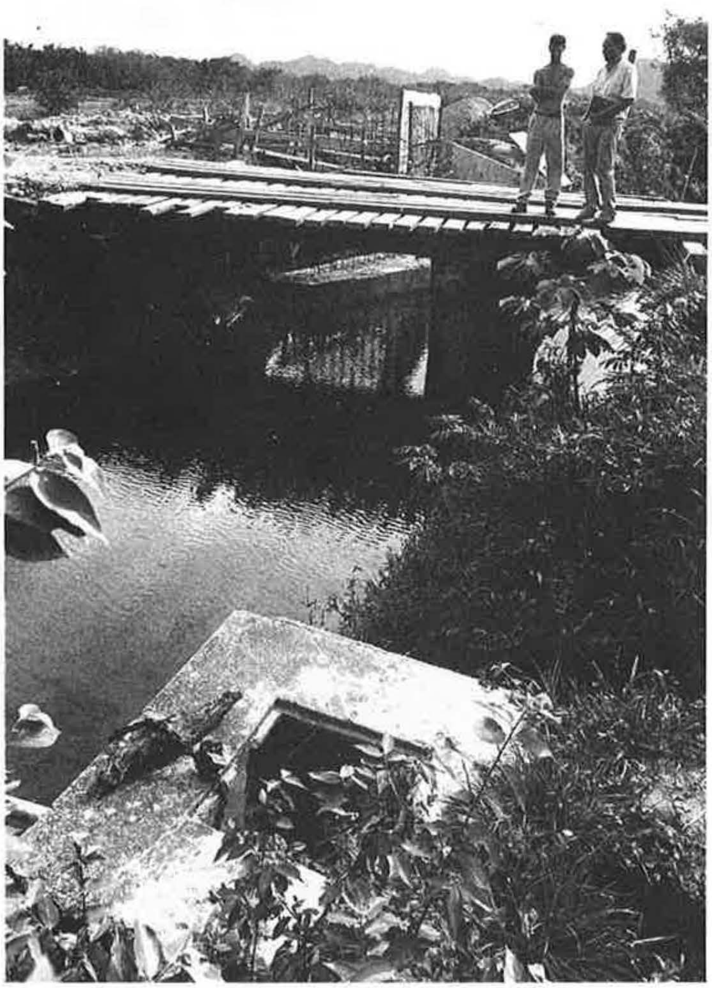


Figure 15 Drinking water intake (foreground) from Quacima river draining citrus lands

to river-banks. It is the most threatened habitat in Belize, judging by the wide distribution and permanence of conversion, the relatively high proportion of the habitat being cleared, and its concurrence with better quality agricultural land.

Lowland riparian forest is known to be the favoured habitat of the internationally endangered Black Howler Monkey (*Alouatta pigra*) and Baird's Tapir (*Tapirus bairdii*), both of which have restricted Central American ranges. These species are however found elsewhere in Belize and all exist within nature or forest reserves in Stann Creek District and other areas. The expansion of the citrus industry is therefore unlikely to be having significant national impacts on wildlife.

Shooting of parrots and woodpeckers may cause reduction in these species locally, although territories may simply be filled by the young from nearby pairs.

The Coastal Zone Management Project has mapped the distribution of rare, endangered, threatened and economically important species along Belize's coastal zone. Riverine and nearshore species at risk from pesticide, fertilizer or sediment contamination originating from the major citrus growing areas, are Morelet's Crocodile (*Crocodylus moreleti*) - especially in the Freshwater Creek (Stann Creek District) catchment, West Indian Manatee (*Trichecus manatus*), shrimp, and reef fish species that migrate inshore.

Overall, the major impact of citriculture is accelerated soil erosion in the first two seasons after land clearance. Retention of substantial riparian buffers, at least for the first three to four years, can significantly reduce transportation of soil into rivers. There is also widespread concern over the inappropriate use of biocides. Training, publicity and education, combined with enforcement of pesticide regulations, are needed. Measures to prevent pollution from processing plants should be introduced, monitored for effectiveness and improved where necessary.

Milpa

Although milpa cultivation is widespread throughout the country, its occurrence on steep slopes adjacent to the Hummingbird Highway is most frequently cited as cause for concern (Figure 16). Refugee settlement along the Hummingbird

Figure 16 Spreading milpa clearance near Hummingbird Highway

Highway dates from 1980. By 1984 a chain of villages and houses extended from three miles (5 km) south of Belmopan for approximately eight miles (13 km). According to Bliss *et al.* (1987), milpa and other small-scale cultivation in 1975 was negligible along the northern Hummingbird Highway, but by 1985 had risen to about 700 acres (300 ha).

There is no current estimate for the area now under cultivation, but new villages have been established adjacent to Salvapan and Las Flores, at Armenia, and at Mile 25, in addition to a chain of isolated milpas along the roadside. All except the last settlement have been established with the help of the United Nations High Commission on Refugees in an attempt to focus dispersed households into village settlements.

The number of registered refugees in the country has grown from 4774 in 1989 to 5395 in April 1991, although it is estimated that these figures constitute only one-fifth of recent Hispanic immigrants. Given continuing immigration and the high rate of population growth amongst new farmers, milpa cultivation along the Hummingbird Highway-Stann Creek Valley road is set to expand further. Although there is seasonally limited access to water along the Caves Branch to Belmopan section of the road, the undulating plain subunit of the Xpicilha Hills with Plains land system is suitable for small-scale agriculture. This is not the case for the valleyside granite and metasediment soils south-east of Over-The-Top Camp, however, where settlement growth is still taking place, the latest example being the Mile 25 village of approximately 25 households. According to farmer interviews, the reason for locating on such seemingly unpromising slopes is simply the lack of alternative available land.

Interviews suggest approximately half the milpero households have members working in the citrus industry itself, and are therefore tied to the Stann Creek Valley. Their own farm is relied upon for security and self-reliance should employment cease. For other immigrants, the attraction is land adjacent to the road which gives easy access and transport of materials to and from the farm.

An aerial reconnaissance along the Hummingbird Highway-Stann Creek Valley road confirms that milpa cultivation is entirely within the North Stann Creek Valley and adjoining valley bottoms, with the exception of three to five milpas in the Macaroni Hill area.

Widespread clearance of steep slopes is evident along the Stann Creek Valley. Farmers suggest that ultimately extension further uphill onto even steeper ground is impractical because of difficulties in tree felling and harvesting. Clearance of mid-slopes is therefore the only option, increasing the likelihood that scattered milpas will begin to coalesce into more extensive clearings and secondary scrub.

Land allocation for farmers along the Hummingbird Highway is through a combination of leasing from land holding companies, sub-lets from individual Belizean leasees, and illegal squatting (on Jack Grant's land and on the Belize Fruit Products estate). The legal situation pertaining to land allocation is summarized in Table 19.

Applications for leasing national land should be made to the Lands Officer (see 'Land Allocation' Section, p 82), who should review the suitability of the land

Table 19 Immigrants, legal status and land allocation

Legal	Able to lease land	Able to have title to land	Work permit status
Illegal immigrant	No	No	No
Legal alien	10 acres	No	No
Refugee	*	No	Temporary
Permanent resident	Yes	Yes	Yes

* Current law does not allow refugees to lease land except under special circumstances such as the Valley of Peace project. In practice, however, the law is not enforced and refugees do lease land
Source: Warner and White (1990)

for the proposed development. A binding decision should then be given as to whether the lease should proceed. In practice, the Belmopan Lands Office is overloaded with work, and the majority of applications are accepted with minimal investigation. Frequently no application is made at all.

Virtually all the agriculturally suitable land is privately owned. Many of the small plots on the valley sides are leased by absentees. Remaining smallholders only have access to marginal steep hills.

There is neither political will nor available staff to remove squatters or milperos from steep slopes.

Fire risk

Vegetation is cut by machete during the early part of the dry season, left to dry, and burnt in April/May. A variety of legislation exists to regulate forest burning but it is ineffective and not enforced. According to local farmers, fire-breaks are only put in place if a neighbour demands one. The lack of fire control during the land clearing phase of new milpa farming is a significant environmental concern. There is however no monitoring of the scale of fire damage.

In severe dry seasons, as in 1991, fires left out of control escaped into surrounding forests, causing visual scarring of the landscape, contributing to gross short-term air pollution, and short- to long-term reduction in biodiversity.

Whilst fires and a certain amount of erosion are a natural part of some ecosystems, frequent burning and accelerated erosion lead to a plagio-climax with radical alteration of species composition, and lower biodiversity. Where soils are thin, such as the tops of karst hills, or steep, like the sides of the Stann Creek Valley, vegetation degenerates to a low pure stand scrub of the bracken-like tiger bush fern (*Dicranopteris pectinata*), which is also increasingly occurring to the south of the Western Highway. Xeromorphic forest communities on steep slopes and karst are particularly vulnerable because of the build-up of combustible dry-leaf litter on the forest floor.

Soil erosion

Land clearance and fires also initiate soil erosion. At the end of the dry season runoff and eroded material collect in drying cracks on new clearings on karst. The network of plant stumps and boulders also minimizes the slope length over which material can be transported. The surface soil has a crumb structure and friable consistence with moderate organic matter and high levels of ash, which contribute to absorption of rainfall impact and moisture. As the wet season progresses however, the cracks close and organic material is decomposed. Geomorphological indications of erosion are limited to micro-features such as small stone fans (10-30 cm across, for example) and shallow rills (Figure 17).

Erosion on karst hills is therefore not catastrophic but is best characterized by an extensive and progressive thinning of hill-top soils in combination with an overall degradation in surface structure reducing fertility and infiltration (Furley, 1987). However, the risk of intensive sheet erosion from major storm events does remain.

Soils used for cultivation along the Stann Creek Valley Road derived from metasediments and granite range from moderately to highly erodible (see Figure 11). Field visits to clearings on the Curasow soil subsuite, for example, showed exposure of fine plant roots within two months of burning, indicating rapid topsoil loss. The siliceous soils are also more susceptible to sheet and mass wasting than soils derived from limestone, and also to gullying especially where derived from granite (Figure 11).

Significant mass erosion has not yet resulted from milpa clearance, but may occur during major storm events, depending on antecedent moisture conditions and the level of plant cover (Figure 18). If soils are relatively bare and already

Figure 17 Small alluvial fan produced by first wet-season rain on a steep denuded karst slope

Figure 18 Slump scars on cleared land along the Hummingbird Highway

near field capacity, localized mass erosion is likely with resultant sediment deposition on roads, farm drains and in streams.

Furley and Newey (1979) and King *et al.* (1989) gave evidence in support of retaining protection forest on karst and metasedimentary and granite hills. To prevent clearance, it will be necessary to provide small farmers with flatter valley-bottom land (not directly on banks of streams or rivers), close enough to ensure access to the estates for any citrus workers, and to provide technical support for intensification of agriculture in areas of established milpa settlement.

Chemical inputs

The use of chemicals by new immigrant milperos is capital constrained, although the ratio of labour to agrochemical costs is turning in favour of artificial inputs (King *et al.*, 1989). About half the milperos - those who work in the citrus plantations - now use chemical inputs (R. Rakena, 1991, personal communication). They have first-hand experience of seeing the positive effects of agrochemicals, and can afford their purchase.

Most milperos cannot afford agrochemicals to control the biggest pests of corn and red kidney beans: army worm and rust in the dry season, and wet blight in the wet season. For citrus, the main chemical input is insecticide for the wee wee ant (*Atta cephalotes*). Mirex granules are most widely used (R. Rakena, 1991, personal communication). Systemic herbicides such as Round Up, are used for weed control around the base of trees. Application rates and frequencies are variable, depending on the amount that can be afforded.

Environmental audit summary

A small but significant number of milperos suffer occasional skin irritation from contact with biocides through leaking knapsack sprayers, inappropriate application methods, etc. (R. Rakena, 1991, personal communication). More training is needed in the correct methods of pesticide handling.

There is no evidence of hillside milpa clearings significantly affecting water quality along the Hummingbird Highway-Stann Creek Valley Road. Streams which pass through the plots tend to drain only small interfluves, and these have high sediment sink capacities. In major flood events, the proportion of sediment contributed by runoff from eroding milpas would be relatively insignificant at their current scale and dispersed distribution.

Localized degradation of soil fertility is the main environmental problem. Repeated clearing and burning of soils, already shown to be highly susceptible to erosion, prevents the recovery of forest, leading to a plagio-climax of inferior ecological diversity. Enforcement of fire-control regulations combined with related education and publicity are required.

Several different sources report increasing hunting pressure and overfishing in areas with rapidly expanding milpa farmer populations; thus reducing the abundance of game species, and possibly driving animals like the curassow (*Crax rubra*) and crested guan (*Penelope purpurascens*) to local extinction. The lack of baseline data on game abundance, plus the difficulty of monitoring sporadic, dispersed and usually nocturnal hunting all inhibit an empirical assessment of the impact of milpero hunting. The commercial harvesting of game meat for market in Belmopan and Belize City may be pushing the rate of exploitation beyond sustainable levels.

Valley-side milpa clearing is highly visible, and has an annually recurrent impact from cutting, drying and burning that lasts several months. It is therefore considered to detract significantly from landscape quality, affecting for example a complementary blend of valley bottom citrus groves with a complete forested backdrop. This detraction of landscape quality could affect tourism.

Sugar-cane

Fertilizer application

Belize Sugar Industries Ltd recommend an application of 18.46.0 at 200 lb/acre (220 kg/ha) when sugar-cane is planted, followed by a side dressing of urea 70 days after emergence. About half the replanted area receives these levels of application, with the rest receiving only about half the recommended quantities of fertilizer. Annual applications of urea at 100 lb/acre (110 kg/ha) are made on approximately 70% of the sugar-cane area. With the rising sugar-cane prices of recent years, there has been an increase in the use of fertilizer, although exact choice is made on the basis of availability and price (e.g. formulations available over 1989 included 18.46.0, 28.28.0, 12.12.24, 17.17.17 and 19.19.19).

Fertilizers are applied in June, July and August, coinciding with periods of heavy rainfall. Contaminated runoff is not likely, however, because of the high residency time of surface water in the area. During this period, catchment areas are 'filling up'. Major surface flows into streams and rivers start only in September. Soils have low permeability, and consequently groundwater contamination is less of a risk than surface water eutrophication. As fertilizer use is increasing, nitrate levels in surface water should be monitored, particularly in the New River and in enclosed water bodies surrounded by sugar-cane cultivation.

Pest control

The primary insect pest affecting sugar-cane is the frog-hopper (*Aeneolamia postica jugata*). It is a sap sucker whose toxic secretions lead to leaf necrosis, substantially reducing the photosynthetic area available to the plant. At present, frog-hopper outbreaks are usually in pockets and highly localized. In the late 1960s and early 1970s however, outbreaks were more serious and pest control was pursued with vigour. Aerial spraying of Azodrin and Sevin continued until 1974, when insect numbers were reduced by severe drought. Its abundance is strongly affected by climate. Drought over May and June will reduce outbreaks, but frog-hoppers proliferate if there is more than 4-5 in (10-12.5 cm) of rain during May with continued moisture, particularly in low-lying areas that are poorly drained (lower slope subunit).

There have been only two recent occasions when extensive aerial spraying has been necessary. Farmers watch for infestation and count nymphs. If numbers pass above a set threshold, the crop is sprayed locally. Azodrin is no longer used. Propoxur or Undane are applied at 1 lb/acre (1 kg/ha), or Sevin at 2 lb/acre (2 kg/ha). Remaining stocks of Supracide will also be used, but it is being phased out because it is not approved by the Pesticide Control Board.

The area sprayed in 1990 was 2000 acres (800 ha) - about 3% of the total area of land under sugar-cane. Impact on the environment from frog-hopper control is relatively minor now that the pesticides used are under regulation by the Pesticide Control Board, and that the need for aerial spraying of the entire sugar-cane area seems to have receded.

The other serious pest is smut (*Ustilago scitaminea*) but new sugar varieties are introduced rather than using biocides. Other minor pests are generally not treated chemically.

Weed control

Approximately 50-60% of the sugar-cane area receives chemical weed control, 20% manual and chemical, and the remainder manual only. A range of herbicides is used. Gramaxone is applied at 2-4 pints/acre (3-6 l/ha), Gespax at 3 pints/acre (4 l/ha), Diuron 3 lb/acre (3 kg/ha), Velpar K3 at 3 lb/acre (3 kg/ha), Asulox at 3 pints/acre (4 l/ha), all usually in combination with 2-4D Amina at 2 pints/acre (3 l/ha). They have a combination of contact and systemic effects, and are applied once a year from knapsack sprayers.

Harvesting

Immediately prior to harvesting, most (90%) sugar-cane fields are burnt, so that the cane is more accessible and the fields are rid of pests and snakes. Once the harvest is complete, all fields are again burnt, with the additional purpose of breaking down crop residues. The smoke and soot from crop fires do not appear to cause concern.

Processing

Cane is processed at Tower Hill by Belize Sugar Industries (BSI) Ltd and at Libertad by Petrojam Belize Ltd. The chief environmental impact associated with the sugar industry is the discharge of processing effluent into the New River during the dry season when the dilution capacity of the river is minimal. Oxygen depletion has killed fish.

Tower Hill produces raw sugar for export. Cane is taken in, is shredded and crushed, and the sucrose is extracted. The remaining filter press mud is dumped at a 50-acre (20-ha) site near the factory during the processing period (December to early June), left until the following December to rot down, and spread again prior to receiving the following year's material on top. Elsewhere, e.g. Swaziland, it is used as fertilizer and has soil conditioning properties, but its bulk in comparison to fertilizer make its widespread use impractical. Thirty tonnes/acre (70 t/ha) would be required to provide equivalent nutrient input to that recommended for fertilizer application. A small proportion is used for horticultural purposes and seed-bed preparation.

Bagasse is the second major by-product. It is used to fuel the boilers that power the entire plant. Any surplus is incinerated. The other products are sugar-rich wastewater. Previously, treatment provided insufficient retention time for the sugars in the wastewater to breakdown. Effluent therefore contributed to excessive algal growth in the lower New River, depleting oxygen levels. Since 1990, new efforts have been made to reduce wastewater, and improve treatment by increasing retention times. The first has entailed reductions in water volumes used in cleaning, and the second in constructing an additional retention pond. All drains in and around the factory, and liquid processing wastes go into a first stage aeration pond. Caustic soda or lime is added to raise the pH sufficiently for a healthy environment for bacterial degradation of the effluent. Waste goes into a second pond for similar treatment and then into a third settling pond. Discharges into the New River are now less frequent (two in the 1991 processing season), and only considered when chemical oxygen demand (COD) levels are below requirements.

Water quality monitoring in the New River was started at BSI in September 1990 to provide background data from which to assess relative impacts of remaining wastewater discharges. The air pollution from Tower Hill during cane processing is not considered to affect local air quality significantly.

Waste discharges from Libertad are partly due to plant cleansing, and processing of cane into high-test molasses. In 1989, 57 000 tonnes of cane were processed, increasing to 100 000 tonnes in 1990. Under full capacity, the plant is cleared fortnightly, but in 1990/91 the factory has been operating at only 45% capacity. There were four washes in the 1991 season, between 10 March and 30 June. The manufacture of molasses requires 12 000 gallons (55 000 l) of water/minute at full operating capacity, taken from the New River tributary on which the Libertad factory is situated, and a groundwater well at Pembroke Hall. The water is used to raise a vacuum in the condensers and in washing the plant. It is then returned at a discharge point 250 yards (230 m) downstream from the inlet. Cleaning produces sugar-rich drain-water effluent from the descaling of evaporators. Hydrochloric acid is used to descale the evaporators. It is then diluted to a pH of 3 before discharge into the river. The majority of the acid is converted into calcium chloride through reaction with calcium carbonate scale.

Caustic soda is also used to remove scale but it is reused after storage in holding tanks.

Currently, all liquid waste at Libertad is deposited into the New River tributary. Pollution is intensified during the dry season when dilution is limited by low flow, especially in March when high winds back up the river and increase the residency time of pollutants. Unpleasant odours and occasional fish kills are blamed on the pollution. Investigations are being pursued by the firm, with a view to instigating treatment.

Pollution related to the whole sugar industry is currently the subject of a special Government Commission of Enquiry, set up following a chemical fire of sodium hydroxide at Tower Hill in 1990. Whilst chemical storage is the project's initial emphasis, the opportunity has been taken to investigate in further detail the wider farm and factory-level environmental considerations.

Environmental audit summary

From the sugar-cane farmer's point of view, there are no significant public health implications of the industry, other than the normal risks associated with pesticide handling. Sporadic effluent discharges have killed fish and produced noxious odours. Any pronouncement of the impact of the sugar industry on water quality should await the findings of the Official Commission of Enquiry.

Testing of well and pump water by the Public Health Bureau shows no significantly high levels of nitrates in groundwater in Orange Walk or Corozal Districts, other than two urban sites where leakage from septic tanks is suspected.

The significance of effluent discharges on the endangered West Indian Manatee in the New River is not known. It comes to the surface to breathe and therefore would not be directly affected by deoxygenation of water. Its aquatic plant food source would however be affected by pollution. The impact of pollution on overall river ecology should be assessed.

Livestock

Livestock rearing in Central America has been lambasted by environmentalists for contributing to deforestation and soil erosion. In Belize, pastures only cover a moderate area, which is relatively stable (see Part 3). Current rates of clearance are approximately 1000 acres/year (400 ha/year) (L. Tergas, 1991, personal communication) but this tends to be for sorghum or other crops, before semi-abandonment to natural pasture. Stocking rates are comparably low for the region and pasture is, generally, extensively managed and under-utilized. Despite this, localized overgrazing does occur at the end of the dry season when grass cover is most meagre.

There has been some increased runoff from channel bank erosion at Mile 40 on the Western Highway on Beaver Dam soils. Overall however, soil erosion is relatively minor in comparison to the total area under pasture but, as indicated at the beginning of this 'Agriculture' section (see p 55), too high a concentration of cattle could cause serious erosion around water-holes.

The Belize Livestock Development Project is promoting the intensification of livestock production, aiming to meet beef demands by increasing stocking densities. It is estimated that this would release 16 000-40 000 acres (6000-16 000 ha) (depending on farmer uptake), for reafforestation of steep slopes and creation of river-bank protection forests. The means by which stocking density would be increased are three-fold: weed control using selective systemic herbicides; manipulation of native legumes for fodder, shade, and sward improvement; and better herd management.

Round Up is the most widely recommended herbicide, and equipment is being devised to apply it directly to weed leaves. Application rates would be variable depending on weed density, but the method of direct application would avoid significant environmental effects. Currently, few inputs can be afforded because livestock production is so economically marginal. Consequently bush-hogging is the only form of weed control carried out at present on 1-2% of land under pasture (L. Tergas, 1991, personal communication). The land intensification of livestock production promoted by the Belize Livestock Development Project includes afforestation for fodder provision, erosion control and river-bank protection as part of the package. The scope for integrating plantation forestry with livestock intensification should be investigated as part of the TFAP.

Shrimps

Shrimp production currently occupies 225 acres (91 ha) of the coastal zone with a further 430 acres (170 ha) of unused ponds. Unlike other Central American countries, ponds have been established outside mangrove forests, substantially reducing their impact on the environment. The Fisheries Department is aware of other environmental considerations relating to shrimp farming, and provides technical advice on their mitigation but there is no compulsion on developers to seek or heed advice. Nutrient-enriched wastewater from ponds is disposed of through a canalized outlet into a river or the sea, the water quality impact of which needs urgent assessment.

Other crops

Both cotton and potatoes rely heavily on intense application of agrochemicals. Should these crops become permanently established, water resources would need protection by maintaining vegetated protection buffers along water-ways, and correct use and disposal of chemicals. Water quality will need monitoring to check pesticide levels and to limit fertilizer contamination to tolerable levels.

Vegetables require intensive inputs of fertilizer, pesticide and irrigation. Trials on appropriate cultivation techniques have been undertaken by BABCO, who have published guidelines on application rates, but there have been a moderate number of cases of pesticide misuse in Belize and Cayo Districts (J. Link, 1991, personal communication). Farmers tend to apply chemicals at greater rates and frequencies than recommended, in order to achieve more immediate and visible results. Specified intervals between final treatment and harvesting are also not always adhered to. These factors increase the possibility of higher pesticide residues than are desirable.

Belize Agribusiness Company liaises with the Pesticide Control Board to try to ensure appropriate use of chemicals but, as the vegetable industry expands, a monitoring capacity will need to be developed to ensure water quality and public health are not affected by pesticide, fertilizer, or irrigation impacts beyond tolerable levels.

INFRASTRUCTURE

Belize is furthering and consolidating its infrastructural framework, primarily in transport, power and solid waste disposal.

Roads

The main road construction has recently been devoted to improving existing routes, notably the upgrading of the road to Sarteneja in 1989, and the 36-mile (56-km) Middlesex to Alta Vista section of the Hummingbird Highway in 1990/91. Environmental Impact Assessments (EIA) for major works of this size are widely considered appropriate by environmentalists and some engineers as a means of minimizing adverse side effects. An equally effective and more practical approach is to employ an environmental consultant with specialist experience in road construction to work with the road engineers to provide immediately workable solutions. A statutory requirement for EIA is however useful in ultimately ensuring environmental protection needs are not pushed aside. A process of consultation with local people, relevant government bodies, such as the departments of Environment and Archaeology, and conservation NGOs (Non Governmental Organizations) is the essence of either approach to ensure all concerns are taken into consideration. The environmental consultant effectively would act as an intermediary between the Ministry of Works and Department of Environment to ensure mutually acceptable construction and environmental standards. In both cases, contractors must follow the recommended environmental regulations. Strict encoding of environmental protection activities in contract documents and Bills of Quantities are required. An environmental roads specialist would need experience in dealing with such documentation.

There is a recognition in the roads section of the Ministry of Works that environmental protection must be considered. Requests were made for assistance in developing an in-house environmental management capability so that, in the medium term and beyond, reliance on outside consultants can be broken. The Ministry of Works is hoping to run a series of engineering training seminars for public and private operators, and it was suggested that these would make a suitable forum for training.

Road widening and river gravel extraction for the upgrading of the Hummingbird Highway are putting large quantities of sediment into the North Stann Creek - much greater quantities than that produced by runoff from agricultural land - although most of the sediment is deposited a few kilometres downstream. The Ministry of Works has a standard road width of 11 ft (3.4 m) per carriageway plus a 6 ft (2 m) shoulder on each side, which has effectively trebled the original width. The standard is applied to all major roads to ensure adequate safety and accommodate any future increases in traffic volume. Standard cost/benefit techniques are not applied, although an indication of road benefits is generated, but based on current traffic levels, a road width of 34 ft (10 m) is difficult to justify. It is also debatable whether having a road of this width actually increases or decreases road safety. At Middlesex for instance, the road has been widened to within feet of roadside houses. Biodegradable netting seeded with rice has been used to protect some of the steep cuttings.

Specialist environmental advice stopped the excavation of aggregate from river-beds for the upgrading of the Stann Creek Valley Road. Road width specifications have also been reduced, thereby minimizing the fill requirements and need for quarrying, although this has caused some concern at Ministry of Works who would rather maintain a standard specification across the country.

The improvement of the Sibun to Belmopan stretch of the Hummingbird Highway is not being financed by an outside agency, and consequently the Ministry of Works will implement a programme of small-scale remedial repairs.

Some new roads are planned. One of these is from Belmopan to Orange Walk via San Felipe. It will provide easier access to major areas of agricultural development, logging and hunting, but it will also be close to nature reserves, and cross a range of archaeologically significant features.

An alternative crossing has been proposed to that of Hawksworth Bridge linking San Ignacio with Santa Elena. The key environmental concern of bridge building is silt release from bank disturbance. It can be prevented by minimizing vegetation clearance, by storage of spoil away from banks where erosion will wash material into the river, by completion of the project and any bank reseeding prior to the onset of the wet season, and by avoiding any non-essential movement of plant on banks to minimize soil compaction and disturbance.

A new access road to Caracol has been proposed by the Department of Archaeology. The existing road network of Mountain Pine Ridge and Chiquibul Forest Reserves should be upgraded, rather than any direct link through the steep terrain of the Vaca Hills north of Caracol, which would encourage non-sustainable and damaging settlement, as is taking place on the steep valley sides along the Hummingbird Highway. Visits to Caracol could thereby be combined with a stay on Mountain Pine Ridge.

Figure 19 is a flow chart showing environmental considerations in road planning. Step 4 should include providing an explanation of the need for the road, financial considerations, likely time-table for the construction and a map of the area indicating environmental concerns, e.g. archaeological sites, drinking water sources etc. The main government and other bodies consulted should include the Public Health Bureau, and Environment, Fisheries, Hydrology (for water supply), Forestry, Archaeology and Agriculture departments, Conservation Division, Belize Tourism Industry Association and Belize Audubon Society. Local communities should also be consulted. The consultations could be co-ordinated through the Land Utilization Authority, the Department of the Environment, or be contracted out for investigation by an environmental consultancy. Alternatively, the Roads Section of the Ministry of Works could hold a series of meetings to determine relevant concerns in order to decide the preferred route, i.e. that which causes the least overall significant environmental damage, yet is still cost-effective.

Step 5 should include design of appropriate mitigatory measures for each phase (land clearing, construction and maintenance), e.g. weir boxes in rivers or drains to retain sediment, appropriate sites for extraction of aggregates, reseeding cleared areas to prevent erosion, culverts and splash stones for drainage control, landscaping to minimize visual impact of the road, dust control by water spraying in the dry season, storage of fine construction materials away from water courses to prevent sedimentation by runoff, and controlled and proper dispersal of solid waste.

Ports

Belize has port facilities at Belize City, Commerce Bight, and most recently Big Creek, completed in 1991 for the export of bananas to Europe. The most visible environmental impact from the port construction at Big Creek arose from the method of dredge disposal. For convenience and cost purposes, dredge spoil was spray-pumped from the river-bed of Big Creek across a belt of riverine mangrove forest into an adjacent shallow lagoon. Drift of fine saline particles scorched the leaves of riverine red mangrove (*Rhizophora mangle*) and killed approximately five acres (2 ha) of forest. Although only a small area was affected, it could have been avoided by piping the dredge spoil. The lagoon itself has been entirely filled and some dredge spoil has spread into the surrounding fringing mangrove, smothering prop roots and killing the trees through asphyxiation. The 37-acre (15-ha) lagoon has become a raised mudflat, unlikely to support sufficient vegetation due to hypersalinity and possible acidification. Although of minor significance in terms of Belize's total coastal lagoon resource, given the benefits of the port to banana growers, by disposing a portion of dredge spoil in other nearby lagoons, the spoil would have been covered by sufficient water depth to be colonized by mangrove and returned to productive ecological use.

Hydroelectric power

Belize relies on oil imports and Mexican power for the provision of electricity. As a means of import substitution and reducing the average cost of supplying power, proposals have repeatedly been made for hydroelectric development within the country. Although providing a clean non-polluting source of energy, hydroelectric schemes are often not liked by conservationists because of the large-scale permanent environmental damage associated with many large dam projects. The size of the proposed facility for Belize on the Macal River is small in comparison, and the scope for damage is therefore relatively low. Attempts are being made to integrate environmental considerations into the project, although the initial phase of building access roads has been excluded. The roads link Arenal to the two prospective Macal River sites. The most likely consequences of road building are localized erosion, which could have been reduced

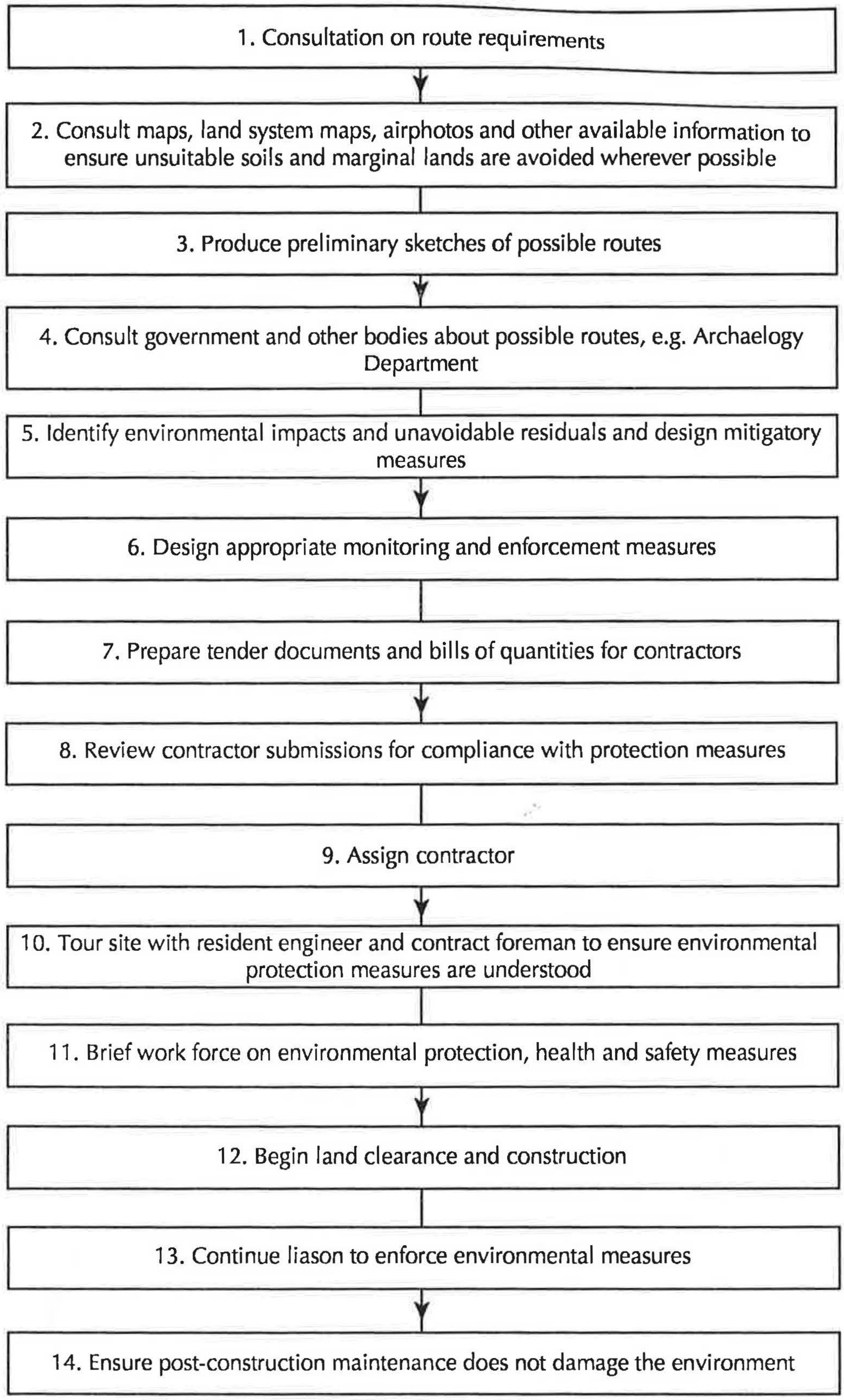


Figure 19 Flow diagram for inclusion of environmental considerations in road planning and design

by using suitable routing and appropriate well-established cambering and drainage techniques.

Whereas the impact of increased sediment load from road construction is more likely to affect stream ecology in upland areas (where aquatic species are adapted to more sediment-free water), siltation will be localized and concentrated during a relatively short construction phase. Sporadic storm events will generate further erosion during the wet season, although the greater discharge will dilute sediment loads to lower levels. Impact on stream ecology is therefore likely to be minor.

The roads can be sited to have minimum intrusion into the high quality Macal landscape. Screening by natural vegetation or vegetated embankments, minimization of high upslope cuttings, and routing parallel with contours in particularly prominent sections of the route can all be used to good effect.

The dam itself is subject to an EIA being carried out by Canadian environmental consultants jointly with the BCES. Efforts are already being made in advance to select an environmentally acceptable engineering option and designs are not yet fixed. A site ecological inventory by a BCES (BCES, 1991b) team has shown the range of aquatic, mammalian, bird, and tree species in the area. Of these, the Central American River Otter (*Lutra longicaudas*) is in most danger, if initial plans for a 0.93-mile (1.5-km) long dry stream bed between the two dams is implemented. This otter is considered an endangered species (Hartshorn *et al.*, 1984) but in Belize they are widespread, although relatively dispersed. Populations are protected in the Cockscomb Wildlife Sanctuary, Mountain Pine Ridge and Chiquibul Forest Reserves for example. Individuals displaced by the dam will come into conflict with other otters already occupying territories along other parts of the Macal, and may not survive. Alternatively, the influx of more individuals may trigger density-dependent feedback which will lead to long-term re-adjustment by reducing the number of offspring produced by each pair.

The impact on the otter population is not likely to be significant. Nonetheless, an estimate of the waterflow required in the 1-mile (1.5-km) inter-dam stretch to support otters has been made, in case the flow can be accommodated in design specifications.

A feeder tunnel to take water from the dam to the turbine hall will be built. It will generate about 55 000 cubic metres of spoil requiring disposal. It is unclear whether it is intended to use this material for fill or aggregate, or whether a dumping site will have to be found. The power plant, dams and associated structures will also need landscaping.

The construction of the 73-mile (119-km) transmission line will open up new forest. The route should provide the least new interference with forest cover, i.e. using existing roads wherever possible. Maintenance costs can also be kept low by providing easier access to power lines.

In the medium to longer term, the potentially most serious implication of the dam will be improved access to steep land which should not be used for agriculture. To counter the threat of sedimentation of the dams caused by resultant deforestation of the surrounding catchment, the Forestry Department has been asked to establish a new forest reserve.

LOCAL WHITE LIME INDUSTRY

Salvadoran migrants arriving in the late 1970s, brought with them the production technology for white lime (also known as burnt or quick lime). The citrus industry is the primary market for white lime, although the banana industry, road construction, shrimp farming and sugar processing are also users. Local deposits of limestone are broken and packed into earth kilns for burning, thereby converting calcium carbonate into calcium oxide. While still hot, water is added to break the blocks into a white powder of slaked lime (calcium hydroxide) which is subsequently applied to citrus orchards where, after rain, the slaked lime and fertilizer infiltrate the soil.

Production has concentrated between Miles 6 to 29 of the Hummingbird Highway. The White Lime Co-operative, with members from St Margaret's village is the main producer controlling 75% of local production capacity.

Between 1980 and 1990, the number of operating kilns along the Hummingbird Highway increased from four to 17, during which time local Belizeans also adopted the technology (Warner and White, 1990). In the production year 1990/91 the White Lime Co-operative fired its 15 kilns 133 times (L. Peraza, 1991, personal communication) producing about 2000 tons (2016 t) of lime powder representing 27% of the total lime used in Belize in that period. The current price paid per 100-lb (45-kg) sack was BZ$ 7.25, less BZ$ 2 transport cost. Appendix 12 quantifies the production components for white lime.

The future of the industry depends upon the success of the citrus industry, although small internal markets - shrimp farming, the small-scale citrus industry and the Belize Sugar Industries - are likely to continue to purchase from local producers.

Fuelwood

The environmental significance of white lime production is its high consumption of fuelwood. Each burn requires an average of 34.1 m³. Fuelwood consumption for the production operations of the White Lime Co-operative in 1990 totalled 4535 m³ (see Appendix 12).

There is general concern that the high demand for fuelwood is having a detrimental effect on surrounding forests. 'Caleros' (lime producers) are accused of felling trees illegally on steep, erodible soils causing soil erosion, sedimentation, loss of biodiversity and an under-utilization of the forest's timber value. The caleros and community representatives, however, claim the socio-economic logistics of clearing forest for fuelwood are prohibitive; involving the felling and chopping of trees without the use of a chainsaw, clearing areas large enough for the moist 'green' wood to dry out and transporting it by hand to the roadside. The return for this labour per 'pante' (3.1 m³) of stacked, roadside fuelwood is BZ$ 20. The caleros claim they can only afford to use wood that has already been cleared for other purposes, such as the expansion of land for citrus production, although some people claim they do cut wood from the forest.

Land clearance along the Hummingbird Highway is already threatening the environment (see section on 'Roads'), so that this supply of fuelwood would no longer be available in the future. To meet an annual production of 2000 tons of lime would require 415 acres (168 ha) of fuelwood plantation to provide a sustainable yield (see Appendix 12).

There might be some patches of forest reserve land that would be released, but most of the available forest reserve land in this area is on steep slopes and should not be used. The most suitable land for plantation is privately owned. The government could investigate whether the land could be purchased by the caleros, or consider providing a loan for the purchase; but further investigation is needed on the economics of this option.

The investigation will also need to consider the alternative option of applying limestone to citrus plantations straight from quarries, without converting it to slaked lime. A particularly suitable lime supply has been found in Toledo District (B. Holland, 1991, personal communication), where the natural dolomitic limestone occurs in a powdered state. It could be argued that the slow weathering of limestone fines in orchards is more economic than the rapid infiltration of slaked lime. The future of the white lime industry should be investigated as part of the Tropical Forestry Action Plan.

WATER QUALITY

Water quality in Belize is analysed by the Public Health Bureau in Belize City and the Water and Sewage Authority (WASA) at Double Run, Mile 17, on the Northern Highway. Both laboratories have chemical and bacteriological capabilities. Table 20 lists those parameters monitored on a regular basis and gives the human tolerable levels set by the Public Health Bureau. Table 21 records water sources and frequency of monitoring. The Public Health Bureau monitors over 600 village pumps and wells, but is not responsible for monitoring the quality of surface water.

Human tolerable levels, given in Table 20 for chloride, fluoride, iron and nitrate, are related to natural phenomena. Levels are most likely to be high in the dry season when water-tables are low. Public Health Bureau tests carried out between 1988 and 1991 in Maskal, Mile 38 on the Old Northern Highway, yielded concentrations for chloride of 408 mg/l and iron of 3 mg/l, and in Paraiso, just north of Corozal, sulphate of 800 mg/l and iron of 3.3 mg/l.

High nitrate levels at pumps are probably due to contamination by local human and livestock effluent leaching into the supply (D. Wilson, 1991, personal communication). Table 22 lists those communities whose groundwater nitrate levels were close to, or above, the human tolerable level of 45 mg/l at some time between 1988 and April 1991.

Freshwater contamination by agricultural runoff is cited as one of the most serious environmental problems in Belize (Pendleton, 1991). The main concern relates to pesticide contamination since there is no detailed monitoring of toxins. Processing of citrus and sugar products remains a source of localized pollution, although reduced somewhat since 1990 by improvements made at Tower Hill by BSI and at Alta Vista by Belize Food Products.

Phosphates and nitrates produced by fertilizer runoff are monitored by the WASA. The highest recorded monthly phosphate level in the North Stann Creek at Dangriga was 0.2 mg/l in March 1990. In the same year, nitrates peaked at 18 mg/l - well below the human tolerable level for nitrate of 45 mg/l set by the Public Health Bureau. Fertilizer contamination does not yet appear to be significant in the Stann Creek Valley.

In rural areas, water is still taken from creeks and rivers despite a nationwide pump installation programme of the Rural Water, Sanitation and Supply Project. Central American immigrant and Mayan communities prefer to use surface flows for drinking and washing. Many regard natural water courses as superior in quality to groundwater from pumps. Of the 500 inhabitants of the refugee village of St Margaret's, 65% use creek water for drinking and washing (L. Wengrzyn, 1991, personal communication). Surface sources are tested by the Public Health Bureau only in response to complaints, or if a new source is brought into the laboratory for quality testing (M. Menzies, 1991, personal communication).

The Hydrology Department proposes monitoring water quality of the main rivers of Belize. Monthly samples will be taken from its 17 gauging stations and passed to WASA for full chemical and bacteriological analysis. Figure 20 shows these gauges and the catchment areas served by them. BSI monitors the water quality of the New River: measuring salinity, temperature, COD, pH and dissolved oxygen since September 1990.

Future legislation and institutional arrangements for integrated water resource management in Belize will be the focus of a forthcoming United Nations Development Programme (UNDP) project (D. Wilson, 1991, personal communication). The project will bring together, among others: WASA, Public Health Bureau, Department of Lands and Survey, Forestry Department, Hydrology Department and the Rural Water, Sanitation and Supply Project.

Table 20 Inventory of chemical and bacteriological parameters monitored by Public Health Bureau and WASA, including human tolerable levels

Parameter	WASA (mg/1)	Public Health Bureau (mg/1)	Human tolerable levels (mg/l)
Alkalinity	*		
Chlorides	*	*	250
Chlorine	*		
Carbon dioxide	*		
Colour	*		
Fluoride	*	*	1.5
Total hardness	*		
Ca hardness	*		
Mg hardness	*		
Iron	*	*	250
Odour	*		
Dissolved oxygen	*		
Sulphate	*		
Hydrogen sulphide	*		
Turbidity	*		
Conductivity	*		
Temperature	*		
pH	*		
Nitrate	*	*	45
Phosphate	*		
Aluminium	*		
Total dissolved solids	*		
Biological oxygen demand	*	*	
COD	*	*	
Total coliform		20/100 ml	
Faecal coliform		10/100 ml	

Source: WASA (Double Run) and Public Health Bureau

Table 21 Water quality monitoring authorities, water sources and frequency of monitoring

Authority	Water source	Analysis		
		Treated	Raw (untreated)	Frequency
WASA	Corozal (pump)	*		Monthly
WASA	Orange Walk (pump)			Monthly
WASA	San Pedro (pump)	*	*	Monthly
WASA	Cay Corker (pump)	*	?	Monthly
WASA	San Ignacio (pump)	*	*	Monthly
WASA	Punta Gorda (pump)	*	*	Monthly
WASA	Double Run (Belize River)	*	*	Monthly
WASA	Belmopan (Roaring Creek)	*	*	Monthly
Public Health Bureau	All rural pumps		*	Every 3rd year
Public Health Bureau	Creek water		*	Infrequently
Hydrology Department	Gauging stations		*	Monthly when operative

Source: WASA, Department of Hydrology and Public Health Bureau

Table 22 Communities affected by high levels of nitrate concentration in groundwater supplies, 1988-91

Community pumps	Nitrate level (mg/l)
San Antonio	38.28
Georgeville	30.36
Georgeville	35.64
Paraiso	44.00
Cristo Rey	40.90
Cristo Rey	51.04
Cristo Rey	60.20
San Pedro	70.48
San Pedro	53.60
San Pedro	38.20

Source: Public Health Bureau

LAND ALLOCATION

Implementation of effective rural planning, depends *inter alia* upon controlled land allocation. When leases are granted, the definition of development should not equate only with land clearance. Some developers clear their leased plot regardless of its suitability, in order to safeguard their application for freehold at a later date. The Physical Planning Section of the Ministry of Natural Resources is reconsidering this incentive for inappropriate land development (J. McGill, 1991, personal communication). A number of development classes could be defined, including a policy class that could be used to categorize 'watershed protection forest' as a form of development, for example. Changes of use from one class to another on national lease land would have to be submitted for approval to the Land Utilization Authority. This reconsideration of the concept of development would contribute significantly to establishing a legal framework for environmentally sensitive rural planning.

Draft legislation to rectify the lack of control over changes of land use on private land, which do not currently go before the Land Utilization Authority, has been submitted by the Physical Planning Section to the Solicitor General and was being redrafted at the time of writing.

The current procedure for leasing national lands and for the present and proposed planning system on national and private lands is summarized in Figures 21, 22 and 23 respectively.

Since one of the main reasons why application is made direct to the Minister, instead of through the formal process, is because the formal process takes a long time, we would recommend removing one or two of the professional procedural steps (e.g. Assistant Lands Officer approval), and use these relieved professional staff to process more applications (increase the number of claims by cutting their length). If ministerial approval has been given without following the formal procedure, it is essential the Land Information Centre (LIC) is consulted before the lease is granted to ensure land is not conferred which would lead to environmental damage and/or not be suitable for agriculture anyway. It is assumed the Lands and Survey Department staff would be assessing environmental suitability in the formal process.

A recent review of the administrative structure of physical planning in Belize (ESP Planning, 1990), suggested the Land Utilization Authority as the most suitable agency for rural planning - a conclusion that reflects present government policy.

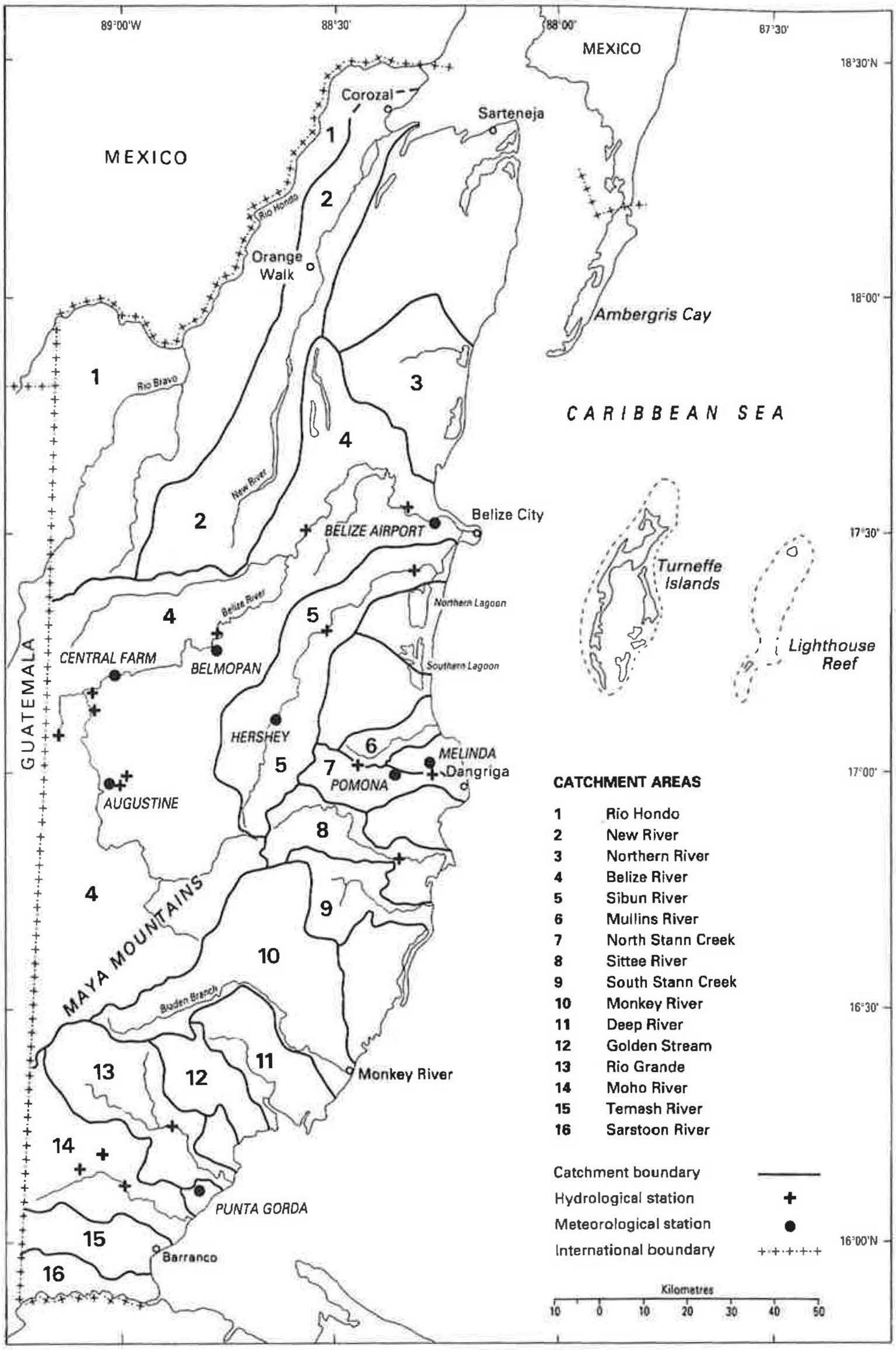
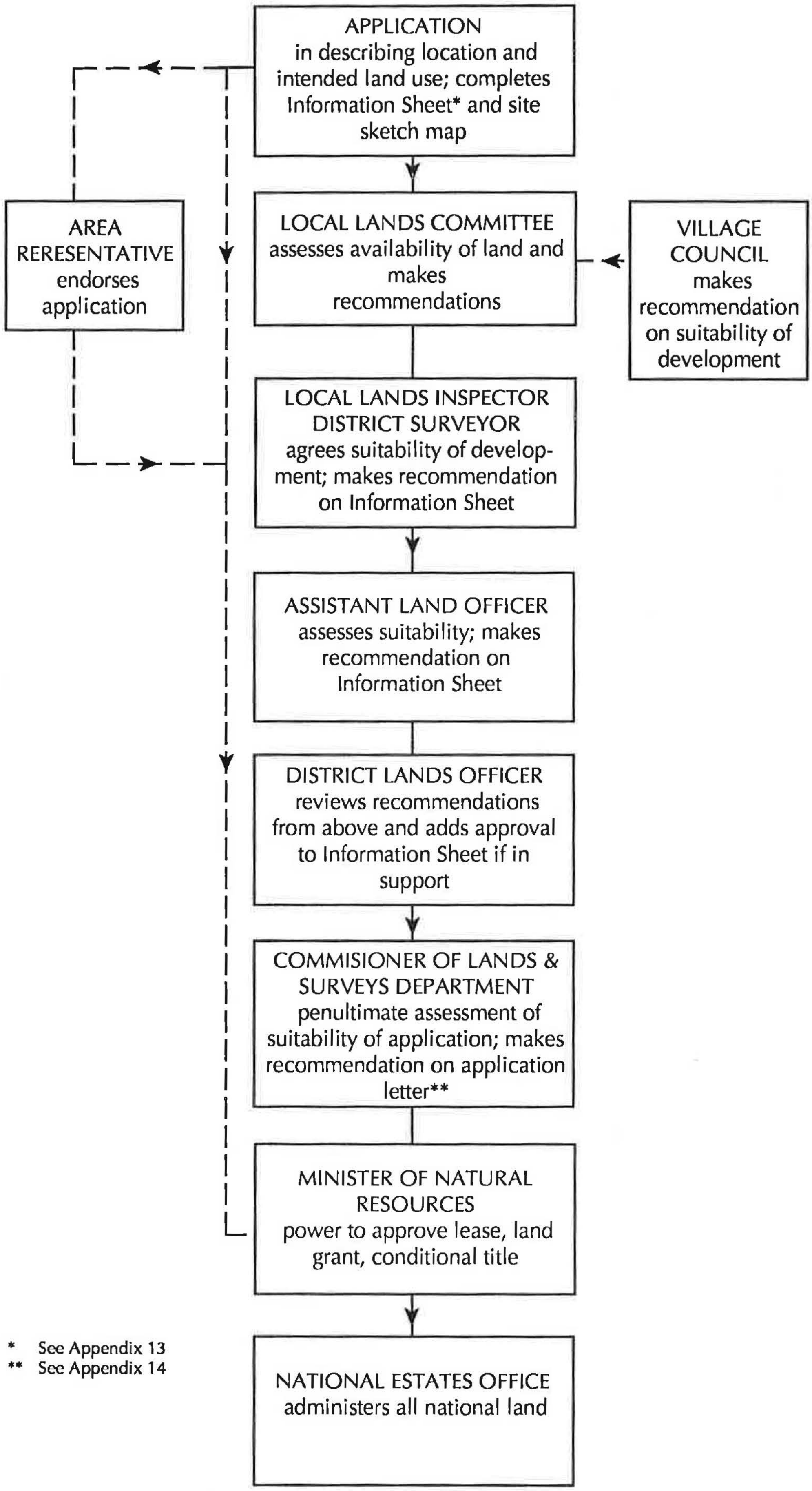


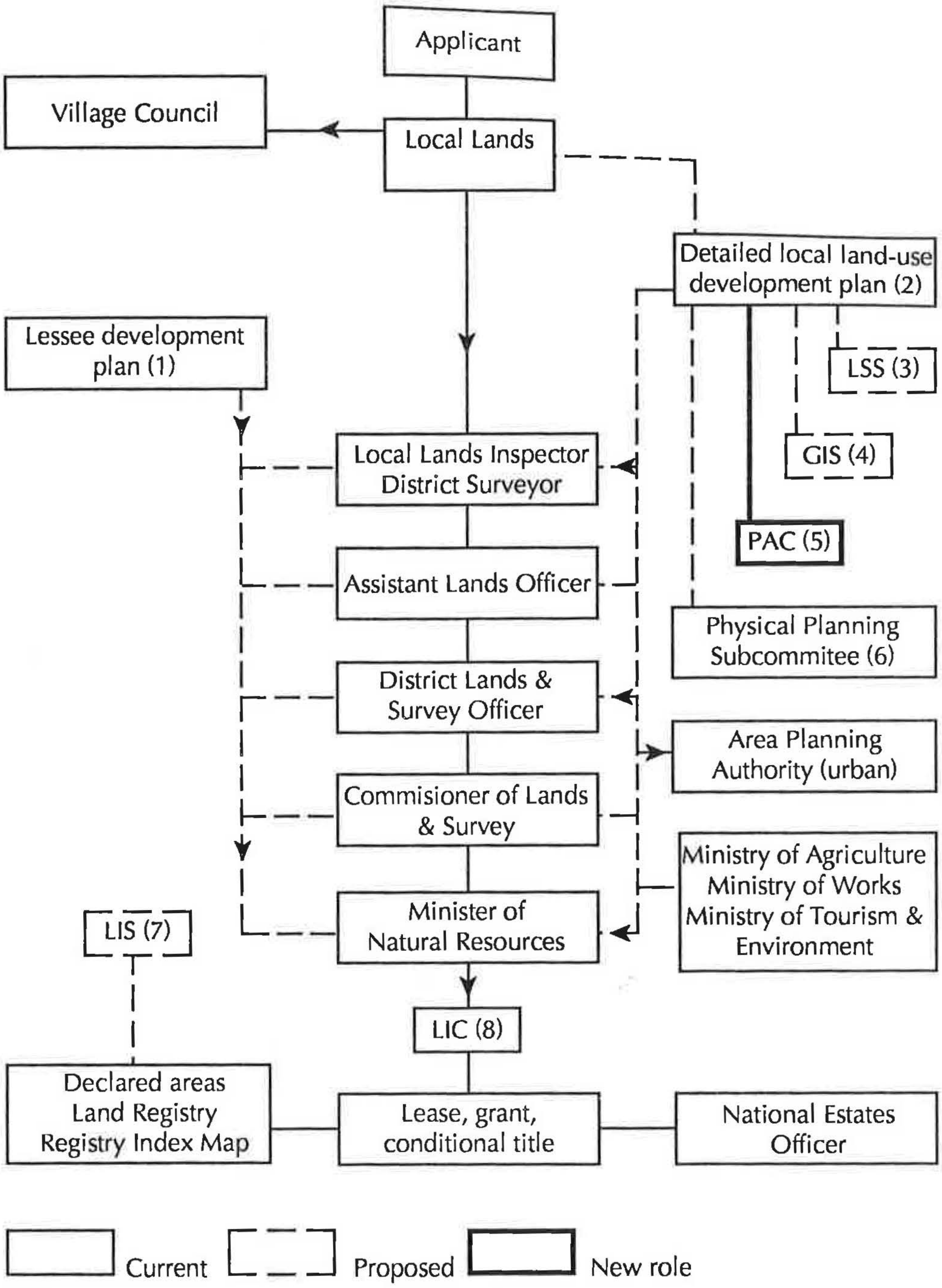
Figure 20 Hydrological network, catchments and location of guage sites



* See Appendix 13
** See Appendix 14

—— Formal procedure — — Informal proceedure

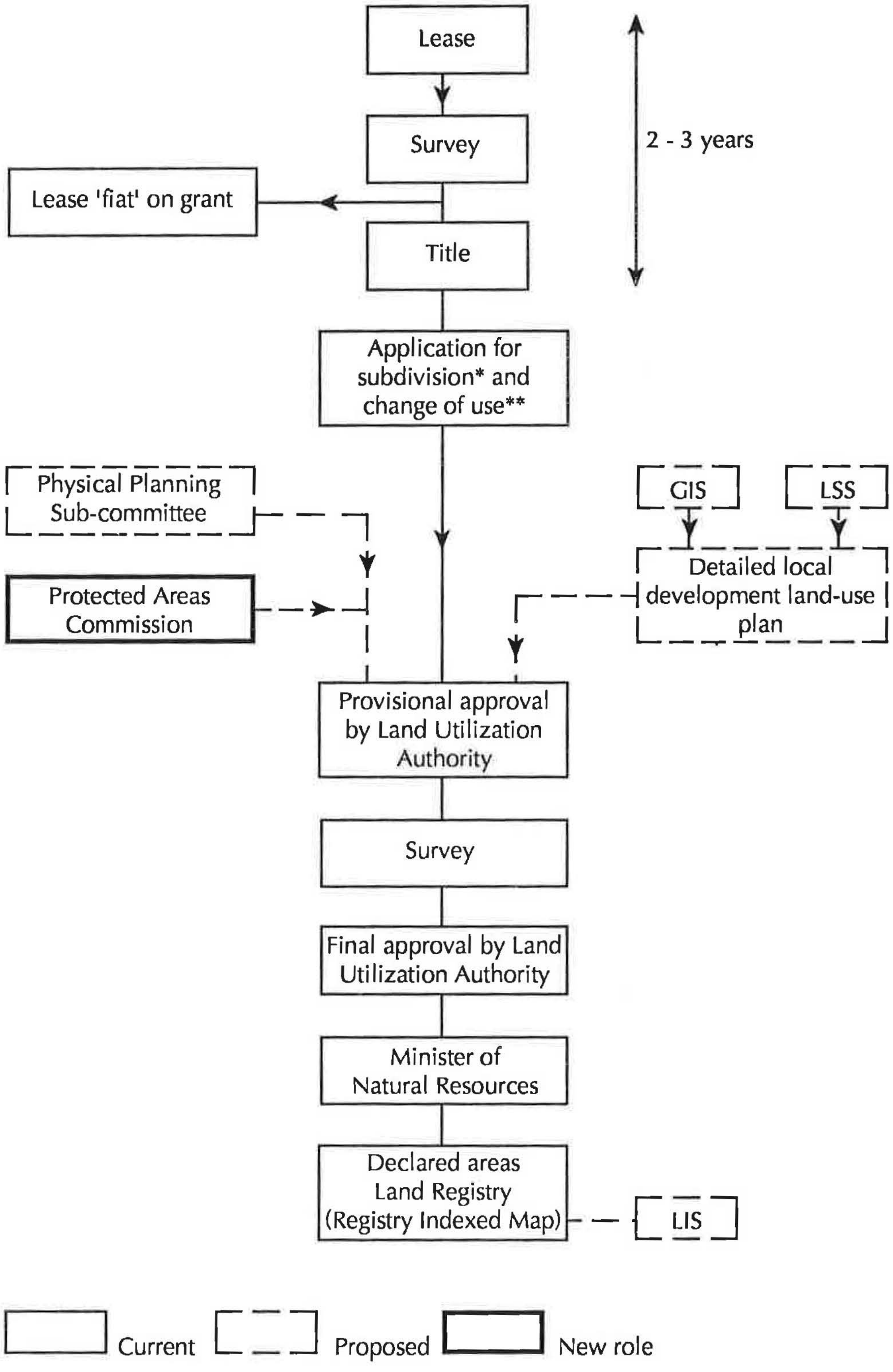
Figure 21 Procedure for leasing national land



Notes

(1) Section 7b of Application Letter, Crown Lands Ordinance, Chapter 147
(2) Amendments to section 7a of Application Form, Crown Lands Ordinance, Chapter 147
(3) Land Suitability Survey
(4) Geographical Information System housed in Department of Lands and Survey
(5) Protected Areas Commission, under Belize Audubon Society or Conservation Division of the Department of Forestry
(6) Part of Ministry of Economic Development
(7) Proposed Lands Information System to be under Department of Lands and Survey
(8) Land Information Centre housing GIS

Figure 22 Current planning system and proposed amendments for national land



* Approved under Land Utilization Ordinance
** Proposed amendment to the Land Utilization Act No .16 of 1981

Figure 23 Current planning system and proposed amendments for private land

ENVIRONMENTAL GUIDELINES FOR DEVELOPMENT

Guidelines for reducing development impacts on the environment will only work if:

(i) it is in the developer's own financial interests to comply with them

(ii) it is the developer's best interests in terms of gaining beneficial publicity

(iii) there is a legal commitment supported by effective punishment for non-compliance

(iv) they are a requirement for planning permission

(v) they are considered reasonable and the developer can afford to comply.

Although calls are frequently made for development guidelines by planners, the more fundamental requirement is ensuring one or more of these conditions can be met. There are already many environmental guidelines most frequently expressed as conditions. Appendix 15 gives the conditions of lease that were imposed when the San Antonio Peanut and Grain Co-operative was granted leasehold of national land, previously part of the Mountain Pine Ridge Forest Reserve, but enforcement of these conditions is minimal because of staff shortages.

COMMUNITY ECOTOURISM

This section appraises the suitability of areas on the mainland of Belize for community-based ecotourism.

General tourism

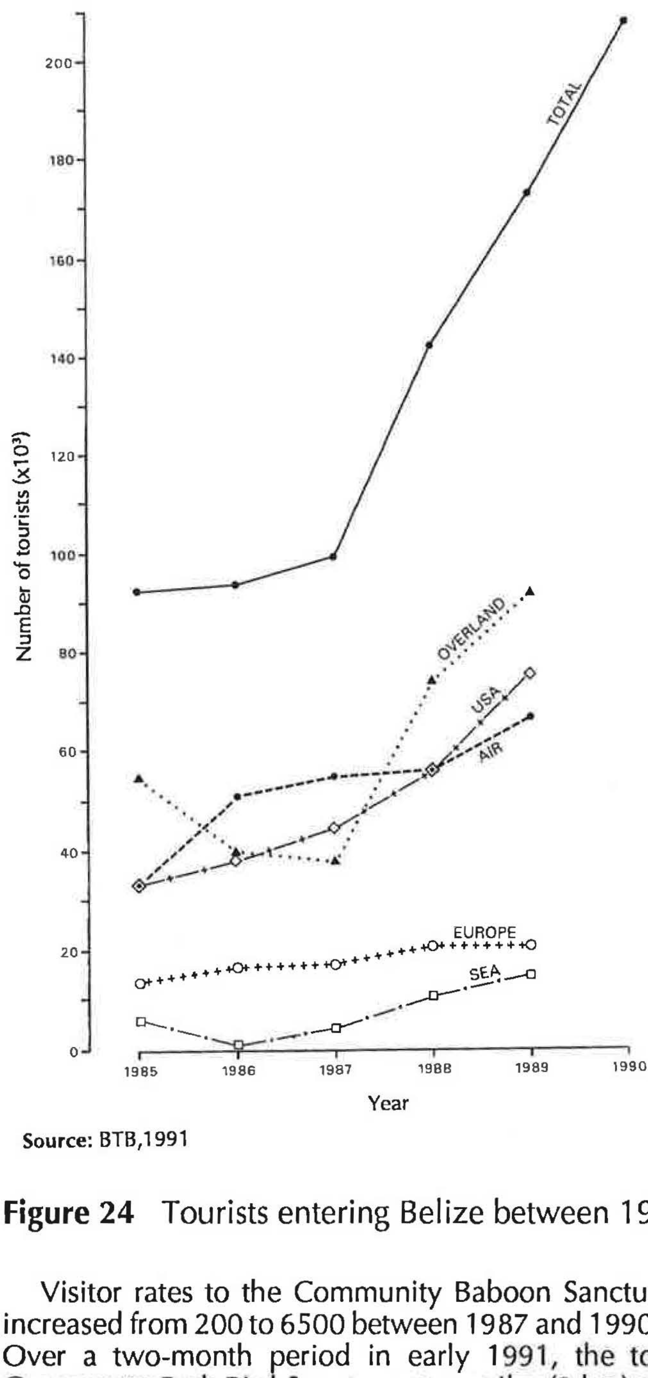
The main tourist season for Belize runs from December through to April. Although North Americans comprise the majority of tourists, Europeans increasingly fill the seasonal gap between May and September.

In 1990 the tourism industry in Belize generated BZ$ 1.15 million of GNP. In the same year, all agricultural activities combined totalled BZ$ 75 million (Amandala, 17 May 1991).

The annual rate of increase in tourists coming to Belize rose 5.8% between 1986 and 1987, and 44.7% between 1989 and 1990 (Belize Tourist Board, 1991, personal communication). Over the period 1985-90 tourist numbers more than doubled to a total of 207 105. Figure 24 gives tourist figures relating to area of origin and mode of arrival. (Disaggregated figures for visitor rates to specific destinations will be available from the Belize Tourist Board (BTB) and the Belize Tourism Industry Association (BTIA), when the data have been compiled). Figure 24 demonstrates the marked increase in tourists in 1987 when Belize was publicized on American television. The graphs of mode of origin show an increase in tourists arriving by air from 1985 to 1987, after which there was a marked increase in overland tourists. Presumably they were most affected by the publicity on American television. The figure also indicates that just over half the tourists arrive overland. The are likely to have less spending money than those arriving by air, but are more likely to be interested in the mainland and ecotourism. The number arriving by air is however also beginning to show an increasing trend.

Mainland visitor trends

Belize's comparative advantage in tourism with respect to the Caribbean Islands, is the barrier reef and mainland ecotourism (BCES, 1990). The extent to which tourists are beginning to venture away from the reef and cays to mainland destinations is demonstrated by an increase in the number of visitors to national parks, nature reserves and historical ruins.



Source: BTB,1991

Figure 24 Tourists entering Belize between 1985 and 1990

Visitor rates to the Community Baboon Sanctuary at Bermudian Landing increased from 200 to 6500 between 1987 and 1990 (Horwich, unpublished a). Over a two-month period in early 1991, the total number of visitors to Guanacaste Park Bird Sanctuary two miles (3 km) north of Belmopan, totalled 1785 (Belize Audubon Society, 1991, park records). Of these, 45% were of foreign origin, 25% Belizean adults and 30% Belizean school children and students. Such high visitor rates had not occurred before in the 18-year history of the park (O. Salis, 1991, personal communication). A tourist excursion route from San Pedro and Cay Corker, up the Northern River to Maskal and on to the Maya ruins at Altun Ha, carries between 20 and 100 tourists a day depending on the season (F. Wesley, 1991, personal communication).

It is difficult to determine visitor trends for specific destinations, because of the lack of compiled statistical data, but the above figures demonstrate that there is now an established tourism market on mainland Belize.

Ecocultural tourism

The GOB Development Plan for 1990-94 (MED, 1991) stresses a need to diversify the tourism product onto the mainland through 'ecocultural' tourism: the exposure of the tourist to both natural and cultural environments. The tourist will be interested in subtropical ecosystems, mountains, caves, waterfalls, rivers, lagoons and beaches in the natural environment; and historical ruins, artifacts, remnants of ancient cultivation systems, and the cultural life styles of the Creole, Garifuna, Maya Mopan and Kekchi people in the cultural environment.

An economic value for the agricultural and fishing activities of individuals can be compared with the value of conserving community-based, i.e. cultural activities. The economic value of the milpa farming system of the Maya Mopan and Kekchi Indians, for example, is low compared with land under commercial crops, but there are significant additional economic benefits to be gained from keeping the culture intact.

Taking the Maya example, the values of culture retention include:

(i) a direct tourism value based on the attraction for tourists of interacting in English with an ancient culture (C. Schmidt, 1991, personal communication), and the benefit this attraction has for hotels and other tourist facilities in the area

(ii) an indirect tourism value related to the marketing publicity of a living ancient culture for the Belize tourist industry.

Local participation in ecocultural tourism

Shrinking internal agricultural markets, declining fish stocks, and increasing involvement in the cash economy, have encouraged local interest in ecotourism (J. Combey, 1991, personal communication). The Government of Belize Development Plan 1990-94 encourages maximum participation by Belizeans in the tourism industry. Tourism co-operatives were promoted to mobilize capital for local investment (MED, 1991).

Cronin (1990) notes two pre-requisites for sustaining an ecocultural tourism industry in the long term: local communities supplying services, and provision for a degree of local control through an appropriate community organization. As part of the investigation into local views on development, nine communities cited by the Ministry of Natural Resources as being located within areas of ecotourism potential were asked about their experience of ecotourism. The nine were: Maskall and Bomba, Gales Point, Dangriga, Monkey River Town, Hopkins, St Margaret's, Placentia, Barranco, and the Maya Mopan and Kekchi communities of southern Toledo District. Figure 25 locates these communities and suggests land-use areas related to the development of community-based ecotourism.

The findings of each community appraisal are given in Appendix 16 and summarized in Tables 23 and 24. The appraisals aim to present the potential of each community for ecotourism from the perspective of the community, rather than from the perspective of the tourism industry. A brief discussion of the key service and organizational components of community-based ecotourism follows the tables.

Service related components

From the field appraisals and Miller (1991), the service opportunities in ecocultural tourism for rural communities in Belize include:

- guide services
- catering services
- hotel and guest-house accommodation
- camping services
- boat rentals and ferrying facilities
- crafts.

Where the community is linked to a national park, nature reserve or ancient monument, further service opportunities include:

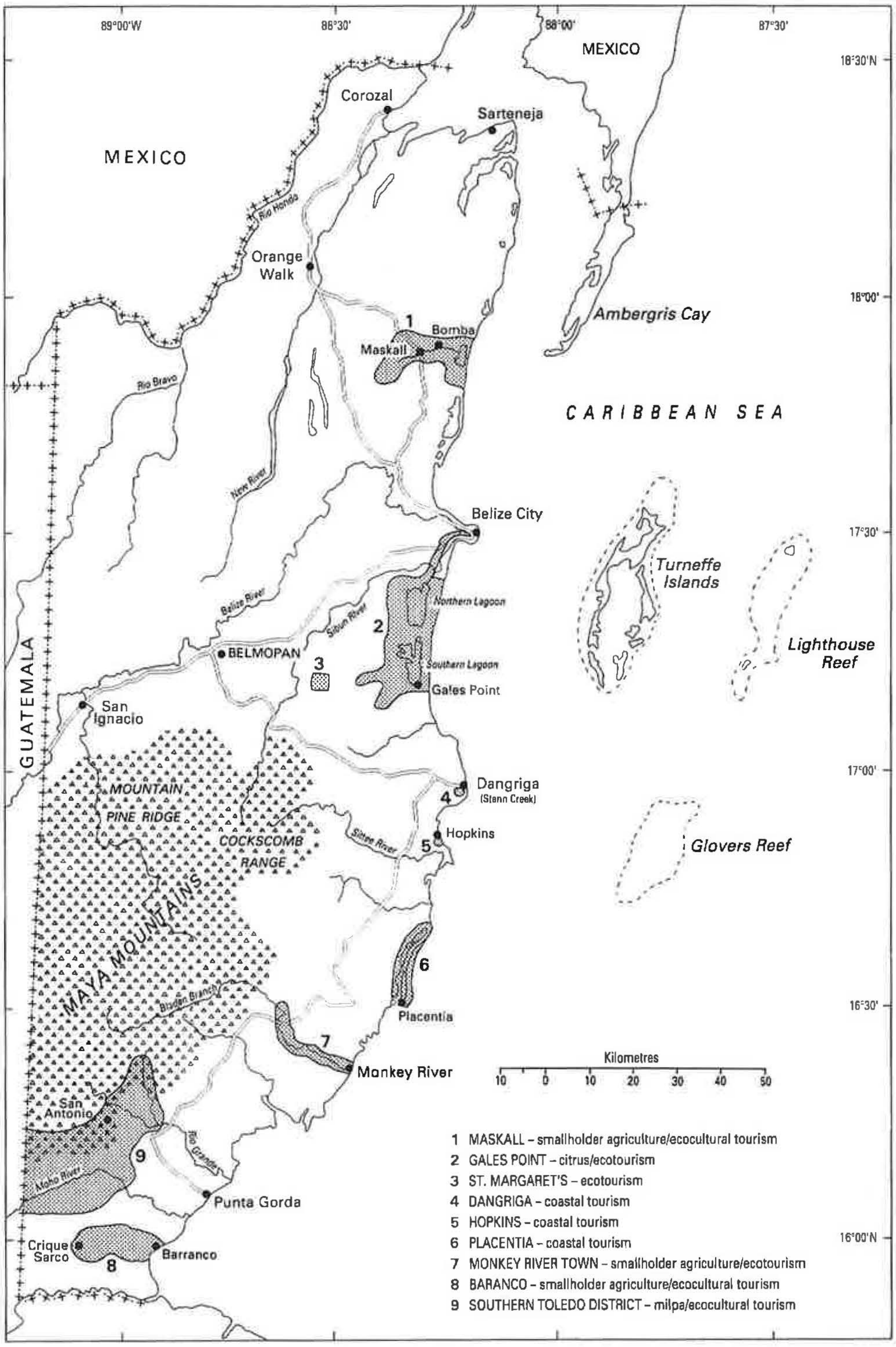


Figure 25 Land-use areas for community-based tourism

- fees collection
- wildlife protection
- regeneration of game into unprotected areas
- environmental education.

Participation by local people in the above services varies between communities. The less dependent a community is on tourism for its livelihood, the more accepting it appears to be towards foreign tourism investment. In Maskall and Barranco, an established tourism presence is viewed as an income-generating opportunity to be serviced though craft sales or guides. However, where there is dependence, or potential dependence, on tourism, communities appear less willing to encourage foreign investors. These communities, e.g. Hopkins and Monkey River Town, place greater importance upon retaining the higher value services of accommodation and catering for themselves.

Higher-value tourist services depend upon availability of land. Declining populations in a number of Creole and Garifuna rural communities produce abandoned land available for tourism but survey delays, caused by the reposses-

Table 23 Summary of the service components for community-based ecotourism in Belize

Strengths	Weaknesses	Opportunities	Threats
Cash income opportunity for rural communities	Lack of investment capital	Design of natural areas under protected areas legislation	No planning mechanism for integrated ecotourism and agriculture development
Guides' local knowledge of coasts, rivers and forest environments	Tourism licence fees and taxes disincentive for locally established accommodation to sanction catering, tour and guide services to others in community	Biological and habitat surveys lend support to ecotourism attraction	Competing private tourism facilities in proximity to local communities
Boat ownership for river and coast ferrying or tours services	High collateral/loan ratio disincentive to local investment	Reallocate abandoned plots for tourist facilities	Short time-frame for community-based ecocultural tourism to become established before opportunities are taken up by outsiders
Culture cooking	Tourism often producing higher land prices	Link into established tourist circuit	
Employment in catering and accommodation services	Tendency for established hotels to retain non-accommodation services	Locally established foreign tourist facilities create service demand and reduce risk for local tourism investment	
Tourism construction absorbs male under-employment	Lack of skill as guides, hosts and in marketing	Village council to review development plans of applications for land in village area	
Scenic road, canal, river, lagoon access routes of high tourism value	Need for abandoned plots to be surveyed before reallocation (see under 'Opportunities')	Central craft outlets purchase from community and sell to tourists	
English and Spanish speaking	Produce for tourists often not produced locally	Membership of Belize TourismIndustry Association (BTIA) for tourism skills training services	
	Lack of reliable electricity and potable water supplies		
	Untreated sewage discharged to tourism use areas and lack of solid waste disposal facilities		

sion and reallocation procedure, hinder local tourism development. Also, once land is repossessed, village councils and/or local lands committees often find they are not consulted as to who should be allocated land for tourist development. Consequently, developments go ahead that are not compatible with a community's plans for local participation and shared benefits.

The sale of private land by local residents to foreign tourism interests is a further problem. There is concern in Hopkins and at Gales Point that, as their villages grow as tourist destinations, land prices will be inflated out of reach of local investors.

Organizational components

A workable organizational structure within a community is essential to retain a sufficient degree of local control of its ecocultural tourism product. Communities in southern Toledo District and Placentia have found tour operators tend not to consult community representatives before embarking on their operations. As a consequence, local participation and benefits have been low and/or inequitably spread.

The proposed organizational structure for Monkey River Town to manage Monkey River Nature Reserve and for St Margaret's to manage Five Blues Lake National Park offers two organizational models where communities retain a degree of local control. These are described in Figures 26 and 27. Both models are developed around the need to manage a protected area, and both propose a non-profit association, registered under the Companies Ordinance Chapter 206, be formed to solicit funds.

The Monkey River model proposes that a local co-operative organize and fund all entrepreneurial activities associated with ecocultural tourism (J. Watler, 1991, personal communication). In the Five Blues Lake model, local entrepre-

Table 24 Summary of the organizational components of community-based ecotourism in Belize

Strengths	Weaknesses	Opportunities	Threats
Fishing and farming co-operatives already established	Lack of consensus for restraint by community to hunt or use products from protected ecotourism areas	Tourism co-operatives and/or associations become member of BTIA for lobbying and management skills training services	Tour operators not co-ordinating activities through elected representatives of communities
Village Council with policy bias toward community-based tourism	BTIA and tour operators not in consultation with community representa-	Existing co-operatives to widen activities to include tourism, compatible with MED 5-year plan	Service and management skills training for co-operatives and associations not forthcoming
tives Consultation between tourism co-operative (or association) and Village Council/alcalde	Weak co-operative and association management plans for protected areas	Affiliation of co-operatives and/or associations to larger hotels to undertake guides, tours, ferrying and craft opportunities	
	Perception that BTIA discourages overnight stay in local communities	Consultation between tour operators and elected community representatives prior to establishing any tourism activities that depend on attraction of the local culture	
		Support for foreign outside investment in hotel facilities to establish tourism demand for crafts and guide services	

neurial projects will be co-ordinated by the village council. By co-ordinatingprojects through an elected body answerable to the community it is aimed to ensure a community-wide level of participation and benefits (Wengryzn, 1991, personal communication). This model also avoids two organizations from the same community needing to solicit funds.

Summary

A principal component for effective community-based ecocultural tourism was identified through the field appraisals. Tour operators need to consult with the village council (and alcalde) of the communities they intend to target before beginning operations. The objective would be to establish the level of local participation, the spread of benefits and intensity of visitors most appropriate to making the venture sustainable in the long term.

PROTECTED AREAS

Intensifying economic development and rapid population growth are leading to increased competition for land, threatening protected areas already designated. Development is the priority and unless protected areas can make a significant contribution to national, social and economic well-being, other forms of development will take priority. By national selection and appropriate management, protected areas:

(i) conserve ecosystems vital for supporting commercially valuable species

(ii) protect the coast from erosion and mitigate pollution

(iii) provide a framework for forest management

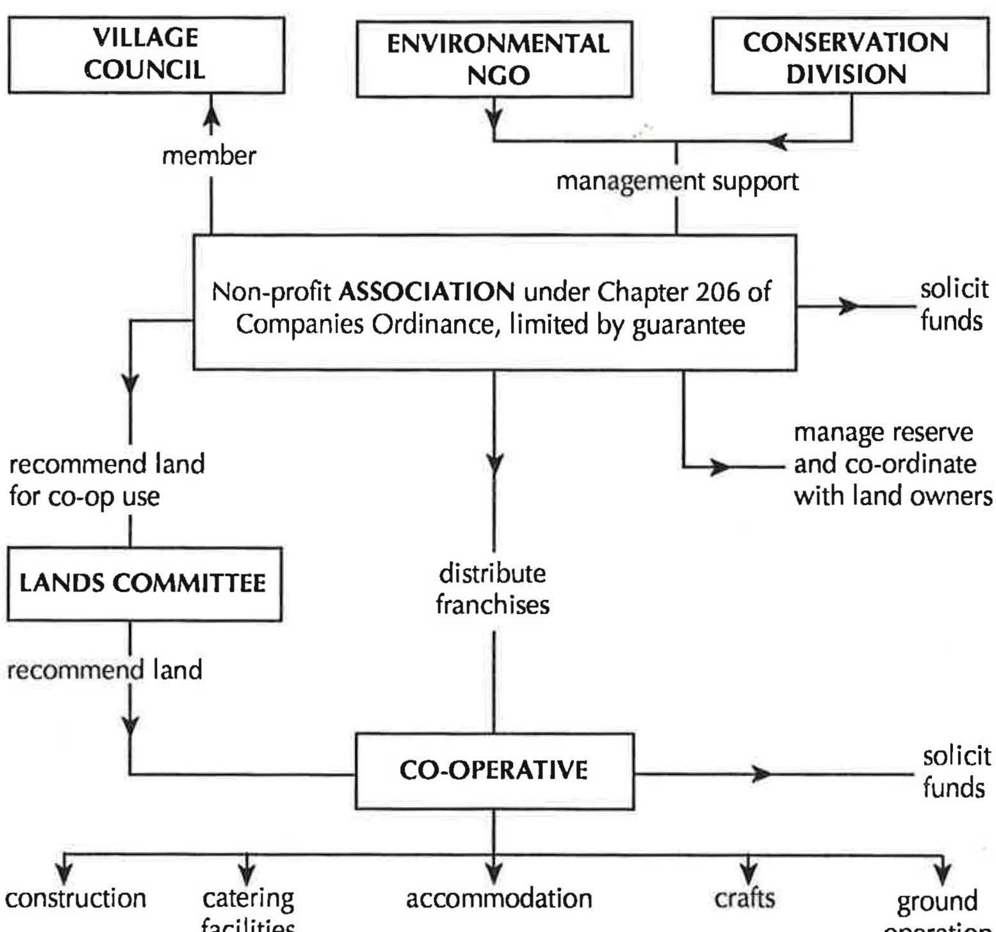


Figure 26 Proposed management organization of Monkey River Town community for Monkey River Nature Preserve

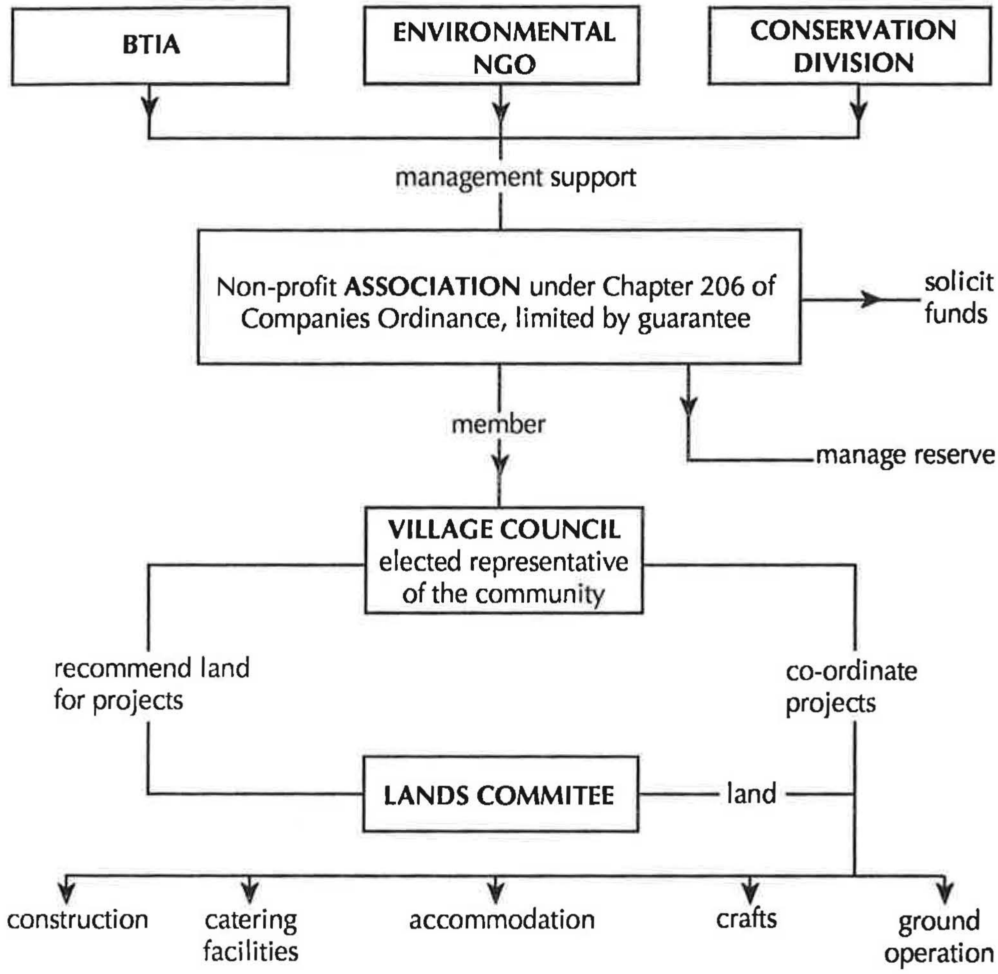


Figure 27 Proposed management organization of St Margaret's Village community for Five Blues Lake National Park

(iv) provide a framework for the preservation of archaeological and other cultural resources

(v) protect the basis of ecotourism

(vi) can be used by local communities for promoting self-help development.

The key feature of protected areas is their capacity for supporting a number of different but often compatible uses, e.g. protecting mangroves to ensure sustained fishery productivity, coastal protection and ecotourism. They help make the most effective use of land and natural resources for the promotion of economic development.

Existing framework for protected area designation

Five different pieces of legislation provide the present range of options for protection area designation (Table 25), but new reserve structures outside the legal framework have had to be revised in response to certain circumstances, such as the Community Baboon Sanctuary along the Belize River. Without legal backing, reserve management is made more complicated however and, consequently, calls have been made for an expanded range of legally defined protected areas (O. Salas, 1991, personal communication; WWF, 1989). The current designations for wildlife protection are indicated in Table 26.

At the time of writing, additional reserve categories are being considered by the Conservation Division helped by a parks management specialist funded by

World Wildlife Fund (WWF)-US. Management activities relevant to the different designations are also being investigated. The emphasis of this report is on the use of criteria in site selection and in determining the appropriate protected area categories, management activities and zoning.

Initial discussions with local conservation NGOs suggest a formalized designation for private reserves together with a wider multiple-use category on private land may be beneficial. Certain existing reserves have already played a *de facto* multiple-use role, e.g. Mountain Pine Ridge Forest Reserve, with tourism, nature conservation, and watershed protection existing alongside forestry operations. A formal multiple-use category would help draw together the various interests involved and integrate joint management. This would be the main benefit of designating biosphere reserves.

Re-definitions of 'development' proposed by the Physical Planning Section of the Ministry of Natural Resources for leased national land have also included protection categories (J. McGill, 1991, personal communication). If approved by cabinet, an additional protected area option, applicable to leased national lands, will become available.

Table 25 Current range of legal protected areas

Legislation	Administered by	Reserve type	Purpose
National Parks System Act (1981)	Ministry of Natural Resources, Forestry Department	National Park Natural Monument Wildlife Sanctuary Conservation Division Belize Audubon Society	Nature conservation recreation, research and education Nature Reserve
Wildlife Protection Act (1981)	Ministry of Natural Resources, Forestry Department, Conservation Division	No hunting areas	Wildlife conservation
Forestry Ordinance (1960)	Ministry of Natural Resources, Forestry Department	Forest Reserves	Forest management and protection forest
Fisheries Ordinance (1977)	Ministry of Agriculture, Fisheries Department	Marine Reserve	Nature conservation
Ancient Monument and Antiquities Act (1981)	Ministry of Tourism and Environment, Archaeology Department	Archaeological Reserve	Protection of archaeological and cultural features

Table 26 Protected area categories

Category	Purpose
National Park	The protection and preservation of natural and scenic values of national significance for the benefit and enjoyment of the public
Nature Reserve	The protection of biological communities or species, and the mainte nance of natural processes in an indisturbed state, in order to have ecologically representative examples of the natural environment available for scientific study, monitoring, education and the maintenance of genetic resources
Wildlife Sanctuary	The protection of nationally significant species, groups of species, biotic communities or physical features requiring specific human manipulation for their perpetuation
Natural Monument	The protection and preservation of nationally significant natural features of special interest or unique characteristics to provide opportunities for interpretation, education, research and public appreciation

Source: National Parks System Act (1981)

The criteria approach to protected area designation

A common approach to selecting sites for designation is to check its suitability against a number of criteria. The advantages of this method are:

(i) it provides a consistent standard for site selection

(ii) it is easily appreciated by local people, civil servants and politicians

(iii) it helps ensure the case for protection is justified

(iv) it identifies the land-use integration required to achieve the synergistic benefits of sound planning

(v) it helps minimize subjectivity in selection

(vi) it makes protected area objectives explicit

(vii) it helps highlight the most suitable type of protected area designation for a site

(viii) the criteria can be applied within a reserve to formulate appropriate management and zoning activities.

The principal drawback with the criteria approach is the need to collect relatively detailed information on natural resources, local communities, etc. in order to consider them objectively. Often the data are not available, e.g. uncertainty over the location of aquifer recharge areas (D. Wilson, 1991, personal communication). In these instances, a best practicable assessment has to be derived through wide consultation and consensus between relevant locals and other specialists.

Pragmatic criteria

Cost of management

Protected areas should only be designated when resources are available for their proper management. This effectively limits designation to the top-ranking sites which can attract funding, or those with some infrastructure already in place. Otherwise, the priority for protected area selection should be sites where a number of uses can be supported within one reserve. Management costs can then be shared, and co-ordinated policing and administration put in place. It is becoming increasingly difficult to protect the integrity of forest or nature reserves because of higher population and development pressure. The costs of reserve management are likely to rise accordingly. Priority should then be given to designating sites whose management is affordable. Where resource implications of management are high, expenditure may be justified if a site qualifies on a number of other priority criteria.

Land tenure

The majority of development control legislation relates to national lands, which therefore provide the greatest scope for protected area designation. More than 50% of Belize is national land. The marine continental shelf and some cays are also under public ownership.

Private reserves have also been established. Formal management agreements, conservation easements, rent backs, or conservation covenants can be explored with private land owners. NGO ownership and establishment of land in trust for the nation, e.g. Programme for Belize, are additional options.

Some landowners may be interested in managing areas unsuitable for conversion to agriculture, as protected areas, particularly for ecotourism, or where farmers use floodplains for agriculture and need watershed protection.

Where there is uncertain ownership or tenure, any form of designation is untenable unless resources are available to determine leasehold or ownership. Widespread squatting may also inhibit protected area designation. Enforcement and relocation of people need to be weighed against the potential protected area benefits to be gained and the implications of doing nothing: perhaps forest loss, over-hunting, or soil erosion. Eight Maya families, for instance, were relocated from the Cockscomb Basin, with assistance from an NGO, to the nearby Maya Centre village when the Cockscomb Wildlife Sanctuary was designated, after a mutually acceptable agreement for compensation had been negotiated. Governments since, however, have been unwilling to tackle the problem of relocating people where environmental damage is being caused even where a wide consensus suggests the land would be best left under protection forest.

Opportunity cost

An estimate should be made of any potential benefits foreclosed by designating a protected area, i.e. its opportunity cost. For agricultural potential, reference should be made to the information and land suitability map series provided by Jenkin *et al.* (1976) and King *et al.* (1986, 1989, 1992). Land suitability for different types of forestry can be determined through consultation with the Forestry Department who are looking at forest management suitability under the TFAP. The Fisheries Department has also established a set of criteria for the assessment of suitability for aquaculture.

Economic evaluation of these alternative land uses can be used to cost any benefits foregone, e.g. crop yields, compared with the potential benefits from designation (see Winpenny, 1991). The sustainability of income, from either option, its sensitivity to fluctuation and distribution, and social versus private benefit must also be considered.

Advantage may be taken of areas where opportunity costs of designation are extremely low, for instance poor agricultural lands, inaccessible areas whose exploitation for forestry is uneconomic, and wetlands. Designation of areas worthless for anything else is more likely to be palatable politically, socially, and economically.

Appropriate activities

Help for Progress, Belize Audubon Society, Belize Enterprise for Sustainable Technology, and Belize Center for Environmental Studies and other NGOs can contribute materials, technical assistance, financial resources, or staff support to protected area initiatives. The support could be vital to overcoming obstacles in protected area establishment. Because of office and staff location, or their own geographical allegiance, NGOs may give preference to protected areas in certain locations.

Degree of threat

Threatened areas rarely make good reserves. They are often expensive to protect, and efforts to isolate the reserve from the threat may fail. Where protected area designation is justified in areas suitable for development, resources will be needed for more policing, prevention of disturbance to water quality, or other management aspects.

Opportunism

Opportunities may arise for unexpected protected area designation caused either by the unexpected provision of financial resources, political support or donations of land by private land owners. Where sites meet several other criteria, the opportunity should be taken.

Local development needs

Local support

Protected areas require the support of a wide base of people, particularly local communities. Their support and co-operation can have a range of benefits, from providing staff to work at the site who already have a good local knowledge of the area, to a degree of informal round-the-clock policing. If settlements occur nearby, protected areas should therefore be located where such support can be achieved.

Local peoples' support and confidence are best achieved by making the reserve meet as many of their needs as possible, e.g. in generating new employment, protecting their water resources, or providing hunting grounds. They should be involved right from the first stages in reserve planning and management, as was done at the Community Baboon Sanctuary, and is proposed for Gales Point and Monkey River reserves.

Whether for ecotourism, plantation forestry, extraction of non-timber forest products, or any other uses, substantial human resources are required to establish and maintain a successful protected area.

Appropriate activators

The willingness to participate and availability of local resources can be determined by circulation of a questionnaire, as was recently used in the prefeasibility phase of the Monkey River Community Nature Reserve (see Appendix 17).

Adjacent landowners are also important particularly where their activities, such as pesticide application, fires for land clearance, or dredging from river beds, may have an impact now or in the future on the proposed protected area. The co-operation of landowners, whose land must be crossed in order to gain access to a site is also necessary.

Overall, the support of the majority of the community is more likely to be achieved if they receive some of the benefits of protected area designation. Appropriate activators with the long-term commitment and organizational capacity to implement the work required are needed to obtain local support. Any shortfalls in technical knowledge can generally be overcome through appropriate training.

Activators could come from the village council, a group of local farmers (e.g. as at the Community Baboon Sanctuary) or single landowners willing to contribute to environmental protection. If such local activators are present, and they have realistic expectations of what benefits can be generated, then an important criterion for protected area selection has been met. Having representatives willing to lobby in Belmopan and Belize City in support of their interests is also important.

Compatible established local uses

There may be potential conflict where people already use an area that is suggested for some form of protection. If this impact is significant, the options will be: explaining the damaging consequences to the settlers, encouraging the appropriate authorities to enforce the law where local uses are illegal, providing compensation in exchange for halting damaging activities where local use is legitimate, or helping to provide alternatives if available. If no acceptable solution can be found to resolve the conflict between established legitimate use and protected area designation, emphasis should be placed on designating sites where there are no current conflicting uses.

Employment needs

Local demand for jobs may influence the location or type of protected area. The employment needs of local people are likely to vary considerably, but will depend on their existing occupations, family commitments, etc. There may be requirements for part- or full-time work, or seasonal employment. The selection of protected areas may therefore respond to localized demand for the type of jobs that can be provided in reserve management. Establishing an ecotourism orientated protected area at Maskall, for example, could generate local employment in an area of farm abandonment.

Public health

Protected areas may diminish pollution or other agents that contribute to public health problems in rural and urban areas. They may also serve to isolate people from sources of pollution, such as the sewage ponds in Belize City. The establishment of a protected area by a local community may also lead to recognition and reduction of upstream or adjacent sources of pollution.

Recreation

There is an increasing demand for recreation especially by those living in urban situations. Various locations, including Blue Hole, Mountain Pine Ridge and Roaring Creek have established recreational roles. They have all received some form of protection through designation. Other areas, already used by local people (for many generations in some instances), may need similar protection if development threatens their integrity. When selecting a protected area, its potential for recreation (for swimming, presence of beaches, etc.) should be considered. Northern and Southern Lagoons and the Burdon Canal are potentially a major recreation resource for local and foreign tourists.

Nature conservation criteria

Diversity

Diversity can be defined as the number and variety of species and habitats found in any one area. It is usually encountered where environmental factors vary significantly over a relatively short distance. Changes in topography (of only a few centimetres in some cases), soil type, or drainage are examples. Habitat edges are consequently typical areas of high biodiversity (MacKinnon *et al.*, 1986). Human influence can either increase or decrease diversity. Large-scale conversion of natural ecosystems to artificial habitats, such as pastures or citrus, will reduce diversity. Conversely, small areas, such as the milpa plots in the Cockscomb Basin have increased the diversity of the overall forest environment. Some flora and fauna can tolerate a wide range of habitat, and can survive alongside human activity, but there are some species which require undisturbed habitats and are vulnerable to human disturbance, in some cases leading to extinction.

Rarity

Rarity may be related to extremely specialized habitat requirements, to direct human pressure (trapping, collecting, hunting, poaching), or indirect human influence (habitat destruction, pollution). For successful long-term protection of rare species, ecological requirements at a particular site must be understood, and human interference must be effectively controlled.

The use of the rarity criterion for protecting species and habitats is, however, complicated. The degree of threat to a species has to be carefully defined (see Appendix 18), and its geographical context requires examination. Species can be widespread and extensive, widespread and restricted, or restricted to one locality but numerous.

The rarity criterion is difficult to use in Belize for delineating reserves because there is a lack of information on the distribution of species which have localized ranges and on the areas where internationally rare species are most abundant. Some research is being carried out, however, e.g. the Critical Habitats Survey (Miller, 1990) for the Flora Mesomericana by the British Natural History Museum and the International Council for Bird Preservation (Limited Range Mesoamericana Project). Rare species are also being reviewed under the Tropical Forestry Action Plan.

Abundance

The selection of protected areas where species are abundant means a greater number of individuals can be protected in a smaller area, which also maximizes the conservation gene pool. The use of the abundance criterion depends on available information on the relative abundance of species between different sites. Consistent fieldwork methodologies are required to make comparisons.

Areas with abundant wildlife are also suitable for ecotourism, e.g. dry-season watering holes, waterfowl roosting sites, and forests with a high proportion of fruiting trees.

The relationship between abundance and diversity has been investigated for a number of years because of their generally mutual exclusivity. Wetland ecosystems, e.g. freshwater marshes, contain an abundance of particular species, but relatively low biodiversity. Both abundance and diversity have ecological and nature conservation value, and therefore sites containing representative ecosystems of both are important for protected areas.

Size

There are many reasons why large areas are more valuable as protected areas than smaller ones (MacKinnon *et al.*, 1986). To offer full protection, sites need to cover complete habitats, rather than nesting grounds or similar individual components. The seven small bird sanctuaries selected to encompass waterfowl nesting colonies are too small to provide adequate protection for the birds. Their breeding, feeding, migratory, roosting, or watering areas all need to be conserved. In another example, individuals of certain tree species are generally extremely widely spaced across the forest and therefore require an extensive reserve area for protection.

Marine species also need an adequate area of protection. Reef fishes migrate between the reef itself, seagrass beds and mangroves. Reserves must be large enough to include the full range of habitats required. The range requirements of manatee (*Trichecus manatus*) and the American crocodile (*Crocodylus acutus*) also need to be established.

Larger units are more likely to contain complete ecological functional units and hence be more self-sustaining. They allow the continuity of ecological processes and linkages, and the uninterrupted flow of propagules and nutrients.

Populations within the reserve must be large enough to be genetically viable, i.e. to prevent reduction in genetic diversity by inbreeding. The experience of animal breeders suggests a minimum breeding population of 50-100 individuals to prevent severe genetic shrinkage in the short term (20-30 generations), and 500 individuals in the long term (Soulé *et al.*, 1982). Small populations reduce immunity to disease and decrease capacity for population regeneration after major catastrophes such as hurricanes. Not all animal types are susceptible however. There is some evidence to suggest that some bird populations, unlike mammals, can regenerate healthily from only a very few individuals.

This type of genetic viability concern does not significantly affect Belize at present because its reserves are generally surrounded by contiguous habitat. Animals can therefore migrate and interbreed freely. The future however may be different. Costa Rica has an internationally renowned series of nature reserves, many of which contain the only forest remaining in an otherwise agricultural countryside. They are islands of habitat, surrounded primarily by grazing pasture. It is becoming apparent that these forest reserves are too small to support genetically viable populations of certain species (E. Boles, J. Bindernagel, 1991, personal communication). Costly management intervention is then necessary, involving the capture, transfer and introduction of new individuals into different forest remnants to boost genetic variability.

The Costa Rican example demonstrates the importance of protecting sufficient areas to ensure long-term conservation of biodiversity at reasonable cost. Reserves do not necessarily have to be single blocks. They can be a number of sites linked by wide ecologically viable habitat corridors. The role of sites as corridors is therefore another component to the size criterion.

In the case of Belize, Rabinowitz (1986) argued that by protecting sufficient area for the prime carnivore - the jaguar (*Panthera onca*) - sufficient habitat will be reserved for all the other species. Although the area required to protect the jaguar is unknown, the area required to protect a generally viable population of puma (*Felis concolor*) is estimated to be 5000 mile^2 (13 000 km^2) which is almost twice the size of the entire Maya Mountains, and underlines the importance of international co-operation with Guatemala and Mexico in achieving sustainable nature conservation.

From a management perspective, larger reserves are also better able to support multiple uses. Disturbance from forestry operations for instance can be spread over a wider area and therefore 'diluted', or can be carried out on an economic scale on rotation, affecting only a relatively small proportion of the site at any one time. Managing a large area as one single unit may also reduce administration and operating costs.

Fragility

The fragility of certain habitats makes them clear candidates for designation. The reef is Belize's most important of this kind. Cave systems, enclosed wetlands and steep mountainous environments are fragile terrestrial habitats.

Representativeness

In order to maintain biodiversity, a representative sample of each habitat in the country must be protected. The broadest possible range of reserves can then be utilized for ecotourism, education and research.

The use of this criterion requires the difficult classification of ecological communities. The Life Zone classification of Holdridge (1967) uses latitude, altitude, rainfall and evapotranspiration parameters, but is rather coarse for a country the size of Belize (see Hartshorn *et al.*, 1984). The vegetation map of Wright *et al.* (1959) provides a more appropriate scale, using classes derived from geological, soil and climatic influences. Associations identified by Wright *et al.*, but not included in existing reserves have been identified by King *et al.* (1992) and BCES (1990). The Wright *et al.* survey was, however, a reconnaissance exercise and inevitably contains inaccuracies (C. Wright, 1991, personal communication). Whereas some of their map can be used as a baseline indicator of the various vegetation communities in Belize, additional research results should be considered as they become available to distinguish further characteristic vegetation communities. Representative areas can then be selected from these.

With the exception of Hecker (1986) and BCES (1991b), a notable omission in ecological research in Belize has been the identification and characterization of freshwater wetland communities. In order to protect wetland resources, which Pendleton (1991) identified as the most seriously threatened component of the Belizean environment, this research should be a priority.

Core refuges

Certain locations by virtue of their physical setting provide core areas where species or habitats are concentrated, either all year, in periods of extreme stress, notably drought, or at particular seasons. They are nature conservation 'hot spots' which merit identification and protection.

Most core areas are determined by water availability during the dry season. Crooked Tree Wildlife Sanctuary for instance is a core area refuge for waterfowl in the Yucatan and Peten regions between January and May. The Upper Bladen Valley is another example, as it is one of the few local areas where dry-season water is available. Game concentrate in the valley to drink, attracting local hunters (M. Johnson, 1989, personal communication). The protection of dry-season pools within mangroves for waterfowl and fisheries is also important, because the birds and a variety of marine species retreat to these refuges as the water levels drop. In time, as the wet season progresses, the remaining habitat is recolonized. Other suitable core sites include spawning areas (freshwater and marine), nesting, roosting, and breeding grounds for bats or other species groups.

Sites for migratory species

Improvements in international liaison between conservation bodies and better knowledge of migratory species have emphasized the role of protected areas for conserving migratory fauna, primarily for birds, which breed in North America in the summer before flying south to winter in the Neotropics. Evidence is accumulating of a severe decline in numbers of these migrants (Keast and Morton, 1980), blamed on tropical deforestation (e.g. Wilcove and Terborgh, 1984). In order to maintain migrant bird populations, their habitats have to be protected across their entire range. Consequently it is necessary to identify the habitats on which these birds depend. Substantial financial resources have already been provided from international conservation NGOs for this work. Wild Wings Inc., for example, has contributed to the establishment and maintenance of the Crooked Tree Wildlife Sanctuary.

Belize is also a party to various international wildlife conventions relevant to migratory species, specifically the Convention on the Conservation of Wetlands of International Importance Especially as Water-fowl Habitat (Ramsar Convention), and the Convention on the Conservation of Migratory Species of Wild Animals (ODA, 1989).

Forestry criteria

Previous exploitation

The current distribution of commercially sized timber has been fundamentally altered by a long history of selective logging, which has diminished the stock of commercial species, particularly in hardwood areas. Forest reserves are therefore most suitable in the few remaining areas where forests have been intensively and repeatedly exploited, e.g. Columbia Forest Reserve (E. Samuels, 1991, personal communication).

Commercial species

The distribution of tree species is related to climate at a broad scale and soils at a local level. Variation of climate within Belize is insufficient to generate wide differences in commercial species distribution. The longer dry season in the north does, however, facilitate access over long periods. Forest reserves are best suited to environments where species in demand will grow, e.g. better-drained acid soils for pine.

Stocking density

Areas with the highest densities of commercial species are obvious candidates for designation as forest reserves. The various inventories to determine commercial species densities (e.g. Johnson and Chaffey, 1973) are being analysed at the time of writing by the Forest Planning and Management Project.

Growth class

The combination of climatic and edaphic characteristics will determine the rate at which trees grow. Drought and trace element deficiencies in the soil are two examples of factors that will tend to retard growth. Limitations of this kind may be overcome if management can support the use of fertilizers. Otherwise, poor growth class limits the economic return on forestry operations and therefore reduces suitability of certain areas as forest reserves.

Access

The construction of forest roads is a major cost in forestry operations and forest reserves are, therefore, best located in areas with existing or easily constructed access. Historically, the most accessible forests have been given over to private concessions. The current forest reserves are consequently in the less accessible parts of the country (J. Howell, 1991, personal communication).

Erosion prevention

See 'Soil protection guidelines' section under 'Forest Cover and Rates of Clearance' (on p 55).

Watershed protection

See 'Water resources' section later (on p 105).

Tourism potential

Accessibility

For tourism, access to a site must be convenient whether on foot, by plane, private vehicle, boat, public transport, or on a tour bus. Since many tourists have only a limited time for sightseeing, it helps if access to a protected are is relatively quick, i.e. near to main (preferably metalled) roads. Sites that can be visited in a day from a major tourist centre like San Ignacio or Belize City have a distinct advantage.

Relation to other sites

Proximity of one site to another also attracts tourists. By creating a chain of protected areas with accommodation and other facilities conveniently within reach along the way, a circuit can be created linking one site to the next. This makes it easier for visitors to take in a number of attractions without having to backtrack or spend excessive amounts of time travelling.

Landscape quality

Research into protected area tourism has shown that the journey to the site contributes significantly to the enjoyment of the visit. The quality of the landscape around the reserve and along the route should therefore be taken into consideration when selecting protected areas. The Caves Branch section of the Hummingbird Highway is a good example. The mixture of grazing pasture, rolling topography, and a backdrop of forested hills provides an attractive lead into the Blue Hole National Park. The converse situation has also to be considered, however, in that areas of poor landscape quality, such as secondary scrub growth or burnt karst forest, detract from the journey to a reserve.

Uniqueness

Tourism is a competitive market and there are likely to be an increasing number of different sites to lure visitors. Unique attractions have a distinct and elevated status. The barrier reef and the Chiquibul Caves are, for example, attractions that no other country in the region can provide. Other natural features like Victoria Peak are also highly individual and of significant appeal. Alternatively, a unique attraction can be created by combining an assemblage of features in an unusual package. The Community Baboon Sanctuary, for example, combines wildlife viewing with a unique form of communal management, which gives visitors an insight into the Belizean way of life as well as local natural history. Sites which contain some form of unique feature of interest to tourists therefore are likely to have a high rating as protected areas.

Suitable carrying capacity

Sites that are particularly susceptible to damage, either physically or ecologically, such as animal breeding grounds and fragile archaeological remains, should be avoided unless sufficient management resources are available to ensure that visitor damage is prevented.

Fees and concessions arrangements

Protected areas (except for Hol Chan Marine Reserve which was set up under different legislation) have not been able to charge entrance fees to visitors due to lack of a fee arrangement in the National Parks System Act. These arrangements are, however, currently under review by a joint World Wildlife Fund - US funded specialist due to report in late 1991.

Future sites for designation should be chosen where concessions can be let (thus reducing the capital costs and management responsibilities associated with establishing certain parts of the reserve infrastructure), and where significant income could be generated from entrance fees.

Safety

Tourists will not visit sites unless their safety is assured.

Ecotourism

Likelihood of seeing wildlife

The selection of protected areas for ecotourism should consider wildlife visibility, particularly where there is a tall forest. Bird-watchers are a particularly numerous group that can be attracted to sites, either by the presence of unusual conspicuous species, e.g. roseate spoonbills (*Ajaia ajaja*), reddish egrets (*Egretta rufescens*) or scarlet macaws (*Ara macao*), or by habitats with a good assemblage of representative species that can easily be seen. Cockscomb Wildlife Sanctuary, for instance, is a prime bird-watching site because the relatively low canopy makes the birds easier to see. Wetlands also generally provide good opportunities for wildlife viewing.

Animals may be faithful to one particular route, feeding area or nesting site, or tolerate viewing at close quarters, and therefore lend themselves to ecotourism. The breeding colony of red-footed boobie (*Sula sula*) at Half Moon Cay Natural Monument is a good example.

Species appeal

Reserves should be sighted so that people can see those species, usually animals, that have a significantly greater appeal to visitors than others, e.g. jaguars (*Panthera onca*), manatees (*Trichecus manatus*), black howler monkeys (*Alouatta figra*) and scarlet macaws (*Ara macao*). The most obvious case in Belize is the Community Baboon Sanctuary.

Naturalness

Little of what is now Belize has not experienced at least some human activity. In certain areas, evidence of human activity: traffic noises, litter (e.g. the mangroves south of Belize City), power lines, settlements, or army activity, all detract from the suitability of an area for ecotourism and consequently tourism-related protected areas.

Archaeology

Archaeological features

With such abundance of Mayan archaeological features in Belize, protection of large structures such as temples, palaces, plazas, ball courts, terraces and the reservoirs should take priority. For smaller structures like house mounds, clusters should be given greater consideration than isolated individual sites.

Size of feature

Larger sites should receive greater priority because smaller features are generally less significant archaeologically and for supporting multiple use.

Representativeness of different periods

Protected sites should range from the prehistoric and the pre-Columbian periods to the historical/colonial period in order to maintain the broadest possible range of cultural assets.

Relative site importance

Relative site importance provides a finer level of priority assessment, e.g. Cuello in Cayo District is a particularly important Mayan feature. Although it is small, it is one of the earliest Mayan sites in the country, dating back 4000 years.

Water resources

Nearshore water quality

The nearshore water quality criterion is related to the protection of the coral reef and other coastal ecosystems. At present, understanding of the transport processes that could, potentially, carry polluted river discharge out over the reef is not sufficiently developed to identify the critical watersheds for nearshore water quality protection. This is a matter of priority concern, however, as agricultural development, particularly in Stann Creek District, is concentrated along the river-banks where fertilizer and biocide runoff, and accelerated bank erosion are potential consequences of development. Once the important off-shore transport patterns are determined, protected area designation can be focussed on the relevant watersheds if investigations show that development impacts are likely to damage coastal habitats.

Maintenance of dry-season flows

Protected areas need to be designated to preserve dry-flow water systems either for people or game, or where pollutants require dispersal, or where significant populations of important nature conservation species occur. Small steep-sided catchments with shallow or impervious soils are particularly vulnerable to reductions in flows when deforested, and therefore should receive priority for protected area designation.

Recharge areas

There is still considerable uncertainty about the location of areas which contribute significantly to the recharge of aquifers, currently or in the longer term, likely to be utilized for domestic, industrial or agricultural purposes. It is impractical at this stage therefore to use this criterion to locate protected areas aimed at conservation of groundwater reserves. Exceptions at a local level are on the cays and coastal strip, where recharge areas tend to be more easily identified.

Flood control

Small, steep, heavily dissected or narrow catchments (or those with a combination of these characteristics) can be susceptible to flooding. This is a particularly serious consideration where bridges, settlements or farm land (particularly heavy investment crops like bananas) are found downstream. Forest clearance, whether of relatively small areas in upper catchments and steep valley sides, or large areas in lower rolling areas, will lead to quicker runoff and more rapid rise in storm-water flows. Flooding of the North Stann Creek is reputedly becoming more regular, and is thought to be related to increased forest clearance in the watershed.

Existing and proposed nature reserves

For details relating to protected areas up to 1989, reference should be made to Zisman (1989), Munro (1983), Zisman and Munro (1989) and ODA (1989). Since then, certain sites have been expanded and new reserves established (Table 27). Guanacaste was officially declared a national park by SI 46 in April 1990. In the same month, but under the Wildlife Protection Act, the land surrounding Shipstern Lagoon was declared a Closed Area to Hunting. In June 1990, Bladen Branch Nature Reserve was designated by SI 66. This reserve

Table 27 New and expanded reserves

Reserve type	Reserve	Area (ha)
National Park	Guanacaste	21
	Blue Hole	233
	Five Blues Lake	358
Natural Monument	Half Moon Cay	4 144
Wildlife Sanctuary	Cockscomb Basin	41 538
	Crooked Tree	1 810
Marine Reserve	Hol Chan	13
Wildlife Sanctuary under previous legislation	Little Guana and other small cays	5
Abandoned Wildlife Sanctuary	Colombia Forest Nature Reserve	2 340
Private Reserves	Bermudian Landing	33 km along river
	Rio Bravo	61 538
	Monkey Bay	433
	Shipstern Reserve	8 907
	Possum Point Biological Station	18

covering 97 042 acres (39 271 ha) has an endowment for management of US$ 100 000 awaiting completion of a management plan. During August 1990, the lease for Society Hall was transferred to the Belize Audubon Society. Cockscomb Basin Wildlife Sanctuary was expanded thirtyfold to 102 444 acres (41 457 ha) by SI 127 in November 1990. A completely new reserve was designated in April 1991 by SI 56: Five Blues Lake National Park in Cayo District resulted from local lobbying to protect an attractive and unusual deep karst lagoon, intended by the local villagers of St Margaret's to support community-based ecotourism. In August 1990, the moratorium on commercial hunting of several species of wildlife was extended until 1992.

Investigations to identify new reserves have been repeatedly carried out over a long period, started by Waight (unpublished) and continued by Deshler (1978), Hartshorn *et al.* (1984), and Miller (1990). A forum was held in the late 1980s to generate a List of Priority Areas for protection.

The Belize Audubon Society now has a full-time Wildlands Officer and Protected Areas Commission (a subcommittee attended by various governmental and NGO representatives), and the Forestry Department has a Conservation Division. These bodies combined are the appropriate authorities to investigate additional protected areas, in addition to the Fisheries Department for Marine Reserves and the Archaeology Department for Archaeological Reserves.

The current focus for new designations is on four sites: the Maya Mountains, the Maya Mountains/Deep River/Port Honduras corridor, the barrier reef, and the Northern and Southern lagoons. For all four, the emphasis has shifted away from nature conservation in isolation towards some form of multiple-use designation.

The Maya Mountains are being assessed in terms of suitability for Biosphere Reserve designation by the Belize Audubon Society, and under the forthcoming USAID-backed sector of the TFAP. There are two schools of thought among the conservationists: either that further designation would achieve no more than provision of the existing protected areas, or that biosphere reserve status would encourage integrated multiple use of forestry, nature conservation, archaeology and ecotourism. Preliminary appropriate biosphere reserve zoning is being investigated following requests from the Minister of Natural Resources.

A second biosphere reserve project is being promoted through the Proyecto Ambiental Para Centro America (PACA) Programme, jointly funded by The Nature Conservancy, Co-operative for American Relief Everywhere and Conservation International. It aims to target an environmental site in each Central American country for biosphere reserve designation. It is a multiple-use approach, aimed over a five-year period. After initial consultations between the PACA team and local conservationists, the most appropriate site in Belize is considered to be the Port Honduras/Deep River/Maya Mountains corridor.

The third most recent project is for the establishment of a Belize Barrier Reef Conservation Area. Funding for this is being pursued through the Global Environmental Facility, administered by the UNDP. This project is a joint initiative, under the ministries of Tourism and Environment, Agriculture and Fisheries, and Natural Resources. It aims to bring the management of the barrier reef and coastal wetlands under one co-ordinated programme, and again the biosphere reserve concept has been raised as potentially suitable.

Northern and Southern lagoons

The fourth area for consideration is the Northern and Southern lagoons. Southern or Manatee Lagoon was recommended for National Park designation in 1968 by the National Parks Study Group and FAO (Deshler, 1978). Munro (1983) and Hartshorn *et al.* (1984) discussed further the area considered appropriate for designation. Northern Lagoon already contains two bird sanctuaries (Bird Cay and an unnamed mangrove cay) designated in 1977 under the Crown Lands Ordinance. The area meets a number of criteria which make it highly suitable for designation, including a high population of manatee (*Trichecus manatus*) and use by local Belizeans for recreation. The village of Gales Point is also promoting a community-based ecotourism venture which depends on the maintenance of the ecological integrity of the lagoons and Manatee River in particular.

The standard agricultural practice of clearing down to river-banks (contrary to lease conditions) leads to greater bank erosion. If this takes place along the rivers feeding Manateee Lagoon, there will be higher suspended sediment loads, which will reduce light penetration through the water column, leading to lowering photosynthetic energy available to algae and benthic vegetation. The other major concern related to agricultural development is the risk of contamination by agricultural chemicals (pesticides and fertilizers) and sewage contamination from a growing rural population.

Runoff from farm lands that leach out pesticides, or the improper use of pesticides, e.g. washing out knapsack sprayers after use in the river (as has been reported elsewhere in Belize), will lead to some contamination of river and lagoon waters with a low flushing capacity. The implications relate to both public health and wildlife protection. Toxins are absorbed by algae at the bottom of the food chain and become concentrated in higher levels as small fish eat algae and larger fish eat numerous small fish etc. This process, known as bio-accumulation, can build up the level of toxins to concentrations which may have significant physiological or behavioural effects. People eating fish might become affected and pisciverous species, notably Morelet's and American crocodiles (*Crocodylus moreleti* and *C. acutus* respectively), are vulnerable. It is unlikely however that, in the short term, pesticide use would be sufficient to lead to such problems although, in the long term, this somewhat 'invisible' problem may appear.

The last agriculturally related risk is enrichment (eutrophication) of Southern Lagoon by fertilizer, runoff and sewage effluent. This will produce better growing conditions in the water column for algae, which in turn reduces oxygen availability for other species and clouds the water, cutting down light penetration.

While the general environmental concerns relating to agricultural development of the Manatee Watershed are clear, there is insufficient site-specific information to develop detailed practical management guidelines. It is therefore recommended that an environmental specialist with experience of the effects of agricultural pollution on subtropical brackish lagoons and nearshore environments, with special reference to manatees, should be commissioned as soon as possible. Environmental protection agencies in Florida are the obvious source of such expertise.

The most immediate pragmatic way of minimizing the risk from erosion or agricultural runoff however, is to enforce the lease conditions which specify a 66-ft (20-m) riparian corridor on both river-banks. This will immediately minimize the risk of accelerated erosion, providing underbrushing is minimized and fire control is used to prevent any damage to the remaining forest belt.

Forest reserves

The criteria used for the selection of existing forest reserves were national lands unsuitable for agriculture, land more profitably used for forestry than any other use, watershed protection, regulation of streamflow, erosion control, stabilization of climate, areas required for local fuelwood or timber production, and suitable as nature reserves (ODA, 1989). Land suitable for agriculture was however included in a number of forest reserves because, to some extent, early forest reserve designation was also seen as an interim designation in which to put national land before it was needed for other developments. A forest reserve review is therefore necessary and is being initiated under Belize's TFAP. Its urgency arises from accelerating unregulated leasing of land within forest reserves.

There is increasing uncertainty about the extent of existing forest reserves, because a high proportion of leasing approved at ministerial level has not yet been fully documented. At the time of writing, dereservations had not been published for about 18 months. The current status of each forest reserve updated from the TFAP (ODA, 1989) is given in Appendix 19. Table 28 summarizes the current information on their extent.

Archaeological reserves

The Department of Archaeology oversees the designation of archaeological reserves. Twelve have been designated at the time of writing, 10 of which are open to the public (J. Morris, 1991, personal communication). The aim is to provide a wide variety of accessible reserves spread across Belize. All but one of the sites covers the actual structure only, and most sites are surrounded by private lands. Lamanai is the exception: a reserve of 1100 acres (450 ha) including Maya structures, two colonial churches, a sugar mill, forest, and lagoon shoreline. This site already plays a threefold role in archaeological protection, tourism, and nature conservation, showing how effectively multiple use can be integrated.

Table 28 Current official and actual extent of forest reserves

Forest reserve	Official area (km^2)	Actual area (km^2)	Notes
Columbia River	417	?	Minor encroachment, including from Guatemala
Commerce Bight	32	?	Possible granting of leases
Deep River	491	?	4 km^2 been leased out and other settlement taking place
Freshwater Creek	296	?	Possible granting of leases
Grant's Work A	31	?	20 ha lease let in 1990/91
Grant's Work B	14	0	Unofficially dereserved in 1990
Machaca Creek	24	?	Forestry Department estimates 23 km^2 remained in 1989. Other leases thought to have been given out since
Manatee	458	?	About to be dereserved in part in late 1991/2, with encroachment already under way
Mango Creek	232	?	A Forestry Department estimate for 1989 puts the remaining forest area at 144 km^2 after unofficial excision for agriculture. Additional leases are uncertain
Maya Mountains	933	933	Probably no change
Mountain Pine Ridge	515	511	Small excision for agriculture, plus fire damage started by military in 1991 and previously
Sibun	430	430	Minor encroachment along Hummingbird Highway
Silk Grass	26	?	Some unofficial leasing suspected, to the extent that the majority of the reserve has gone
Sittee	379	379	Thought to be intact

Part 5

Dynamic mapping - role of GIS

INTRODUCTION

Although maps are the only effective way of representing spatial information, there are various problems with putting all the data on a 'final' map. Principal among them are cost, boundary belief, data portrayal limitation and inbuilt anachronism. All of these problems have been encountered during the NRI surveys, emphasized not altogether disadvantageously by the sequential nature of the surveys. Most of them can be overcome with a Geographical Information System (GIS) whereby all the data are stored in a computer, which can be updated at any time, and from which maps can be produced cheaply - after the initial installation cost - although a printing press will still be needed to produce maps in bulk.

MAP UPDATING

All thematic maps are approximations because they are based on extrapolation from limited sampling. The average density of soil observation points for the NRI surveys was one/4 mile^2 (/11 km^2), but irregularly distributed because of access difficulties. The land system and subunit boundaries are extrapolated from these sample sites using field observation during travel to soil observation points, geological maps, which are themselves only approximations, and remote sensing imagery comprising aerial photography and satellite imagery. Landform- and vegetation-defined land systems and subunits can usually be defined reasonably clearly from stereoscopic examination of aerial photography and colour discrimination of the satellite imagery, but soil-defined boundaries are based on the assumption that the soils are associated with particular rock types (as indicated by the geological maps and remote sensing imagery), landforms and vegetation types. Sometimes landforms cannot be discriminated beneath the forest cover, e.g. the Toledo Floodplains subunits along the Swasey and Bladen branches; and sometimes soil observations cannot be correlated with the geological map or remote sensing imagery, and the land system or subunit boundaries can only be presumed, e.g. the Louisville and Jobo plain boundaries east of Orange Walk. It must also be remembered that the mapping scale is only 1:100 000 and therefore does not provide the detail expected of larger scales.

We estimate the maps are 80-90% accurate. As new surveys are undertaken, map errors are noted and field observation made, the maps will need updating, which is easily accomplished on a GIS. All the land system and land-use maps compiled during the NRI surveys, have been put onto the NRI GIS; the data will be transferred to Belize as soon as a GIS is installed in Belize. The land-use data can be updated from satellite imagery.

DATA PRESENTATION

Thematic maps are limited by the amount of data that can be presented. We would like to have produced additional maps showing the land suitability for each crop separately, coloured according to suitability value. Then the areas suitable for citrus, for example, can be seen at a glance (in one particular colour) instead of having to read down the citrus column in the key. Some experimental separate crop suitability maps of the Toledo survey have already been produced by Edinburgh University and well received, although the presentation of mixed suitability designations (e.g. S1>S3 or S2-N1) have not yet been satisfactorily resolved. Mixed designations should ideally be indicated by mixed colour presentation, so that S1>S3 would appear as green for S1 say with a thin yellow stripe (for S3 say); S1-N2 would appear as equal width stripes representing S1 and N2. Current output devices do not appear to be capable of making this presentation, so the last experiments used both shading and colours to indicate the suitability class: S1>S3 was given the S1 colour but S3 shading, S2-N1 was given both shadings (representing S2 and N1) with the higher class colour to give an optimistic impression, or the lower class colour to give a pessimistic impression! Superimposition of both colours did not seem to work.

Overlaying land-use maps on to the land system maps would show how much agriculturally potential land is still available which has not already been used. This can easily be done on the GIS, but will need updating by digitizing the land-use mapping in progress in the Ministry of Natural Resources at the time of writing, and using satellite imagery for future years. The 1979 1:250 000 scale land tenure map has also been digitized, so that areas with agricultural potential on national land and in forest reserves can be portrayed.

Land suitability criteria were initially determined by the soil specialists on the team. A meeting was then held with local agricultural officers, at which the suitability of each soil type for a range of crops was considered. The land resources specialist compiled this information into a subunit format, although the specific soil suitability also appears in the reports.

There are two limitations to this procedure: one is the necessary limit to the range of crops that can be considered; the other is the lack of information on which to base some suitability judgements. At the time of the NRI surveys, it is based on the best specialist and local experience available. Subsequent agricultural information, provided for example by the performance of a new crop on an as yet untried soil, could result in reassessment of the suitability rating.

This latter aspect of the land evaluation has been addressed in the current project by giving values to all the basic information which is either explicitly or implicitly used to generate land suitability values. By this means, it is hoped land suitability maps for any crop can be produced by specifying the criteria needed to grow the crop and putting that information into the GIS. Changing economic circumstances could force additional constraints or release them, and new land suitability maps could be produced, based on these changed criteria.

LAND QUALITY CLASSIFICATION

The subunits have each been classified according to a range of basic land qualities or limitations. Where applicable, zero values are given to the class that is least limiting to agricultural development, and the highest value to the class that is most limiting. The class values for each land quality for each subunit have been entered into the GIS.

The class ranges were decided according to what appeared significant, based on either the surveys' or wider experience, with a bias towards overclassification because it is much easier to group previously defined classes than define new ones by subdividing old ones. The classification is intended to initiate a working base for map production on demand. More suitable classifications will probably emerge once the system is tested. The land qualities considered are as follows:

General access
Access to sea (for shrimp mariculture)
Access to citrus processing factory
Access to sugar processing factory
Size of manageable unit
Air temperature
Rainfall
Water availability

Flooding risk
Wetness
Moisture availability
Salinity
Pollution risk
Soil degradation hazard
Erosion risk
Rooting conditions
Soil workability
Mechanization potential
Nutrients.

In addition both the Ministry of Agriculture and Fisheries' preferred five-class agricultural valuation and the Ministry of Natural Resources' three-class agricultural valuation have been entered into the GIS. These values could well be changed according to economic circumstances. A rough four-class conservation value has been included, based on areas that need protection because of steep slopes, are already recommended for conservation, or have an obvious biodiversity, i.e. recognizable on remote sensing imagery, such as the Glady and Backshore land system types. They are often signified as a minority value, e.g. 3>1, to indicate that most of the unit has only a marginal conservation value, but parts should be preserved for biodiversity.

General access

Three classes are assigned:

0 - easily accessible
1 - currently rather inaccessible but could fairly easily be made accessible
2 - likely to remain inaccessible for some time

Access to sea

Access to sea is currently seen as applicable only to shrimp mariculture. It has only two classes: accessible (0) or inaccessible (1) based on what appears to be a reasonable distance from the sea, i.e. less than 1 mile (2 km). A coastal corridor could also be demarcated by the GIS.

Access to citrus processing factory

Two classes - accessible (0) and inaccessible (1) - have been assigned to access to a citrus processing factory, based on areas that currently appear to be accessible, including northern Cayo District and most of Toledo District but excluding areas north of the Belize Valley.

Access to sugar processing factory

Two classes - accessible (0) and inaccessible (1) - are defined for access to a sugar processing factory. Accessible areas are north-eastern Orange Walk District (north of Indian Church), Corozal District and Belize District north of the Belize Valley.

Size of manageable unit

Four sizes of manageable unit are defined:

0 - greater than 300 acres (120 ha) - most economical size
1 - 50 to 300 acres (20 to 120 ha) - 50 acres minimal size for banana plantation and typical maximum size of smallholder unit
2 - 5 to 50 acres (2 to 20 ha) - 5 acres minimal size for sugar-cane
3 - less than 5 acres (2 ha)

Air temperature

Air temperature is related to altitude. Much of the Maya Mountains and Western Uplands are above 400 m, whereas the highest parts tend to be above 800 m. Three classes are defined to represent these altitude ranges:

0 - <400 m
1 - 400-800 m
2 - >800 m

Rainfall

The sparse distribution of rainfall stations, the interannual variability and the quite wide range of crop tolerance oppose any attempt at exact isohyet assessment. Instead the land regions are taken as rainfall classes. They are considered significantly different enough for most crop assessment:

0 - Maya Mountains
1 - Toledo Foothills, Southern Coastal Plain
2 - Central Coastal Plain, Eastern Foothills
3 - Western Uplands
4 - Central Foothills, Northern Coastal Plain, Bravo Hills

Water availability

Five classes are assigned:

0 - very high
1 - high
2 - moderate
3 - low
4 - very low

Flooding risk

Sixteen classes of flooding risk have been assessed - which is probably too excessive - but at this stage, it was decided there was no point in amalgamating them until the system has been tested. The classes are:

0 - no flooding risk
1 - exceptional flooding risk - about every 1000 years: alluvial wash, terrace and dissected terrace subunits, excluding the dissected terrace in the Stann Creek Valley which is a remnant of the old course of the North Stann Creek
2 - high floodplain bench with a flooding risk of about every 20 years. Strand plain bars are also included in this class
3 - high floodplain bench backland
4 - flooding every few years: flat, pitted, low and braided plains of the Pine land system type
5 - flooding annually or every few years, but greater inundation than class 4: floodplain, low floodplain bench and high tidal flat
6 - low floodplain bench backland
7 - low floodplain bench backswamp, redeposited old alluvial wash
8 - swamp or marsh forest plain
9 - glady forest plain, Corozal Swamps
10 - savanna plain subunit
11 - clumped tree savanna subunit
12 - tree savanna subunit, saline plain
13 - savanna subunit
14 - herbaceous swamp, strand plain swale, very poorly drained basin subunit
15 - swamp, mangrove, swamp with mangrove

Wetness

Eight wetness classes have been assigned, based mainly on a comparative analysis of the inherent soil drainage of all the different soil subsuites, as indicated by how the effect of poor drainage affects the growing of cacao, citrus and pasture:

0 - well drained
1 - moderately well drained
2 - moderately well to imperfectly drained
3 - imperfectly drained
4 - poorly drained
5 - very poorly drained, wet for long periods
6 - very poorly drained, wet for most of wet season
7 - permanently wet

Moisture availability

Twelve moisture availability classes were defined, based mainly on a comparative analysis of how this limitation affects all the different soil subsuites for growing cacao, citrus and pasture:

0 - no moisture availability limitation
1 - free drainage preventing the occasional crop from being highly suitable
2 - deep granitic sandy loam to sandy clay
3 - stony sandy clay loam
4 - stony sand to stony sandy loam
5 - loamy sand or variably shallow and droughty
6 - rather droughty coarse sand or very stony soil
7 - deep granitic sand
8 - free to excessively drained sand
9 - variably shallow soil preventing most crop growth
10 - deep raw sand with excessive permeability
11 - soils so shallow and droughty that most crops are totally unsuitable

Salinity

A salinity scale was devised according to likely extent of saline soils:

0 - no saline soils
1 - glady land system type or subunit (H)
2 - backshore land system type (N)
3 - saline plain (sl subunit)
4 - tree savanna subunit (ts) of Corozal Saline Swamps land system or swamp with mangrove subunit of Hondo Swamps land system
5 - savanna (ss) or swamp subunits of Corozal Saline Swamps land system
6 - low tidal flat subunit of the TY land system

Pollution risk

Pollution risk was arbitrarily assessed in three classes, mainly according to whether a subunit was likely to be downstream or downslope from fertilizer or herbicide application, now or in the near future:

0 - low risk
1 - medium risk
2 - high risk

Soil degradation hazard

Three soil degradation hazard classes were recognized, based on the likelihood of capping, due mostly to over-exposure of bare soils to raindrop impact and excessive wheeling:

0 - none
1 - moderate
2 - severe

Erosion risk

Erosion risk depends upon both slope and rock type. A classification has therefore been assigned to each, and erosion risk can be considered a combination of the two (see Part 4):

Slope

0 - less than 1°: plain subunit
1 - 1 to 5°: undulating plain
2 - 5 to 25°: rolling plain
3 - 5 to 25°: local relief greater than 30 m: hills
4 - 25 to 35°: steep slopes
5 - greater than or equal to 30°: karst subunit

Rock type

0 - recent alluvium
1 - old alluvium
2 - Toledo Beds
3 - limestone
4 - metasediments
5 - granite

Rooting conditions

Eight rooting condition classes have been assigned, based mainly on a comparative analysis of how this limitation affects all the different soil subsuites for growing cacao, citrus and pasture:

0 - no impedance to rooting
1 - firm to compact soil
2 - less than 50 cm to bedrock (shallow)
3 - very stony
4 - shallow and very stony or compact subsoil
5 - 25 to 50 cm to bedrock
6 - 10 to 25 cm to bedrock, or extremely compact soil at a depth of less than 60 cm
7 - surface gravel to bedrock or ferricrete at surface

Soil workability

Eleven classes of soil workability were assigned, based on an assessment of how it had been considered as a limitation in the crop suitability assessments, and on the degree of soil compaction and wetness:

0 - easily workable
1 - rather compact
2 - imperfect drainage
3 - poor drainage
4 - variably shallow
5 - stony soil or compact
6 - very stony soil
7 - 25 to 50 cm to bedrock (very shallow)
8 - very stony and very shallow
9 - stony, very shallow and imperfect drainage; or very compact
10 - swamp

Mechanization potential

Six mechanization potential classes have been assigned:

0 - no limitation to mechanization
1 - rolling plain
2 - swampy
3 - rocky
4 - steep slopes
5 - rock

Nutrients

Nutrient information is provided by the soil analyses. Based mainly on criteria suggested by Young (1976), Landon (1984) and Land Resources Department (LRD) and Bina Program (1989), the following indicators were chosen to represent nutrient status: topsoil and subsoil cation exchange capacity (CEC), and topsoil total nitrogen, available phosphorus, total phosphorus, exchangeable potassium and pH. Agriculturists may wish to add others more applicable to their concern. The data are available in the soil analyses, and can be entered into the GIS. The assigned classes are:

Topsoil and subsoil CEC (me/100 g)

0 - more than 40
1 - 25 to 40
2 - 17 to 24
3 - 5 to 16
4 - less than 5

Total nitrogen (%)

0 - more than 0.2
1 - 0.1 to 0.2
2 - less than 0.1

Available phosphorus (ppm) (Bray for acid soils, Olsen for alkaline)

0 - more than 40
1 - 30 to 40
2 - 26 to 30
3 - 16 to 25
4 - 10 to 15
5 - 8 to 9
6 - 5 to 7
7 - less than 4

Total phosphorus (ppm) (Perchloric acid extract)

0 - more than 1000
1 - 200 to 1000
2 - 60 to 200
3 - 41 to 60
4 - 21 to 40
5 - 10 to 20
6 - less than 10

Exchangeable potassium (me/100 g)

0 - more than 1.0
1 - 0.6 to 1.0
2 - 0.4 to 0.6
3 - 0.2 to 0.4
4 - 0.1 to 0.2
5 - less than 0.1

pH (1:5 1M KCl)

0	-	greater than 8.5
1	-	8.1 to 8.5
2	-	7.6 to 8.0
3	-	7.1 to 7.5
4	-	6.6 to 7.0
5	-	6.1 to 6.5
6	-	5.6 to 6.0
7	-	5.1 to 5.5
8	-	4.6 to 5.0
9	-	4.0 to 4.5
10	-	less than 4.0

Part 6

Recommended use of the landscape

LAND POTENTIAL

Belize has 380 mile^2 (990 km^2), 4% of the total land area in the country, with an agricultural value of 1, i.e. having high to very high income potential. It does not compare with the fertile alluvial and volcanic soils of Asia, or even with some of the more fertile soils elsewhere in Central America, but it includes the floodplain soils of the major Belizean rivers which, although generally acid, respond well to fertilizers. Most of this land is already under cultivation: mainly citrus and lately bananas. It is suitable for most crops.

The Toledo Uplands are also included in this category, although even their fertility and physical workability cannot support overuse of the milpa cultivation system. As indicated in Part 2, investigations are under way to initiate a cash crop economy.

Belize also has 1080 mile^2 (2790 km^2),12% of the country, of second-class agricultural land: land which has a good chance of financial success. It includes most of the undulating and flat but well drained land of limestone, mainly on the Northern Coastal Plain and includes the land under sugar-cane in Corozal and Orange Walk Districts. This land is mostly suitable for arable, pasture and sugar-cane. Fertility is generally high, but citrus should be avoided because of the risk of lime chlorosis and droughtiness.

Some 1370 mile^2 (4480 km^2), 20% of the country, of class 3 agricultural land have a moderate chance of financial success with good management, but are unlikely to provide an economic return under poor management. Most of this land is also on limestone but includes the better, but still imperfectly, drained land in Toledo District on the Southern Coastal Plain. Poor drainage is one of the main problems for much of this land, but some of the limestone soils in the north suffer from moisture deficiency. Some of this land is also difficult to work because of compaction or shallow depth to bedrock.

The chances of making a living on another fifth of the country 1800 mile^2 (4670 km^2) are only marginal (class 4) even with skilled management and high inputs. Most of this land has similar, but more extreme, problems to those in class 3, i.e. really poorly drained, shallow or droughty.

Unfortunately the largest area of land 3876 mile^2 (10 040 km^2), 44% of the country, is rated as having an extremely small chance of financial success (class 5). It is mostly the steep slopes of the Maya Mountains and limestone karst.

MARKET POTENTIAL

Crops are needed both to feed the nation and bring in cash income. Not many crops need to be grown to sustain a population of only 191 000, and the country is mainly self-sufficient in basic meat and vegetables, although food is still imported. Mechanized rice production (to avoid rice imports) in the high rainfall area of Toledo District has not proved successful. Mechanized rice production in the drier north of the country may prove more successful.

Our economic analysis in Part 3 indicated sugar-cane gives one of the highest rates of return, but the market is saturated. Sugar-cane cultivation should therefore continue but not expand.

Citrus is the most popular recent crop, encouraging large numbers of people to obtain land. If the whole country became a citrus estate, the quantity produced would not be sufficient to affect the international market; but both the people and the country's economy will be extremely vulnerable if too much reliance is placed on one crop. It is nevertheless clearly one of the crops that should be produced for export, but not on marginal and worse land, and limestone soils should be avoided.

As indicated in our Stann Creek report, the climate is not ideal for bananas. There are always likely to be problems with cold weather and disease, and there is already talk of diversification within the banana industry. The industry should be maintained, but not expanded, until the economics of production can be proved to withstand the effects of chilling and disease.

Cacao is well suited to Belizean conditions, as might be expected for a plant that grows in the wild. Unfortunately its price has steadily declined over the last 15 years, but there are signs that it may be bottoming out. It is therefore a gambler's crop. If land and inputs can be afforded, it should be grown in the hope that the market will pick up.

Some of the deeper sands are suited to cashew production which could be developed.

The lack of apparent official export opportunities for cattle discourage expansion of the cattle industry.

The general conclusion must be that the country should not concentrate too much on one crop. Diversification is essential to avoid disruption of the country's and people's economy.

Our recommended land-use map (Map 1) avoids recommending particular crops on the best soils. Instead, the general agricultural quality of the land is indicated and only where land qualities are limiting is particular land use sometimes indicated.

FUTURE POTENTIAL

The 10% of the country on agricultural class 1 and 2 land is, will and should be mostly used for growing food and cash crops, albeit taking care to maintain productivity and not to impinge adversely on neighbouring, downslope and downstream lands, water and people, as outlined in Part 4.

The large area of class 5 land should remain under protection forest, but this should not be considered a wasted asset. Where steep slopes occur among agricultural land and communities, the forest will protect the slopes from erosion so that agricultural land and communities are not put at risk from landslides and mudslides, and water reserves are protected both to maintain supply and prevent flooding.

Where steep slopes occur in large but more remote areas, such as in the Maya Mountains, the protection forest is again important to regulate water flow and erosion, and provide a healthy environment for agriculture, tourism and forestry.

This report has not discussed forestry because it was written before the Forest Planning and Management Project. The most rational use of the class 4 land however is forest management and production.

We are left with the 20% of class 3 land, some of which is already under smallholder cultivation, some in Toledo District under citrus or bananas, and some areas are proposed for development by smallholders or Mennonites, but most is still under forest (including land held by Programme for Belize). Some of this land should be made available for smallholder agriculture as the need arises. Otherwise its most profitable use is probably forest management and production. Some of the land would be suitable for cashew (as indicated on Map 1), if and when the cashew market is established.

Having considered how the national resources could be used generally, we now look at those resources in more detail at a district level by referring to Map 1, which indicates how land should be conserved or developed. This is not intended to be a definitive map. The forest estate will be planned under the Forest Planning and Management Project. The designation of critical habitats for protection forms part of the Natural Resources Management Project.

COROZAL DISTRICT

Figure 5 shows Corozal District has the largest rural population (21 332). Between 1960 and 1980 it had the greatest rural population growth rate of any district. It also has the greatest rural population density at 28 people/mile^2 (11/km^2). The people are mostly concentrated in the sugar-growing area in the north-west.

Most of the class 2 agricultural land (there is no class 1 land) is already under sugar cultivation. A small area in the extreme north-west is still available according to a satellite image dated 20 November 1990, but also according to that image, most of the land north of Sapote Lagoon is disappearing under sugar-cane: about a third of the land that was uncultivated at the time of the 1987 satellite image is now under sugar-cane. Part 3 of this report has already indicated that the market will not take further expansion of the sugar industry.

The largest area of unused land is the plain subunit in the Xaibe Plain land system which is rated 2-3 in agricultural value depending on soil depth. It could be developed for smallholder cultivation and, once papaya production is established, it could become a cash crop for the area. The coastal belt could possibly be developed for ecotourism (see 'Belize District 'section).

ORANGE WALK DISTRICT

Orange Walk District had the largest rural population in 1970. It is now just in third place after Cayo, but it does have the second highest rural population density at 10 people/mile^2 (four/km^2), nevertheless still less than half Corozal.

Most of the class 2 agricultural land suitable for sugar-cane, is already under sugar-cane in the northern part of the district. The available national land in the north-eastern part of the district, east of Orange Walk town, has a very patchy potential. Most of it is class 4 with very marginal potential. The open savanna land is best left as a national park. There are a few patches of land suitable for smallholder agriculture, but it would make more sense to use the rather better land over the border in Corozal District.

Most of the rest of the district is privately owned, of which 152 000 acres (61 500 ha) is in the Rio Bravo Conservation Management Area. The land north of 'Rio Bravo' has mainly very stony soils, and is mostly suitable only for pasture, as currently used. The low marsh forest plain in the Blue Creek Plain in the extreme north-west might be suitable for growing rice. The land to the south and east of 'Rio Bravo' is class 2-3 agricultural land and, if required, could be developed for agriculture. Otherwise, it is best left as forest management and production.

The crest of the Pine Ridge land between New River Lagoon and Western and Revenge Lagoons, and west of Ramgoat Creek, has deep sand which could be used for growing cashew. The rest of the Pine Ridge should be kept under pine management.

BELIZE DISTRICT

Belize District has the lowest rural population density in the country at eight people/mile^2 (three/km^2). After growing as fast as the northern districts, its rate of population growth declined shortly after 1970, according to the census figures. Hartshorn *et al.* (1984), using unpublished data by W. Davidson, indicate movement after 1970 from the northern part of the district to Belize City, and from the southern part of the district to the United States of America - apparently, due to the economic downturn, particularly disbanding of pine logging, following Hurricane Hattie (C. Rich, 1992, personal communication). It may also be due to a change in urban and rural definitions. Nevertheless, it is clear the district has a low population density, with good reason.

The northern part of the district (north of the Belize class River) is 4-5 class agricultural land. There are old coconut plantations along the Old Northern Highway, which have mostly been smothered by forest regrowth, and there is some agricultural development in the north-east, including pineapples at Corazalito. Maize and vegetables are also grown, most of which are sold to Belize City. Significantly, there is very little development along the New Northern Highway, which is mostly through pine savanna. The development there is mainly for commuting to Belize City.

There is however some tourism potential, mainly associated with the archaeological site at Altun Ha (see Appendix 16). As indicated by Map 1, most of the area north of the Belize River and east of the Revenge and Northern lagoons is recommended for development as a combination of smallholder agriculture and ecotourism.

Crooked Tree Island and the area between Revenge Lagoon and Bight Swamp are suitable cashew growing areas, but the latter area has been developed for Florida-stye residences. The pine savanna north-west of the Belize River should be kept under pine management, but the broadleaf forest area along Spanish Creek could be developed for smallholder agriculture with rice as a possible cash crop.

There appears to be some land between Mussel Creek and the Belize River which is above the level of annual flooding, looks like good agricultural land, and is being cultivated near Sebastian Bridge and further south at Big Falls. Much of the Lower Belize Floodplains seems mostly suitable for pasture or rice.

The Community Baboon Sanctuary is in the Lower Belize Floodplains, and Mussel Creek has been suggested as a wildlife sanctuary (Hartshorn *et al.*, 1984) and as an extension to the baboon sanctuary (Parks and Reserves Planning Workshop, 1987). Most of the rest of the land between the Sibun and Belize floodplains is unsuitable for agriculture, and could all be considered a national park. The Almond Hill Pine Ridge could be used for urban development. The Sibun Floodplain itself has some good agricultural land.

Much of the land south of the Sibun River has recently become accessible from the Manatee Road connecting the Western Highway with Dangriga. Most of it, particularly in the south-western part of the district, lies in a karst land system type (Hummingbird Plain with Hills land system) but a quarter of the land system lies on flat alluvial plain, containing both good recent and poor old alluvium. It is best suited to smallholder farmers who can pick out the best parts.

Most of the rest of the land south of the Sibun River is unsuited to agriculture. The Northern and Southern lagoons contain a diversity of fauna, including "the largest known manatee breeding ground in the entire Caribbean basin" (Miller, 1990), and the lagoons are increasingly visited by tourists. The pine ridge also contains some interesting geomorphological features: limestone hums surrounded by moats caused by the interaction between acid pine ridge soils and the limestone. Much of this area is therefore recommended as a national park.

CAYO DISTRICT

Cayo District has a rural population density of only 10 people/mile² (four/km²), but the whole population is concentrated in the north. If the sparsely populated Western Uplands and Maya Mountains land regions are excluded, the rural population density becomes 21 people/mile² (eight /km²) - twice that of Orange Walk, but not as high as Corozal. However Figure 5 demonstrates that over the last 11 years, the population has been rising faster in Cayo District than in any other district, presumably mainly due to the influx of refugees.

There still appears to be some good unused agricultural land in the Lower Belize Floodplains in the north-east of the district, although it is almost entirely private land. There are smallholder settlement schemes for the north-western part of the district, much of which is class 2 agricultural land, but some is only class 3.

The best land in the Upper Belize Floodplains is already under cultivation, as is much of the class 3 land west of San Ignacio. Some of the land among the karst hills south of the Western Highway is class 2, but the karst hillslopes should be protected. Most of this land is however already under cultivation - mainly only the inaccessible parts remaining. The undulating plain north of the Central Foothills east of Belmopan is mainly class 2, but east of Cotton Tree, it is only really suitable for pasture.

Most of the good agricultural land in the Cayo Floodplains land system is under cultivation or pasture. Those parts not already cultivated need a soil survey before allocating land, because it has a very variable quality ranging from class 1 to class 5. The worst land should be put under pine management or plantation. As with Belize District, the Hummingbird Plain with Hills land system, mostly east of Dry Creek, is best suited to smallholder agriculture.

Much of the south-eastern part of the district, comprising the Richardson Peak Mountains land system, should be left under protection forest. Most of the Western Uplands should also be left under protection forest, leaving the Mountain Pine Plateau to mainly pine management, and the more gentle slopes of the south-eastern part of the Western Uplands to broadleaf forest management and possibly production.

STANN CREEK DISTRICT

Stann Creek District has a rural population density of 10 people/mile^2 (four /km^2) - about the same as Orange Walk - but as with Cayo, much of the land (about half) is occupied by the Maya Mountains which should be left under protection forest. The rural population density on the Coastal Plain and Eastern Foothills is 26 people/mile^2 (10/km^2) which is nearly as dense as Corozal District, with the highest rural population density.

Stann Creek District has both some of the best and worst soils in the country. The best soils are in the Stann Creek Coastal and Toledo floodplains and Stann Creek Valley land systems. There is still some land available in the coastal floodplains, but not much.

Foreign investors have started citrus plantations on the very poor 'pine ridge' soils of the Puletan Plain land system in the south of the district - attracted by the low initial capitalization costs of not having to clear forest. However, this land is only suitable for pine management. There should be no further agricultural development of this land, except possibly for mangoes. Although much of the rest of the pine savanna is not as bad as the Puletan Plain in the south, it is very unlikely that it would be profitable for growing citrus, or any other agricultural enterprise, and should also be left under pine management. Of the areas with 'broken ridge' vegetation (transitional low broadleaf forest), only the undulating plain south of the North Stann Creek Valley seems at all suitable for citrus (moderately to marginally suitable). It is indicated as class 3 agricultural land on Map 1.

There are a few small patches of land highly suitable for cashew - too small to show on Map 1 - but are indicated as the Matamore Strand Plain land system in the Stann Creek District report. The broken ridge land referred to above is also best suited to cashew.

The recommendations for the foothills have been discussed in Part 2 mainly in the 'Land systems on granite' section of the 'Hills Land Regions'; the Stann Creek Valley is discussed under 'Land systems on recent alluvium' section of the 'Hills Land Regions'. One point should be emphasized again here: the Middle Swasey Basin should be reserved for the local smallholders in that area to give them a chance to develop a sustainable agricultural system which includes cash crops.

TOLEDO DISTRICT

Toledo District has a rural population density of eight people/mile^2 (three/km^2) - about the same as Belize District - but, whereas the rate of growth of the rural population of Belize District has declined over the last 20 years, the rate of growth of the rural population of Toledo District is steadily increasing.

The Maya Mountains and steep limestone hills in the north-west of the district should be left under forest protection. The pine savanna in the north-east of the district should be left under pine management, but the floodplains of the Bladen and Swasey branches, demarcated by the broadleaf forest, are good agricultural land that could be developed. The area of alluvial fans (Governor Plain land system), where the Swasey and Bladen and their tributaries first debouch on to the coastal plain, is probably best put under pine plantation.

Miller (1990) has suggested the Deep River Forest Reserve "should be planned within the framework of the multiple-use biosphere model", partly because it would be the only example of forest reserve connecting the sea with the hinterland, and partly for protection of the Port Honduras cays. About half the reserve is on pine savanna, suitable only for pine management. Most of the rest of it is poorly drained land - only really suitable for management of indigenous forest or forest plantation; it could be put under protection forest.

Within the rest of the limestone terrain (i.e. Xpicilha Hills land system), the undulating, rolling, hilly and low and low medium karst subunits (V, R, H, LK and LMK respectively) are most suitable for smallholder agriculture. The steeper slopes should be protected.

The Toledo Uplands have already been discussed in Part 2. There is some hilly land still unused in the west but most of the unused land is too steep for sustainable development. Intensified but sustainable development is needed. On the coastal plain, the better drained parts (particularly the R and H subunits) of the Machaca Plain north of Punta Gorda, represent good agricultural land suitable for tree crops, but most of the rest of the plain (particularly the U subunit) is suitable only for some smallholder agriculture, together with forest management (and possibly production) of the more poorly drained parts (particularly the N subunit).

Mechanized lowland rice production has not proved economic on the Toledo Swamps land system, and it is suggested most of this land should be left under forest. The better drained parts could be used for pasture.

Most of the Temash Plain, south-west of the Punta Gorda, is imperfectly drained; it is suitable for indigenous forest management and possibly plantation. The moderately drained parts can be used for smallholder agriculture. The rivers traversing this southern part of Toledo District have tourist potential. The mangrove and swamp forest along the district coast should be preserved.

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Appendices

APPENDIX 1: ALPHABETICAL LISTING OF LAND SYSTEMS AS DESCRIBED IN PART 2

AB	Ambergris Strand Plain	COASTAL PLAINS	Land systems on recent alluvium
AI	North Ambergris Plain		Land systems on limestone
AN	West Ambergris Plain		Glady (H) and Backshore (N) land system types
BF	Lower Belize Floodplains		Land systems on recent alluvium
BH	Estevez Plain		Glady (H) and Backshore (N) land system types
BJ	Jobo Plain		Land systems on limestone
BK	Beaver Dam Plain		
BN	Maskall Plain		Glady (H) and Backshore (N) land system types
BP	Belize Plain		Land systems on old alluvium
BW	Belize swamps		Waterlogged land system type (W)
BX	Hummingbird Plain with Hills	HILLS LAND REGIONS	Land systems on limestone
BZ	Belize River Plain	COASTAL PLAINS	
CF	Cayo Floodplains	HILLS LAND REGIONS	Land systems on recent alluvium
CK	Belmopan Plain	COASTAL PLAINS	Land systems on limestone
CR	Copetilla Mountains	MAYA MOUNTAINS	Rugged land system type (R)
CX	Vaca Hills	HILLS LAND REGIONS	Land systems on limestone
CZ	Round Hole Plain	COASTAL PLAINS	
FP	San Felipe Plain		Land systems on old alluvium
HF	Spanish Creek Plain		Land systems on recent alluvium
HX	Wamil Plain with Hills	HILLS LAND REGIONS	Land systems on limestone
HZ	Hill Bank Plain	COASTAL PLAINS	
IF	Upper Belize Floodplains	COASTAL PLAINS	Land systems on recent alluvium
IK	Ramonal Hills	HILLS LAND REGIONS	Land systems on limestone
IZ	Hermitage Plain		
JI	Consejo Plain	COASTAL PLAINS	
KP	Crooked Tree Plain		Land systems on old alluvium
LK	Spanish Lookout Plain		Land systems on limestone
LW	Cadena Creek Plain		Waterlogged land system type (W)
LX	Pilar Camp Hills	HILLS LAND REGIONS	Land systems on limestone
MF	Maya Mountains Flood -plains	MAYA MOUNTAINS	Valley land systems
MP	Mountain Pine Plateau		Plateau land systems
NH	Blue Creek Plain	HILLS LAND REGIONS	Land systems on limestone
NK	Neustadt Plain		
NW	Neustadt Swamps		Land systems on recent alluvium
OA	Albion Island Plain with Hills		Land systems on limestone
OD	Neuendorf Escarpment		
OK	Shipyard Plain	COASTAL PLAINS	
OP	August Pine Plain		Land systems on old alluvium
OQ	Yalbac Dissected Cuesta	HILLS LAND REGIONS	Land systems on limestone
OW	Hondo Swamps	COASTAL PLAINS	Waterlogged land system type (W)
OX	Gallon Jug Plain with Hills	HILLS LAND REGIONS	Land systems on limestone
OZ	Lazaro Plain	COASTAL PLAINS	
QP	Tok Plain		Land systems on old alluvium
SB	Stann Creek Strand Plain		Land systems on recent alluvium
SF	Stann Creek Coastal Flood-plains	COASTAL PLAINS	Land systems on recent alluvium
SM	Matamore Strand Plain		
SO	Ossory Plain with Hills	HILLS LAND REGIONS	Ossory Plain with Hills (SO)
		MAYA MOUNTAINS	Valley land systems
SP	Stann Creek Coastal Plain	COASTAL PLAINS	Land systems on old alluvium
SS	Stopper Plain with Hills	HILLS LAND REGIONS	Land systems on granite (S)
SV	Stann Creek Valley		Land systems on recent alluvium
SW	Sibal Swamps	COASTAL PLAINS	Waterlogged land system type (W)
TB	Toledo Strand Plain		Land systems on recent alluvium
TC	Chiquibul Valleys	MAYA MOUNTAINS	Rugged land system type (R)
TE	Pesoro Plain	HILLS LAND REGIONS	Land systems on recent alluvium
TF	Toledo Floodplains	COASTAL PLAINS	
TG	Governor Plain		

TL	Palmasito Plain	MAYA MOUNTAINS	Plateau land systems
TM	Machaca Plain	COASTAL PLAINS	Land systems on Toledo Beds
TP	Puletan Plain		Land systems on old alluvium
TR	Richardson Peak Mountains	MAYA MOUNTAINS	Rugged land system type (R)
TS	Stopper Escarpment with Plain	HILLS LAND REGIONS	Land systems on granite
TT	Temash Plain	COASTAL PLAINS	Land systems on Toledo Beds
TU	Toledo Uplands	HILLS LAND REGIONS	Toledo Uplands (TU)
TW	Toledo Swamps	COASTAL PLAINS	Waterlogged land system type (W)
TX	Xpicilha Hills	HILLS LAND REGIONS	Land systems on limestone
TY	Saline Swamps	COASTAL PLAINS	Saline Swamps land system type (Y)
VF	Chiquibul Terraces	HILLS LAND REGIONS	Land systems on recent alluvium
VL	Chapayal Plateau	MAYA MOUNTAINS	Plateau land systems
ZH	Northern Bulkhead Plain	COASTAL PLAINS	Glady (H) and Backshore (N) land system types
ZI	Xaibe Plain		Land systems on limestone
ZN	Shipstern Plain		Glady (H) and Backshore (N) land system types
ZW	Corozal Swamps		Waterlogged land system type (W)
ZY	Corozal Saline Swamps		Saline Swamps land system type (Y)
ZZ	Louisville Plain		Land systems on limestone

APPENDIX 2: 1991 GROSS MARGIN ANALYSIS FOR DRYLAND RICE IN SOUTHERN TOLEDO DISTRICT

Establishment and maintenance (1 acre)

Operation	*Quantity*	*Rate (BZ$)*	*Total cost (BZ$)*
Fell wamil	15 man-days	16	240
Burn and chop	2 man-days	16	32
Seed	20 lb	0.3	6
Hard seeding	5 man-days	16	80
Spraying 2-4D(1)	0.25 man-days	16	4
Spraying 2-4D(2)	0.25 man-days	16	4
Herbicide	0.5 gal	32.5	16.25
Subtotal			382.25
of which, bought-in inputs		=	22.25
own and community labour		=	360

Harvesting

Operation	*Quantity*	*Rate (BZ$)*	*Total cost (BZ$)*
Harvest	5 man-days	16	80
Thresh	15 bags	0.4	6
Transport to mill	15 bags	1.25	18.75
Subtotal			104.75
of which, bought-in inputs		=	24.75
own and community labour		=	80
TOTAL			487

Yield of 1500 lb at 22 cents/lb produces gross income of BZ$ 330
Gross margin is BZ$ -157
Margin on bought-in inputs is BZ$ 283
Implied wage rate/man-day is BZ$ 10.3

APPENDIX 3: 1991 GROSS MARGIN ANALYSIS FOR SMALLHOLDER PRODUCTION OF SWAMP RICE IN SOUTHERN TOLEDO DISTRICT

Establishment and maintenance (1 acre)

Operation	*Quantity*	*Rate (BZ$)*	*Total cost (BZ$)*
Fell wamil	15 man-days	16	240
Burn and chop	2 man-days	16	32
Seed	20 lb	0.3	6
Hard seeding	5 man-days	16	80
Spraying 2-4D(1)	0.25 man-days	16	4
Spraying 2-4D(2)	0.25 man-days	16	4
Herbicide	0.5 gal	32.5	16.25
Subtotal			382.25
of which, bought-in inputs		=	22.25
own and community labour		=	360

Harvesting

Operation	*Quantity*	*Rate (BZ$)*	*Total cost (BZ$)*
Harvest	5 man-days	16	80
Thresh	25 bags	0.4	10
Transport to mill	25 bags	1.25	31.25
Subtotal			121.25
of which, bought-in inputs		=	41.25
own and community labour		=	80
TOTAL			503.5

Yield of 2500 lb at 22 cents/lb produces gross income of BZ$ 550
Gross margin is BZ$ 46.5 or 9%
Margin on bought-in inputs is BZ$ 486.5
Implied wage rate/man-day is BZ$ 17.69

APPENDIX 4: 1991 GROSS MARGIN ANALYSIS FOR SUGAR-CANE ON A FARM NEAR ORANGE WALK TOWN

Establishment (1 acre)

Operation	*Cost (BZ$)*
Rome plough	105
Harrow	40
Furrowing	35
Off barring	35
Plants	100
Cut and load seed	40
Transport	80
Manual planting	65
Covering seeds	30
Knapsack-operated weed control	40
Herbicide	100.12
Fertilizer	76
Manual fertilizer application	6.25
Sutotal	752.37

Maintenance (years 2-8)

Operation	*Cost/year (BZ$)*
Tillage (moulding)	35
Knapsack-operated weed control	20
Herbicide	39
Fertilizer	24
Fertilizer application (manual)	2.5
Subtotal	120.5

Volume variable costs

Harvesting and transport	*BZ$/long ton*
Harvesting and loading	12
Transport off farm	10
Subtotal	22

Annual cost and returns @ BZ$ 55/long ton

Year	*1*	*2*	*3-8*	*9*
Tons produced for sale	0	25	20	20
Sales income (BZ$)	0	1375	1100	1100
Volume variable costs (BZ$)	0	550	440	440
Volume variable costs (% sales)	0	40	40	40
Maintenance costs (% sales)	0	9	11	11
Total expenses/year (BZ$)	752.37	670.5	560.5	440
Gross margin (BZ$)	-752.37	704.5	539.5	660
Percentage gross margin	-100	105	96	150

Financial internal rate of return is 0.81

APPENDIX 5: 1991 GROSS MARGIN ANALYSIS FOR SUGAR-CANE IN COROZAL DISTRICT

Establishment (1 acre)

Operation	*Cost (BZ$)*
Rome plough	105
Harrow	40
Furrowing	35
Off barring	35
Plants	100
Cut and load seed	40
Transport	80
Manual planting	65
Covering seeds	30
Knapsack-operated weed control	40

Herbicide	100.12
Fertilizer	76
Manual fertilizer application	6.25
Subtotal	752.37

Maintenance (years 2-8)

Operation	*Cost/year (BZ$)*
Tillage (moulding)	35
Knapsack-operated weed control	20
Herbicide	39
Fertilizer	24
Fertilizer application (manual)	2.5
Subtotal	120.5

Volume variable costs

Harvesting and transport	*BZ$/long ton*
Harvesting and loading	12
Transport off farm	18
Subtotal	30

Annual cost and returns @ BZ$ 55/long ton

Year	*1*	*2*	*3-8*	*9*
Tons produced for sale	0	25	20	20
Sales income (BZ$)	0	1375	1100	1100
Volume variable costs (BZ$)	0	750	600	600
Volume variable costs (% sales)	0	55	55	55
Maintenance costs (% sales)	0	9	11	11
Total expenses/year (BZ$)	752.37	870.5	720.5	600
Gross margin (BZ$)	-752.37	504.5	379.5	500
Percentage gross margin	-100	58	53	83

Financial internal rate of return is 0.55

APPENDIX 6: 1991 GROSS MARGIN ANALYSIS FOR MECHANIZED PRODUCTION OF ORANGES FOR CONCENTRATE MANUFACTURE IN STANN CREEK DISTRICT

Establishment costs (BZ$ 1 acre)

Operation *Year*	*1*	*2-4*
Contract clearance	700	
Drainage excavation	300	
Lining and holing	55	
116 plants @ BZ$ 3	348	
Planting and supplying gaps	30	
Bush-hogging	40	40
Weed control machete	70	70
Knapsack-operated pest control	15	15
Pesticide	30	30
Manual pest control	15	15
Granular pesticide	20	20
Knapsack-operated control of fungi/blight	10	10
Chemical control of fungi/blight	15	15
Fertilizer	40	40
Manual fertilizer application	10	10
Lime	40	40
Manual lime application	10	10
Subtotal	1748	315

Maintenance (years 5-20)

Operation	*Cost (BZ$)*
Bush-hogging	40
Weed control machete	45
Knapsack-operated weed control	15

Herbicide	15
Knapsack-operated pest control	15
Pesticide	30
Manual pest control	15
Granular pesticide	20
Knapsack-operated control of fungi/blight	10
Chemical control of fungi/blight	15
Fertilizer	230
Manual fertilizer application	30
Lime	20
Manual lime application	15
Subtotal	515

Volume variable costs

Harvesting and transport	*BZ$/box*
Picking	0.55
Transport in farm	0.05
Transport off farm	0.65
Subtotal	1.25

Annual costs and returns @ BZ$ 10/box

Year	*1*	*2-4*	*5*	*6*	*7*	*8-20*
Boxes produced for sale	0	0	50	100	200	300
Sales income (BZ$)	0	0	500	1000	2000	3000
Volume variable costs (BZ$)	0	0	62.5	125	250	375
Volume variable costs (% sales)	0	0	12.5	12.5	12.5	12.5
Maintenance costs (% sales)	0	0	103	52	26	17
Total expenses/year (BZ$)	1748	315	577.5	640	765	890
Gross margin (BZ$)	-1748	-315	-77.5	360	1235	2110
Percentage gross margin	-100	-100	-13	56	161	237

Cumulative net cash flow

Year	*BZ$*
1	-1 748
2	-2 063
3	-2 378
4	-2 693
5	-2 770.5
6	-2 410.5
7	-1 175.5
8	934.5
9	3 044.5
10	5 154.5
11	7 264.5
12	9 374.5
13	11 484.5
14	13 594.5
15	15 704.5
16	17 814.5
17	19 924.5
18	22 034.5
19	24 144.5
20	26 254.5

Financial internal rate of return is 0.24

APPENDIX 7: 1991 GROSS MARGIN ANALYSIS FOR SMALLHOLDER ORANGE PRODUCTION (FOR CONCENTRATE MANUFACTURE) IN STANN CREEK DISTRICT

Establishment costs (BZ$ 1 acre)

Operation *Year*	*1*	*2-4*
Burning	200	
Bushing and stumping	100	
Drainage excavation	50	
Lining and holing	55	
116 plants @ BZ$ 3	348	
Planting and supplying gaps	30	
Weed control machete	90	90

Knapsack-operated pest control	15	15
Pesticide	30	30
Manual pest control	15	15
Granular pesticide	20	20
Knapsack-operated control of fungi/blight	10	10
Chemical control of fungi/blight	15	15
Fertilizer	40	40
Manual fertilizer application	10	10
Lime	40	40
Manual lime application	10	10
Subtotal	1078	295

Maintenance (years 5-20)

Operation	*Cost (BZ$)*
Weed control machete	90
Knapsack-operated weed control	15
Herbicide	15
Knapsack-operated pest control	15
Pesticide	30
Manual pest control	15
Granular pesticide	20
Knapsack-operated control of fungi/blight	10
Chemical control of fungi/blight	15
Fertilizer	100
Manual fertilizer application	30
Lime	10
Manual lime application	10
Subtotal	375

Volume variable costs

Harvesting and transport	*BZ$/box*
Picking	0.55
Transport in farm	0.05
Transport off farm	0.75
Subtotal	1.35

Annual costs and returns @ BZ$ 10/box

Year	*1*	*2-4*	*5*	*6*	*7*	*8-20*
Boxes produced for sale	0	0	50	100	200	250
Sales income (BZ$)	0	0	500	1000	2000	2500
Volume variable costs (BZ$)	0	0	67.5	135	270	337.5
Volume variable costs (% sales)	0	0	13.5	13.5	13.5	13.5
Maintenance costs (% sales)	0	0	75	37.5	18.75	15
Total expenses/year (BZ$)	1078	295	442.5	510	645	712.5
Gross margin (BZ$)	-1078	-295	57.5	490	1355	1787.5
Percentage gross margin	-100	-100	-13	96	210	251

Cumulative net cash flow

Year	*BZ$*
1	-1 078
2	-1 373
3	-1 668
4	-1 963
5	-1 905.5
6	-1 415.5
7	-60.6
8	1 727
9	3 514.5
10	5 302
11	7 089.5
12	8 877
13	10 664.5
14	12 452
15	14 239.5
16	16 027
17	17 814.5
18	19 602
19	21 389.5
20	23 177

Financial internal rate of return is 0.29

APPENDIX 8: 1991 GROSS MARGIN ANALYSIS FOR MECHANIZED PRODUCTION OF ORANGES IN SOUTHERN TOLEDO DISTRICT FOR CONCENTRATE MANUFACTURE IN STANN CREEK DISTRICT

Establishment costs (BZ$ 1 acre)

Operation *Year*	*1*	*2-4*
Contract clearance	700	
Drainage excavation	300	
Lining and holing	55	
116 plants @ BZ$ 3	348	
Planting and supplying gaps	30	
Bush-hogging	40	40
Weed control machete	70	70
Knapsack-operated pest control	15	15
Pesticide	30	30
Manual pest control	15	15
Granular pesticide	20	20
Knapsack-operated control of fungi/blight	10	10
Chemical control of fungi/blight	15	15
Fertilizer	40	40
Manual fertilizer application	10	10
Lime	40	40
Manual lime application	10	10
Subtotal	1748	315

Maintenance (years 5-20)

Operation	*Cost (BZ$)*
Bush-hogging	40
Weed control machete	45
Knapsack-operated weed control	15
Herbicide	15
Knapsack-operated pest control	15
Pesticide	30
Manual pest control	15
Granular pesticide	20
Knapsack-operated control of fungi/blight	10
Chemical control of fungi/blight	15
Fertilizer	230
Manual fertilizer application	30
Lime	20
Manual lime application	15
Subtotal	515

Volume variable costs

Harvesting and transport	*BZ$/box*
Picking	0.5
Transport in farm	0.05
Transport off farm	1.7
Subtotal	2.25

Annual costs and returns @ BZ$ 10/box

Year	*1*	*2-4*	*5*	*6*	*7*	*8-20*
Boxes produced for sale	0	0	50	100	200	300
Sales income (BZ$)	0	0	500	1000	2000	3000
Volume variable costs (BZ$)	0	0	112.5	225	450	675
Volume variable costs (% sales)	0	0	22.5	22.5	22.5	22.5
Maintenance costs (% sales)	0	0	103	52	26	17
Total expenses/year (BZ$)	1748	315	627.5	740	965	1190
Gross margin (BZ$)	-1748	-315	-127.5	260	1035	1810
Percentage gross margin	-100	-100	-20	35	107	152

Cumulative net cash flow

Year	*BZ$*
1	-1 748
2	-2 063
3	-2 378
4	-2 693
5	-2 820.5
6	-2 560.5
7	-1 525.5
8	284.5
9	2 094.5
10	3 904.5
11	5 714.5
12	7 524.5
13	9 334.5
14	11 144.5
15	12 954.5
16	14 764.5
17	16 574.5
18	18 384.5
19	20 194.5
20	22 004.5

Financial internal rate of return is 0.21

APPENDIX 9: 1991 GROSS MARGIN ANALYSIS FOR SMALLHOLDER PRODUCTION OF ORANGES IN SOUTHERN TOLEDO DISTRICT FOR CONCENTRATE MANUFACTURE IN STANN CREEK DISTRICT

Establishment costs (BZ$ 1 acre)

Operation *Year*	*1*	*2-4*
Burning	200	
Bushing and stumping	100	
Drainage excavation	50	
Lining and holing	55	
116 plants @ BZ$ 3	348	
Planting and supplying gaps	30	
Weed control machete	90	90
Knapsack-operated pest control	15	15
Pesticide	30	30
Manual pest control	15	15
Granular pesticide	20	20
Knapsack-operated control of fungi/blight	10	10
Chemical control of fungi/blight	15	15
Fertilizer	40	40
Manual fertilizer application	10	10
Lime	40	40
Manual lime application	10	10
Subtotal	1078	295

Maintenance (years 5-20)

Operation	*Cost (BZ$)*
Weed control machete	90
Knapsack-operated weed control	15
Herbicide	15
Knapsack-operated pest control	15
Pesticide	30
Manual pest control	15
Granular pesticide	20
Knapsack-operated control of fungi/blight	10
Chemical control of fungi/blight	15
Fertilizer	100
Manual fertilizer application	30
Lime	10
Manual lime application	10
Subtotal	375

Volume variable costs

Harvesting and transport	*BZ$/box*
Picking	0.5
Transport in farm	0.05
Transport off farm	2
Subtotal	2.55

Annual costs and returns @ BZ$ 10/box

Year	*1*	*2-4*	*5*	*6*	*7*	*8-20*
Boxes produced for sale	0	0	50	100	200	250
Sales income (BZ$)	0	0	500	1000	2000	2500
Volume variable costs (BZ$)	0	0	127.5	255	510	637.5
Volume variable costs (% sales)	0	0	25.5	25.5	25.5	25.5
Maintenance costs (% sales)	0	0	75	37.5	18.75	15
Total expenses/year (BZ$)	1078	295	502.5	630	885	1012.5
Gross margin (BZ$)	-1078	-295	-2.5	370	1115	1487.5
Percentage gross margin	-100	-100	0	59	126	147

Cumulative net cash flow

Year	*BZ$*
1	-1 078
2	-1 373
3	-1 668
4	-1 963
5	-1 965.5
6	-1 595.5
7	-480.5
8	1 007
9	2 494.5
10	3 982
11	5 469.5
12	6 957
13	8 444.5
14	9 932
15	11 419.5
16	12 907
17	14 394.5
18	15 882
19	17 369.5
20	18 857

Financial internal rate of return is 0.25

APPENDIX 10: 1991 GROSS MARGIN ANALYSIS FOR BANANAS

Establishment (1 acre)

Operation	*Cost (BZ$)*
Roads	200
Cableways	1 200
Contract cleaning	700
Drainage excavation	1 500
Irrigation installation	2 000
Lining and holing	55
Plants	1 000
Planting and supplying gaps	300
Tree props	150
Weed control machete	300
Knapsack-operated weed control	60
Herbicide	45
Manual pest control	20
Pesticide	300
Aerial-operated control of fungi/blight	90
Fertilizer	400
Manual fertilizer application	50
Lime	40
Manual lime application	10
Bagging	300
Irrigation	700
Subtotal	10 020

Maintenance cost (BZ$ 1 acre)

Operation *Year*	*2 - 9*	*10*
Weed control machete	80	80
Knapsack-operated weed control	60	60
Herbicide	45	45
Manual pest control	20	20
Granular pesticide	300	
Aerial-operated control of fungi/blight	900	900
Fertilizer	700	
Manual fertilizer application	50	50
Lime	40	40
Manual lime application	10	10
Bagging and deflowering	500	500
Irrigation	700	700
Subtotal	3 405	2 405

Volume variable costs

Harvesting, packing and transport	*BZ$/box*
Transport in farm	0.40
Packaging materials	2.40
Packing labour	0.85
Packing overhead	0.40
Transport off farm	0.55
Subtotal	4.60

Annual cost and returns @ BZ$ 55/box

Year	*1*	*2*	*3*	*4-6*	*7*	*8*	*9*	*10*
Boxes produced for sale	0	450	600	700	650	550	500	350
Sales income (BZ$)	0	7 200	9 600	11 200	10 400	8 800	8 000	5 600
Volume variable costs (BZ$)	0	2 070	2 760	3 220	2 990	2 530	2 300	1 610
Volume variable costs (% sales)	0	28.75	28.75	28.75	28.75	28.75	28.75	28.75
Maintenance costs (% rates)	0	47	35	30	33	39	43	43
Total expenses/year (BZ$)	10 020	5 475	6 165	6 625	6 395	5 935	5 700	4 015
Gross margin (BZ$)	-10 020	1 725	3 435	4 575	4 005	2 865	2 295	1 585
Percentage gross margin	-100	32	56	69	63	48	40	39

Cumulative net cash flow

Year	BZ$
1	-10 020
2	-8 295
3	-4 860
4	-285
5	4 290
6	8 865
7	12 870
8	15 735
9	18 030
10	19 615

Financial internal rate of return is 0.22

APPENDIX 11: 1991 GROSS MARGIN ANALYSIS FOR MECHANIZED PRODUCTION OF SWAMP RICE IN SOUTHERN TOLEDO DISTRICT

Establishment and maintenance (1 acre)

Operation	*Quantity*	*Rate (BZ$)*	*Total cost (BZ$)*
Rome plough			45
Cross plough			45
Harrow			25
Pick sticks	0.5 man-days	16	8
Planting and fertilizing			10
Seeds	100 lb	0.3	30
Fertilizers	100 lb	0.35	35
Spraying herbax	0.5 man-days	16	8
Herbax	0.5 gal	40	20

Spraying 2-4D	0.5 gal	40	20
Spray insecticide	0.25 man-days	16	4
Subtotal			250

Harvesting

Operation	*Quantity*	*Rate (BZ$)*	*Total cost (BZ$)*
Combine harvesting	2500 lb	0.03	75
Bagging	0.5 man-days	16	8
Transport to mill	25 bags	1.25	31.25
Subtotal			114.25

Yield of 2500 lb at 22 cents/lb produces gross income of BZ$ 550
Gross margin is BZ$ 185.75 or 51%

APPENDIX 12: FUELWOOD CONSUMPTION OF THE WHITE LIME CO-OPERATIVE IN 1990

Productivity for kiln (tons)

Productivity/burn	15
Total productivity	1991

Markets (tons)

Pomona (citrus)	1561
Citrus Growers Association	136.4
Banana Growers Association	227.2
VR Enterprises (road)	66.4

Current fuelwood consumption

One 'pante' of stacked wood (m^3)	3.1
Number of pantes/kiln burn	
West season	13
Dry season	10
Average over year	11
Average fuelwood/burn (m^3)	34.1
Number of burns/year (15 kilns)	133
Total consumption of fuelwood (m^3)	4535.3
Fuelwood consumption/ton of white lime produced (m^3)	2.3

Plantation fuelwood consumption

Number of pantes/kiln burn	8
Total consumption of fuelwood (m^3)	3298.4
Fuelwood consumption/ton of white lime produced (m^3)	1.66

Sustained plantation yields (m^3/ha)

Year	*1*	*2*	*3*	*4*	*5*	*6-20*
Cleared forest	10	10	10	10	10	0
Plantation	0	5	10	15	20	20
Total (cleared forest)			50			
Total (plantation)			350			
Yield/year			20	(8 m^3/acre)		

Fuelwood consumption for 2000 tons white lime is 3320 m^3

Area of plantation to meet 2000 tons production/year is 415 acres (168 ha)

APPENDIX 13: APPLICANT'S INFORMATION SHEET FOR LEASING NATIONAL LAND

Lands and Survey Department
Information Sheet

1. NAME.. 2. AGE..
3. ADDRESS...
4. NATIONALITY............................ 5. OCCUPATION............................
6. NO. OF YEARS IN BELIZE............ 7. PROOF OF RESIDENCY..............
8. MARRIED/SINGLE....................... 9. NAME OF SPOUSE.....................
10. SIZE OF FAMILY.........................11. NO. WORKING..........................
12. AGE(S) BOYS.............................13. AGE(S) GIRLS.............................
14. OTHER DEPENDENTS...
15. NO. OF LOTS/ACRES HELD ALREADY: 16. ANY OTHER IMMEDIATE FAMILY OCCUPY LAND?
    (a) CROWN................................. (c) CROWN................................
    (b) PRIVATE................................ (d) PRIVATE...............................
17. AMOUNT OF ACRES/LOTS NOW ALLIED FOR..................................
18. LOCATION...
19. AMOUNT OF ACRES CAN WORK ANNUALLY....................................
20. TYPE OF INTENDED DEVELOPMENT: (a) AGRICULTURE.......................
    (b) RESIDENTIAL............................ (c) COMMERCIAL.......................
    (d) INDUSTRIAL............................ (e) OTHER.................................
21. FINANCIAL ABILITY:PERSONAL........... LOANS.................................
    (a) Are you in a financial position to *build* within a year?
    ....
    (b) What is the expected time for completion?......................................
    (c) Are you in a financial position to commence *development* within a year?...
    (d) What is the expected time for completion of development?................
    (e) Give evidence of financial position whether by personal savings or loans...
22. RECOMMENDATIONS: *Signature of Applicant*:...............................
    DATE:
23. RECOMMENDATIONS: ....
    DATE: A.L.O./L.I. District
24. RECOMMENDATIONS: ....
    DATE: Chairman, AD Hoc Committee
25. RECOMMENDATIONS: ....
    L.O. District
26. COMMENTS: ....
    P.L.O
    ....
    N.E.O.

APPENDIX 14: APPLICATION LETTER FOR LEASING NATIONAL LAND

BELIZE: LANDS AND SURVEYS DEPARTMENT
BELMOPAN
CAYO DISTRICT

NO.: ....
In replying please quote the above number.

....
....
....
....

Dear Sir/Madam

Your application to lease...
situate in...
was submitted to the Hon. Minister of Natural Resources on the......................
when it was approved subject to the Crown Lands Ordinance Chapter 147 and of the conditions published in Gazette Notice No. 48 of 27th January, 1934 as are applicable to this lease, and to the following conditions:

1. The term of the lease shall be for .... year(s) *(however the lessee will have the option to extend the lease for a further term of years provided that the conditions of the lease are fulfilled).
2. The rent payable shall be at a commencing rent of.......... dollars and .... cents per annum payable in advance and subject to 5 yearly reviews, the adjusted rent not to exceed 7% of the prevailing open market value of unimproved land in the locality.
3. Payment of the proportional rent of .... dollars and .... cents for the year 19.. must be made to the Lands Office .... or to this office within two months from the date of this letter of approval.

   Failure to pay the proportional rent and/or enter into possession of the land approved within two months from the date of this letter or at an approved later date, shall make the approval voidable.
4. Rents paid on this leasehold interest will be credited towards the purchase price.
5. (a) Non-payment of rent at the specified time;

   (b) Any disposition or transfer of the whole or any part of the land without written permission from the Minister;

   (c) Non-observance of or non-compliance with any of the conditions herein contained or referred to;

   shall in every instance authorize the Minister by notice to the *Gazette* to declare this lease forfeited and thereupon the same shall cease and become null and void, to all intents and purposes, and the land may be entered upon by or on behalf of Her Majesty, Her heirs and successors by any person duly authorized so to so, and possession thereof may be resumed as the property of Her Majesty, Her heirs and successors, and in such case the lesseee shall have no claim to compensation for any improvements or outlay made thereon.
6. Ancient monuments, relics and mounds are strictly reserved and do not pass under this demise.

7 (a) The land approved to the lessee must be developed at a rate of .... acres per annum and maintained in a state of permanent improvements in accordance with good agricultural practices.

* delete if not applicable

(b) The land approved to the lessee must be developed in accordance with a Development Plan submitted by the lessee on .... 19.. and approved by the Minister of Natural Resources; and/or, in accordance with the further conditions attached hereto.

8. Where the acreage approved to the lessee is in the aggregate 50 acres or over, the lessee *must*, commencing on the *sixth month* from the date of approval and thereafter at the end of every twelfth month while this lease is in being, submit a written report detailing the improvements carried out to the land, to the Commissioner of Lands and Surveys.

9. Where a portion or the whole of the lands approved to the leseee consists of steep or uneven terrain, such land shall not be utilized where the possibility of erosion or ecological damage could occur.

   Any damage to the land could make the lessee liable to make good the costs of restoration due to nuisance or negligence which may be recoverable by the Government of Belize or any other affected party.

10. Where land approved to the lessee is situated outside a City, Town or village and adjoins any running stream, river or open water, a 66-foot strip of land along any running stream, river or open water must be left in its natural state unless otherwise approved to be used in a specified manner by the Minister of Natural Resources.

11. Where the lessee fails to carry out improvements in accordance with the approved scheme to the satisfaction of the Minister of Natural Resources. The lessee will not qualify for a Minister's Fiat (Grant) or a Land Certificate.

   (a) The lessee shall have an option to purchase the land provided all the conditions of the lease shall have been first carried out.

12. The word 'Lessee' shall be read to include and be applicable to the lessee as well as the executors, administraors, and allowed assigned of such lessee as fully to all intents and purposes as if they had in every instance been specifically mentioned.

13. Precious metals, ores, gems, jewels, coals, fossil fuels, timber and dyewood are strictly reserved and do not pass under this demise. The right of entry on the premises to search for, dig out, fell or cut (as the case may be), and remove any of the above, is reserved to Her Majesty, Her heirs or successors.

Please sign and *return copy* within (2) two months time, failure to do so may result in the lease agreement being VOID.

I, ...hereby acknowledge receipt of and acceptance of the above lease conditions and promise to abide by them.

Date: ....

Yours respectfully,

for Commissioner of Lands and Surveys

cc: L.R.A./Lands and Surveys Department, Belmopan
His Worship, The Lord Mayor, Belize City

APPENDIX 15: CONDITIONS FOR LEASING LAND TO THE SAN ANTONIO PEANUT AND GRAIN CO-OPERATIVE

Supplementary leasehold conditions for land to be de-reserved within the Mountain Pine Ridge Forest Reserve: approximately 650 acres west of Little Vaqueros Creek and north of Privassion Creek.

The co-operative shall be obliged to comply with the following conditions which shall be binding on the lease and on the conditions of sale if and when the land is purchased:

(i) The natural vegetation on the hills and sides of the hills shall be left undisturbed apart from the use of the dead trees for firewood.

(ii) A 66-ft wide reserve shall be observed beside the Little Vaqueros and Privassion Creeks. Vehicular access to the Creeks is not permitted.

(iii) A 200 ft by 200 ft (40 000 ft^2) reserve shall be reserved around any ancient ruins and caves.

(iv) No hunting shall be permitted.

(v) No vehicular access to the land shall be permitted apart from the Pine Ridge - Chito road.

(vi) Any palms of the *Schiltia concolor* variety (a protected species) shall be left undisturbed.

(vii) The co-operative shall give 24 hours notice to the Divisional Forestry Officer prior to the burning of cut vegetation. A 6-ft minimum fire prevention line must be cleared prior to burning.

(viii) Any application of chemical fertilizer or pesticide shall be undertaken only when permitted by the Chief Forestry Officer.

(ix) Any plans for the establishment of permanent residence on the land must be reported to the lands Officer for Cayo District.

Maskall and Bomba

Background

Maskall is located on the Old Northern Highway, eight miles (12 km) north of the Maya ruins at Altun Ha. Its population at the last *quick count* was approximately 800 (Ganet, 1991, personal communication). Bomba is three miles (5 km) to the east on the Northern River with a population of about 80. The influx of Central Americans continues to increase the population of Maskall. Smallholder agriculture and some logging remain the main activities. Tourism is emerging as a third activity, with an income opportunity tied primarily to wood carving along the route from Maskall to Altun Ha. A foreign-owned hotel to the north of the village has established an excursion route bringing tourists from San Pedro and Cay Caulker, through the Northern River Lagoon, up the Northern River to Bomba, and from there by road to Altun Ha. The excursion route is now managed by Belizean operators from San Pedro and Maskall. Depending on the season, between 10 and 100 tourists a day use this route (Wendling, 1991, personal communication).

Community ecotourism service and organization SWOT* summary

STRENGTHS

Services
- Locally owned woodcarving outlet purchasing from local carvers
- Foreign hotel has already established tourist demand for road transport and craft services
- Community located on scenic excursion route
- Local employment at hotel (12-18 in peak season)

Organization
- Hotel in consultation with Village Council

WEAKNESSES

Services
- Hotel retains catering services

Organization
- No community co-operative utilizing tourism opportunity

OPPORTUNITIES

Services
- Government to maintain Old Northern Highway rather than invest in link road to New Northern Highway
- Catering and accommodation facilities
- Local produce sold to tourists on route
- Abandoned land either side of Northern River allocated as 'green leases' to community members

THREATS
- Land either side of Northern River scenic excursion route reallocated and developed without consultation with Village Council or local Lands Committee

Gales Point

Background

Completion of the Manatee Road from the Western Highway to Dangriga in 1989, opened up land to the west of Southern and Northern lagoons as potential citrus lands. There are proposals to co-ordinate development of the area as an integration of agriculture, tourism and nature conservation (J. Lyons, 1991,

* Strengths - weaknesses - opportunities - threats

personal communication). Gales Point, on the peninsula jutting north into Southern Lagoon, is proposed as the focus of a Community Manatee Sanctuary along the lines of the Bermudian Landing Community Baboon Sanctuary (Horwich, unpublished b). The area designated is 17°10' to 17°20'N and 88°30'W to sea but its western extent in the south should be more restricted to allow for agricultural development on class 1 and 2 agricultural land (see Map 1). The area has a variety of habitats, major edge effects and richness of species: manatee, tarpon, water birds, turtles, spider monkeys and others. Access to Gales Point is either by road or river-canal-lagoon from Belize City.

There is house-to-house electricity and water supply. Sewage is deposited untreated into Fishers Bight east of the peninsula. A hotel is to be constructed using capital and design plans arranged through the Ministry of Tourism and the Environment. Underemployment is increasing with fishing in decline and little agricultural activity. Some hunting continues in the area around Southern Lagoon. A foreign-owned and managed tourist lodge is located at the tip of the peninsula.

Community ecotourism service and organization SWOT summary

STRENGTHS

Services
- Hotel to be managed by a community co-operative
- Highly scenic canal-river-lagoon access route to village

Organization
- Village Council to oversee co-operative activities
- Area representative is the Minister for Tourism and the Environment

WEAKNESSES

Services
- No catering facilities for tourists
- Produce is imported from Belize City

Organization
- Lack of co-operative experience

OPPORTUNITIES

Services
- Guided tours of terrestrial and lagoon environments
- Fishing trips in lagoons and along the coast
- Negotiate locate hotel sewage pit to be on private land at the southern end of the peninsula

Organization
- Village Council to co-ordinate tourism activities following consultation with Department of Fisheries' Coastal Zone Management Plan
- Department of Lands and Survey to consult with Village Council and Coastal Zone Management Plan concerning integrated land-use plan
- Membership of Belize Tourism Industry Association (BTIA) for training and lobbying services

THREATS
- Siltation and pesticide contamination of the shallow Southern Lagoon caused by agricultural activity in Manatee area
- Quality of Southern Lagoon for bathing may be affected by an increase in tourist-related untreated sewage
- Because water supply to village is piped from Quamina Creek, located in a citrus area, pesticide runoff, siltation and irrigation may adversely effect water quality in the future
- Wildlife corridors along water courses feeding lagoons are also those areas between Pine Ridge soils suited to citrus

St Margaret's

Background

St Margaret's Village lies between the Sibun River and Mile 27 on the Hummingbird Highway. The population is approximately 500, and rising (L. Wengrzyn, 1991, personal communication). The water supply comes from hand pumps and creek waters. There is no house-to-house electricity supply nor telecommunications infrastructure. Five Blues Lake lies four miles (6 km) north-east of Over the Top Camp at Mile 32. The lake and surrounding 800 acres (324 ha) have been designated a national park under the National Parks Systems Act of 1981. Road access to the park is seasonal involving the crossing of Dry Creek. The Village Council proposes establishing a non-profit association for the community to manage and benefit from the park as a tourist attraction.

Community ecotourism service and organization SWOT summary

STRENGTHS

Services	• Attraction due to designation of lake as a national park and cited as a 'critical habitat' (BCES, 1989) • Preliminary site report completed
Organization	• Strong link between proposed Association of Friends of Five Blues Lake and Village Council

WEAKNESSES

Services	• No experience of supplying tourists with crafts, tours, food etc. • No restaurant or overnight-stay facilities in village
Organization	• Tourism income opportunities not to be co-ordinated as a co-operative or group

OPPORTUNITIES

Services	• Boating facilities • Sale of local crafts • Catering facilities in village • Lakeside boat and beverage facilities • Guides and warden • Publicize Five Blues Lake though same channels as for other reserves • Village gravity-fed water system to be installed soon
Organization	• Co-ordinate tourism income opportunities within community • Two-way radio to link lake area to village • Membership of BTIA for training and lobbying services

THREATS	• 25 acres (10 ha) of undeveloped private land bordering park area now with access road; citrus development may encroach on park

Dangriga

Background

The traditional mixed farming and fishing system of the Garifuna is coming increasingly under pressure. Affordable land can only be found at an uneconomical travelling distance, and the closure of the local Liman College has removed valuable training and extension services. Within the coastal waters, fishing stocks are competed for by Honduran trawlers under government licence. Lack of training restricts development of deep-sea commercial fishing.

Dangriga is served by road, sea and air, with access to the reef and cays. The town has house-to-house electricity and water supply, tourist accommodation and catering outlets.

Community ecotourism service and organization SWOT summary

STRENGTHS

Services
- Knowledge of local waters, reef and cays
- Water transport 'skiffs'

Organization
- Fishing co-operative formed

WEAKNESSES

Services
- Existing hotels tend to retain catering and touring facilities
- No guide/tour experience or training
- Lack of collateral for venture capital

OPPORTUNITIES

Services
- Tours services, guide services, ferrying, guest houses, skiff rentals, Garifuna cooking culture
- Fishing trips (day/night)

Organization
- Newly formed fishing co-operative to widen its co-ordinated activities to include tourism
- Affiliation of co-operative to larger hotels for guides, tours and ferrying
- Membership of BTIA for training and lobbying services

THREATS
- Foreign and local competition in tourist services; 'big man put little man out of business'

Hopkins

Background

A linear coastal village 8 miles (13 km) south of Dangriga, with a Garifuna population of approximately 250 (E. Castio, 1991, personal communication). Mixed agriculture is practised inland of the swamp to the west. The women are mostly employed at South Stann Creek banana processing plant, at a rate of BZ$ 12/day. An established women's co-operative owns and manages Sandy Beach, a resort with accommodation for eight. Tourists stay in the village an average of two to three days. Handicrafts and snacks are sold to visitors independently of the co-operative. The village has no house-to-house electricity or water supply infrastructure. The local lands committee has increasing demands for land by tourism prospectors.

Community ecotourism service and organization SWOT summary

STRENGTHS:

Services
- Fishing trips, reef and cay tours available
- Overnight accommodation established
- Garifuna cooking culture

Organization
- Strong village council with policy to encourage tourism development by local people i.e. 'the natural way'

WEAKNESSES

Services
- No land left for community tourist expansion south of the village; four acres (1.6 ha) left to the north

Organization • Tourism licence fees and taxes are disincentives for encouraging additional catering and tour facilities to non-members

OPPORTUNITIES

Services
- Camping, additional catering facilities
- Reallocate abandoned lots in village for local tourism projects.
- Link into Cockscombe tourist market through advertising at urban tourist centres
- Women to spearhead future tourist development: rent rooms, additional catering facilities (replacement of banana labour)

Organization
- Expand co-operative to include non-Sandy Beach affiliates
- Membership of BTIA for training and lobbying services

THREATS
- Possible conflict of interest between the Village Council (and its recommendations to Lands Committee over approving land for tourist development), and ownership of first and only local tourism accommodation
- Non-community 20 acre (8 ha) plot at south end of village proposes tourism development without participation of local people or consultation with village council

Placentia

Background

Placentia village is located at the southern-most tip of the 11 mile (17 km) Plancentia peninsula. The current population of approximately 450 supports five hotels with an average of 12 rooms each and length of stay varying from days to weeks (P. Neal, 1991, personal communication). Most tourist facilities are foreign owned and Belizean managed. The village has house-to-house electricity supply with rainwater or wells as water supply. Sewage discharge is to ground cesspits. All land in the village is privately owned. There is no lands committee as in other villages. Traditional fishing occupations are in decline and underemployment is rising. There are no agricultural lands.

Community ecotourism service and organization SWOT summary

STRENGTHS

Services
- Local participation in catering facilities, not limited to hotels
- Construction of tourism facilities absorbs underemployment

WEAKNESSES

Services
- Despite expansion of tourism, the local community benefits only as waiters and guides: 'there is a limit to the number of people who can be guides'
- Groundwater supply rates nearing capacity in dry season; cost to secure supply from Big Creek BZ$ 500 000
- Land prices are beyond reach of potential local entrepreneurs
- Land bought and sold without awareness by local people of intended facilities
- Imbalance in cost of investment between Belizeans and foreigners due to high collateral to loan ratio for tourism ventures in Belize

Organization • No community-based organization to participate in, and benefit from, tourism expansion

OPPORTUNITIES

Services	• As an established tourist destination, security of custom reduces risk for investment ventures by local people
Organization	• Establish local organization, e.g. tourism co-operative to solicit funds and co-ordinate community participation with existing businesses • Membership of BTIA for training and lobbying services

THREATS • Expansion of tourism may locate on beach-front land for sale between Placentia and Seine Bight villages without consultation with local people

Monkey River

Background

Monkey River town is at the mouth of the Monkey River, on its south bank. Its declining population currently stands at approximately 250 (J. Watler, 1991, personal communication) due in part to a deterioration of fishing activities. Cultivation of the banks of the river is also in decline, though citrus is being considered by some. There is no house-to-house electricity nor water supply. In the dry season, when rainwater has been consumed, clean water is brought in by boat from Big Creek. The local community fear they are being polluted from the banana operation at Cowpen although no related sickness has yet been reported. The town has an established fishing co-operative. The Association for the Preservation of Monkey River, registered under Chapter 206 of the Companies Ordinance, is a community enterprise with the objective of managing, as a nature reserve, land a quarter of a mile (0.4 km) either side of the river from Monkey River town to its confluence with the Bladen and Swasey Branches.

Community ecotourism service and organization SWOT summary

STRENGTHS

Services	• Local knowledge of coast, river and land • Ferrying • Due to out-migration, land is available for tourist facilities
Organization	• Established fishing co-operative

WEAKNESSES

Services	• Produce for tourists not grown locally, imported from Independence village • Awaiting abandoned plots to be surveyed before they can be used for tourism facilities
Organization	• Consent for scheme needed from 500-600 landowners along bank of Monkey River • Area not yet designated as a reserve under law

OPPORTUNITIES

Services	• Fishing co-operative members to take franchises to provide catering facilities, crafts, and run 'ground operations' - skiff rentals, guide services, river and land tours • Assistance from Co-operative for American Relief Everywhere (CARE) to place dry-season wells
Organization	• Association able to solicit management funds • Nicolait Associates to be approached to assist in management plan and conduct a survey of landowners

- Organizational structure may be a role model for community managed national park/nature reserves (refer to Figure 25)
- Membership of BTIA for training and lobbying services

THREATS

- Preliminary development plans have been produced for large-scale tourism development to south of Monkey River town

Barranco

Background

Barranco is the southern-most coastal village in Belize, lying on the north shore of the Temash River, 10 miles (16 km) south-west of Punta Gorda. Its declining Garifuna population is now at around 230 (A. Loredo, 1991, personal communication). Fishing and mixed agriculture activities are both in decline. Facilities include house-to-house electricity, rain-storage vats and wells and pit latrines. The Barranco Women's Association for Development has been established to produce crafts for sale to tourists in Punta Gorda.

Community ecotourism service and organization SWOT summary

STRENGTHS

Services

- Craft making
- Houses for rent

Organization:

- Established women's association for tourism
- The Toledo Ecotourism Association (TEA), a private organization based in Punta Gorda, includes members from the Barranco community

WEAKNESSES

Services

- No tour, guide or catering services

Organization

- BTIA not in consultation with community

OPPORTUNITIES

Services

- BTIA to establish craft centre outlet in Punta Gorda
- River and coast fishing trips
- Expeditions by river and land to Crique Sarco
- Guesthouse
- Separate catering facilities

Organization

- Village Council in consultation with TEA and BTIA to form community organization (association or co-operative) to manage guesthouse and tourism activities
- Membership of BTIA for training and lobbying services

THREATS

- None

Southern Toledo District

Background

There are 22 Mopan and Kekchi Indian villages, with a combined population of about 5000, scattered around Southern Toledo District. They cover an area from Crique Sarco, on the Temash River in the far south-west (15°93'N, 89°07'W), to San Miguel, (16°18'M, 88°55'W) on the Rio Grande River, north-west of Punta Gorda. Within this area, 70 277 acres (28 441 ha) of land are declared as Indian Reservation under the Crown Lands Ordinance (P. Coc, 1991, personal communication). Pressure for land is growing due to a combination of: better health care; immigration (particularly of Kekchi Indians from Guatemala); the government's practice of leasing land to individuals inside the reservation*; and an increase in cultivation by individual farmers (C. Wright, 1991, personal communication).

Mopan and Kekchi Indians in this region are now involved in the cash economy, needing to buy clothes and pay school fees. Planting additional land with rice and maize to earn cash is now common but this puts a strain on the availability of labour, and increases pressure on lands outside the reservation. Planting tree crops as an alternative is equally problematic. Settled farming projects have faltered due to delays in capital loans, combined with repayment difficulties tied to the accumulation of interest payments during the period before crops come in to production (D. Bol, 1991, personal communication). The income-generating opportunity of ecocultural tourism can thus be viewed in light of the complications of investing capital and labour in smallholder agriculture.

Tourism opportunities presented by the physical and cultural environments of the Mopan and Keckhi communities are already appreciated. A 'village guesthouse ecotrail program' has been undertaken by the TEA - a Punta Gorda-based private association with three to four members from each of six villages (C. Schmidt, 1991, personal communication). Members of the TEA have been provided with materials to construct guesthouses. Once these facilities are operational, members co-ordinate associated guided tours of local caves, waterfalls and Maya ruins, and encourage the community to provide entertainment, meals and crafts. The TEA development plan supposes four guesthouses in each of 22 Maya villages. The villages are to be zoned for ecotrails and agriculture.

Alternative to the TEA plan is the Controlled Tourism Project proposed by the Maya Community Cultural Council (MCCC). The Project envisages community-to-community extension for members to learn from other indigenous communities involved in ecocultural tourism. Once established, tourist services are to be organised through the MCCC and village councils (P. Coc, 1991, personal communication).

Community ecotourism service and organization SWOT summary

STRENGTHS

Services
- Local crafts generate individual cash income. Local people who have a knowledge of the forest environment are hired as guides
- Opportunity to interact in English and Spanish with Mopan and Kekchi cultures

Organization
- Community and cultural authority of the MCCC with respect to communities and outside funding agencies
- Trust of alcaldes and village councils to organize equitable benefit from tourism opportunity

WEAKNESSES

Services
- Cultural inertia of dependence on surface flow for drinking, washing and bathing. Potential problems may arise as land is leased to settled agriculture upstream
- If numbers of tourists are too small, then only a few in the community receive cash benefits. Loss of traditional hunting areas if ecotrail zoning plan adopted

Organization
- Division between the members of TEA and the rest of the

* For San Antonio, 7.5% of the 20 785 acres (8412 ha) assigned to the village area have been leased to 40 individuals. Since most continue to practice milpa on reservation land, this represents an increase in population density of approximately 10%, where total population is 2500 (Matola, 1990) with an average household of 10 persons.

community - "those five men will keep all the money" (L. Pana, 1991, personal communication)

- Absence of consultation between TEA and the respective alcaldes and village councils of each community
- Perception of Maya communities and TEA that BTIA is hesitant to encourage overnight stay in villages away from its member's accommodation.
- Slow speed at which MCCC is developing its Controlled Tourism Project, and the lack of appreciation of aspirations of village councils and alcaldes
- Lack of involvement of the MCCC in the development of the Munda Maya and in the July 1991 ecotourism conference

OPPORTUNITIES

Services

- Larger numbers to be assigned to all households wishing to partake ensures equity of distribution of cash benefits from meals, guide services and craft sales
- Punta Gorda craft centre to purchase from village women co-operatives

Organization

- To ensure equity of participation and benefits, all tourism services at the village level to be co-ordinated through both the first and second alcaldes and the Village Council
- To ensure a degree of local control of the tourism opportunity, all tour operators to consult first with MCCC, or the BTIA if in role of representing concerns of MCCC
- Round-table workshop between TEA, BTIA, MCCC, village council representative, and alcaldes of TEA's six pilot villages to agree a realistic degree of participation, benefits and local control in the ecocultural tourism opportunities

THREATS

- Without a degree of local control, acceptable to the elected members of each community, local divisions may undermine the sense of equity within Maya culture

APPENDIX 17: TOLEDO NORTH FISHERMEN CO-OPERATIVE SOCIETY HUMAN RESOURCES SURVEY QUESTIONNAIRE

HUMAN RESOURCES SURVEY

Conducted by TOLEDO NORTH FISHERMEN CO-OPERATIVE SOCIETY LTD

The purpose of this survey is to determine how many people within the community want to work and the type of employment they are qualified to do or are trainable for. All information confidential.

1. Name...
2. Age.............................. Date of birth...
3. Sex....................... Male.................. Female.....................................
4. Nationality..
5. Marital status .... Married.................Single .... Other...........................
6. No. of children............ Ages:...
7. Schools attended:
   School............................ From.......To........ Graduated..Yes........No........
   School............................From.......To........ Graduated..Yes........No........
8. Employment experience:
   Employer....................... Type of work............... How long?...................
   Employer....................... Type of work............... How long?...................
9. Type of employment trained for:...
   Give brief experience:...
10. Are you willing to receive training?............Yes............No......................
11. Can you take training away from home?.... Yes............No......................
12. Do you have children of pre-school ages?........... How Many?.................
13. If day-care services were provided to your pre-schoolers, would this free you up to take employment?.. Yes..............No......................................
14. How many hours per day can you work?..
15. Can you operate any type of vehicle? Do you have a valid drivers' licence?
    ....
    Name vehicle or equipment (office or otherwise) that you can operate
    ....
16. List any special skills you may have:...
    ....

Signature of Interviewer..

APPENDIX 18: INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE (IUCN) - THREATENED SPECIES CATEGORIES

Species identified as threatened by IUCN are assigned a category indicating the degree of threat. Definitions are as follows:

EXTINCT (Ex)

Species not definitely located in the wild during the past 50 years (criterion as used by the Convention on International Trade in Endangered Species of Wild Fauna and Flora).

NB On a few occasions, the category Ex? has been assigned; this denotes that it is virtually certain that the taxon has recently become extinct.

ENDANGERED (E)

Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating.

Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction. Also included are taxa that may be extinct but have definitely been seen in the wild in the past 50 years.

VULNERABLE (V)

Taxa believed likely to move into the 'Endangered' category in the near future if the causal factors continue operating.

Included are taxa of which most or all the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security has not yet been assured; and taxa with populations that are still abundant but are under threat from severe adverse factors throughout their range.

NB In practice, 'Endangered' and 'Vulnerable' categories may include, temporarily, taxa whose populations are beginning to recover as a result of remedial action, but whose recovery is insufficient to justify their transfer to another category.

RARE (R)

Taxa with small world populations that are not at present 'Endangered' or 'Vulnerable', but are at risk.

These taxa are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

INDETERMINATE (I)

Taxa *known* to be 'Endangered', 'Vulnerable' or 'Rare' but where there is not enough information to say which of the three categories is appropriate.

INSUFFICIENTLY KNOWN (K)

Taxa that are *suspected* but not definitely known to belong to any of the above categories because of lack of information.

K Taxa which are currently under review by ICBP (International Council for Bird Protection) and which are likely to be designated a category in the near future.

THREATENED (T)

Threatened is a general term to denote species which are 'Endangered', 'Vulnerable', 'Rare', 'Indeterminate', or 'Insufficiently Known' and should not be confused with the use of the same term by the US Office of Endangered Species. It is used here to identify taxa comprised of several sub-taxa which have differing status categories.

COMMERCIALLY THREATENED (CT)

Taxa not currently threatened with extinction, but most or all of whose populations are threatened as a sustainable commercial resource, or will become so, unless their exploitation is regulated.

This category applies only to taxa whose populations are assumed to be relatively large.

NB In practice, this category has only been used for marine species of commercial importance that are being overfished in several parts of their ranges.

APPENDIX 19: FOREST RESERVE STATUS

The information given below is updated from ODA (1989).

Chiquibul

Gazetted by SR & O 55 in 1956 with an original area of 714 mile² (1849 km²). Some logging has been allowed in the extreme north-western corner, and there is some milpa encroachment from Guatemala.

Cockscombe Basin

Gazetted by SI 93 in 1984 with an original area of 154 mile² (399 km²). It became a Wildlife Sanctuary in 1990 (SI 127) covering 160 mile² (415 km²).

Columbia River

Gazetted by SI 33 in 1954 with an original area of 173 mile² (448 km²), but already a Crown Forest Reserve by 1930. It was reduced to 161 mile² (417 km²) in 1977 by SI 40. The rectangle excised for milpa farming had contained the Forestry Department (FD) taungya plantations of *Swietenia* established 1955-63. The rectangle was re-cleared for farming in 1975. There is minor milpa encroachment around the borders of the whole reserve, including across the international boundary from Guatemala. A logging concession was given to a Mexican company in June 1991.

Commerce Bight

Gazetted by SI 46 in 1977 with an original area of 20 mile² (52 km²), although FD records indicate an area of 17 mile² (44 km²). The reserve was reduced to 14.5 mile² (37.6 km²) in 1982, and divided into two portions 2436 acres (986 ha) and 6864 acres (2778 ha) (S1 59). SI 49 of 1989 reduced the size of the two portions to 1302 acres (527 ha) and 6612 acres (2676 ha).

Deep River

Gazetted by SR & O 49 in 1941 with an original area of 157.5 mile² (408 km²). Sometime before 1977 the reserve was enlarged to 228 mile² (591 km²), of which about 1000 acres (400 ha) have subsequently been leased out.

Freshwater Creek

A Crown Forest Reserve by 1930, it was subsequently gazetted by SR & O 12 in 1960 with an original area of 114 mile² (296 km²). The 1977 FD records indicate an area of 116 mile² (301 km²), by which time the Honey Jib Camp Forest Reserve had been included. At the time of the King *et al.* (1992) land resource assessment (1990), the whole forest was under a short-term licence, with logging concentrated in the eastern half.

Golden Stream

Golden Stream was de-reserved in the 1950s.

Grant's Work

Gazetted by SR & O 47 in 1941 with an original area of 28.6 mile² (74.1 km²). It is divided into two parts (A and B), but the boundaries seem to have been altered several times. In 1977 the FD recorded a total area of 29 mile² (75 km²). According to ODA (1989) it was apparently reduced to 15.17 mile² (39.30 km²) in 1980 (SI 65), and 13.31 mile² (34.48 km²) in 1985/6 (SI 56/67); but these areas may just refer to the size of Grant's Work A, since King *et al.* (1989) recorded areas of 12.51 $mile^2$ (32.40 km^2) for Grant's Work A (as re-described in 1987 by SI 24), and 5.25 $mile^2$ (13.60 km^2) for Grant's Work B. Subsequently Grant's Work A was reduced to 11.98 $mile^2$ (31.03 km^2) in 1989; and suffered further reductions of about 75 acres (30 ha) in 1989 (SI 95), and 50 acres (20 ha) in 1990/1 by granting of leases. Grant's Work B was largely cleared for citrus in 1990, with no publication of appropriate de-reservation statutory instrumentation.

Iguana Creek

Iguana Creek Forest Reserve seems to have been taken over by the Mennonite settlement of Spanish Lookout, possibly because of the de-reservation recommendation of Wright *et al.* (1959) who argued that the forest had little value, and the area was needed for the resettlement of the former inhabitants of Yalbac village.

Machaca Creek

Gazetted by SR & O 24 in 1963 with an original area of 15.93 $mile^2$ (41.26 km^2). It was reduced to 9.15 $mile^2$ (23.70 km^2) in 1977 (SI 41). The FD estimate at the time of ODA (1989) was 8.68 $mile^2$ (22.5 km^2). Its current status is uncertain.

Manatee

Gazetted by SR & O 21 in 1959 with an original area of 177 $mile^2$ (459 km^2). A part is being de-reserved as the Manatee Development Plan.

Mango Creek

Gazetted by SR & O 6 in 1960 with an original area of 104 $mile^2$ (270 km^2). it was de-reserved in 1969 for large-scale commercial horticulture, but re-established when the project failed. The reserve was subsequently progressively reduced to 103 $mile^2$ (267 km^2) in 1977 (SI 43), 102.5 $mile^2$ (265.5 km^2) in 1986 (SI 68), and 90 $mile^2$ (232 km^2) in 1987 (SI 25 and 47). ODA (1989) records an FD estimate of 55.6 $mile^2$ (144 km^2) after an excision for which there does not seem to be any gazette notice. ODA (1989) has recorded the intended clearance of 4680 acres (1894 ha) for citrus and 15 000 acres (6000 ha) for five plantations by Plantation and Estates Limited.

Maskalls

No information obtained about the original notification. The reserve was extended in 1949 (SR & O 11), but had been lost by the late 1950s.

Maya Mountains

Gazetted by SI 42 in 1977 with an original ara of 362 $mile^2$ (938 km^2). An excision of 976 acres (395 ha) for a banana plantation at Medina Bank in 1979 (SI 13) reduced its area to 360.5 $mile^2$ (934 km^2).

Mountain Pine Ridge

Gazetted as a protection forest in 1944, and reclassified as a production forest in 1952. The first gazette notice on file is SR & O 19 of 1959 (207 $mile^2$ (536 km^2)), but the area was reduced in 1977 to 199 $mile^2$ (515 km^2) (SI 49). A further 840 acres (340 ha) were leased to farmers from San Antonio in 1990 (see Appendix 15), but the change was not formalized by statute.

Sibun

A Crown Forest Reserve by 1930, it was subsequently gazetted by SR & O 20 in 1959 with an original area of 199 $mile^2$ (515 km^2). SI 48 reduced the area to 166 $mile^2$ (430 km^2) in 1977. Some encroachment from the Hummingbird Highway has been tolerated, and a short-term licence was given for some of the accessible land close to the road.

Silk Grass

Gazetted by Notice 624 in 1922 with an original area of 10.5 mile^2 (27.2 km^2). The FD recorded 11 mile^2 (28.5 km^2) in 1977, but it was reduced to 10 mile^2 (26 km^2) in 1982 (SI 60). A further unknown area has since been leased out, but no statutory instrument has been published to describe the remaining area.

Sittee River

Gazetted by SI 47 in 1977 with an original aera of 146.7 mile^2 (380.1 km^2).

Swasey-Bladen

Gazetted by SR & O 6 in 1960 with an original area of 24 mile^2 (62 km^2).

Vaca

A Crown Forest Reserve by 1930.

Xcanha

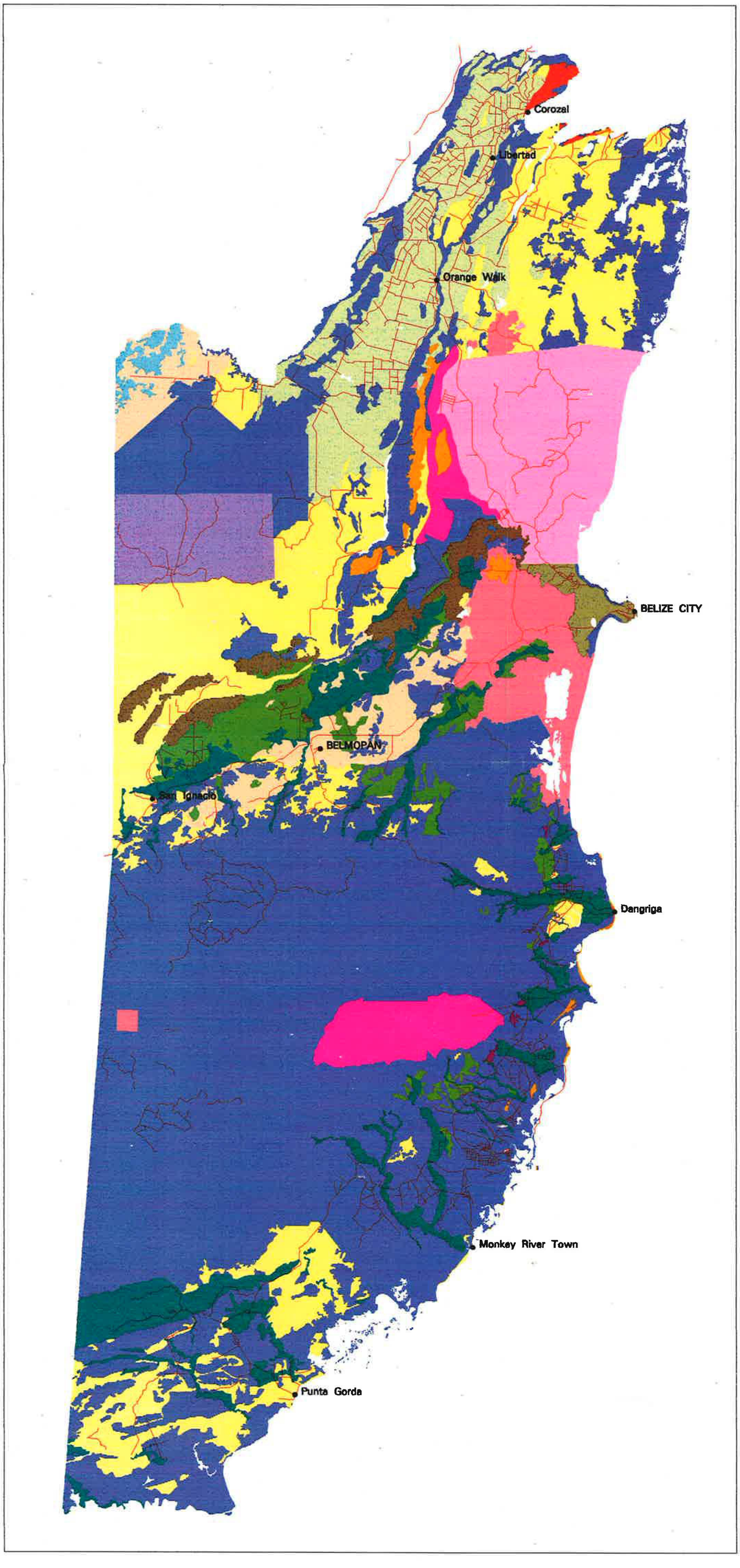
A Forest Reserve by 1955.

Yalbac Creek

Gazetted by SR & O 46 in 1956 with an orginal area of 71 mile^2 (184 km^2). Although the gazette unusually state that the reserve was designed 'to preserve from cultivation a valuable tract of mahogany forest', it no longer exists.

BELIZE 1:800,000

RECOMMENDED USE OF THE LANDSCAPE



LEGEND

- Grade 1 agricultural land, suitable for citrus, etc.
- Grade 2 agricultural land
- Grade 2 agricultural land, recommended for sugar-cane
- Marginal agricultural land
- Land suitable for cashew
- Land suitable for pasture
- Land suitable for rice
- Some land suitable for pasture, some for rice
- Protection forest
- Wildlife sanctuary
- Land suitable for controlled small-scale agriculture and ecotourism
- National Park
- Protection forest with limited agriculture
- Land reccomended for urban development
- Land suitable for tourism
- Land suitable for road gravel extraction

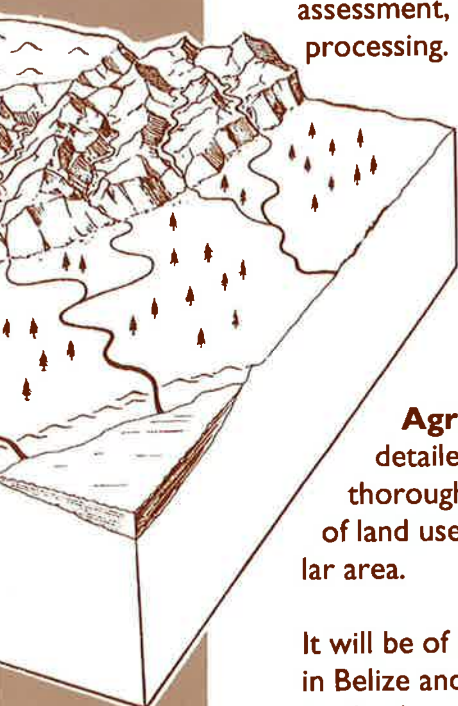
SHEET HISTORY

Base map derived from 1:50,000 series DOS 4499 Thematic data derived from 1:100,000 Land Systems maps by Dr R B King published by the Natural Resources Institute, Chatham Maritime, Chatham, Kent ME4 4TB, 1992.

Projection : Universal Transverse Mercator Zone 16
Datum : 1927 North America Spheroid : Clarke 1866

Natural Resources Institute

The Bulletin series presents the results of research and practical scientific work carried out by the Natural Resources Institute. It covers a wide spectrum of topics relevant to development issues ranging from land use assessment, through agricultural production and protection, to storage and processing.



Each Bulletin presents a detailed synthesis of the results and conclusions within one specialized area, and will be of particular relevance to colleagues within that field and others working on sustainable resource management in developing countries.

Agricultural Development Prospects in Belize completes the detailed land resources assessment undertaken by NRI. It presents a thorough picture of prospects in rural Belize and indicates the best type of land use - from smallholder cultivation to conservation - for a particular area.

It will be of specific interest to all involved in agriculture and conservation in Belize and also to those wishing to learn more about the application of the land systems and GIS approaches to rural managment.