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STATE OF THE ENVIRONMENT REPORT 2004

Mission Statement

The Environmental Management Authority is committed to protecting and conserving the natural environment to enhance the quality of life by promoting:

• Environmentally responsible behaviour •

• Development and enforcement of environmental legislation •

• Encouragement of voluntary compliance •

• The use of economic and other incentives •

This is to be achieved in an atmosphere of mutual respect, professionalism, accountability, transparency, collaboration and social responsibility.

Chairman's Message

The 2004 Annual Report is a significant advancement for the EMA in its capacity as a coordinating and collaborating agency. This state of the environment report is an assessment of the contribution of ecosystem services of the Northern Range of Trinidad and Tobago to human well-being. It is the result of a remarkable jointly lead pro bono collaboration between several civic society organizations and private individuals with the EMA and employees of several government Ministries and agencies acting in their personal capacities. We are particularly grateful to The Cropper Foundation and The University of the West Indies as well as the Permanent Secretaries and senior officers of several Ministries who gave of their personal time to guide the effort. The work was also supported by grant funding provided by the Millennium Assessment launched by Kofi Annan, the Secretary General of the United Nations in 2001.

In 2003 when the assessment was launched potential users summarised their expectations as follows:

On the part of the public sector: The assessment should seek to contribute to:

- Piloting an approach to multi-sectoral, integrated and inter-departmental collaboration and joint undertakings within the public sector; and between the public sector and academia/civic society/community initiatives;
- The country's current long-term planning exercise: the 2020 Vision;
- The establishment of a decision-making framework which might provide more comprehensive and integrated analysis of issues and options, within which specific proposals and ideas could be examined relating to use, management, and conservation of the assets of the Northern Range; this would contribute to a decision support system for public agencies;
- Examination of trade-offs within the response options of the assessment that would illustrate how such trade-offs might be handled; this would enable decision making to be more robust (eg. in relation to the use of hillsides of the Northern Range for housing);
- Eventual establishment of a scientific data base that will:
  - illustrate the characteristics of and catalogue the range of services provided by the Northern Range
  - underpin decision-making in the public sector (relating to preventative advice, mitigation measures, etc.)
  - be readily accessible and user friendly to all users
  - be accessible to communities;

- Methodological approaches for engaging with communities (eg. on the intentions and policy decisions of the Ministry of Works and Transport relating to infrastructure facilities);
- Provision of metadata for use by the Environmental Management Authority as an input into its National Environmental Information System;
- Articulation, in due course, of development standards and guidelines for planning purposes, taking into consideration factors such as carrying capacity, risks etc.;

On the part of civic society organisations: The Trinidad & Tobago chapter of The Tropical Re-Leaf Foundation is associated with the assessment as it will contribute directly to its own commitment to community reforestation of tropical regions generally, and to the Northern Range on which it is focused locally. The Trust for Sustainable Livelihoods promotes sustainable livelihoods: the watershed/community component of the assessment, insofar as it facilitates communities in identifying potential of the watersheds for sustainable livelihood activities, would contribute the groundwork which can be carried forward through the programme activities of the Trust. Part of the programme interest of The Cropper Foundation is to contribute to public policy for sustainable development. The assessment is explicitly geared to do so. The Trinidad & Tobago Citizens' Agenda Network (T&T CAN!) catalyses and facilitates citizens and citizen groups to actively contribute to the agenda and approaches to development. The assessment, having an origin routed in the civic society sector and involving a cross-section of groups and individuals, provides a demonstration of this organisation's raison d'etre and of one approach to influencing the country's official agenda. The fact that all the above organisations are at the centre of leadership, organisation and management of the assessment is not coincidental: the nature, process, rationale and anticipated outcomes of the assessment will contribute to their respective developmental interests.

- Assisting the country in making decisions that will help to meet its obligations under various international agreements relating to the environment and to sustainable development;
- General public awareness of environment-and-development issues and public understanding of the country's water resources policy, and biodiversity strategy and action plan;
- Use, application and implementation of the array of recommendations and policies which have over time been proposed but not taken up by the system: e.g. land-use map, forest management policy, environmentally sensitive areas; parks and protected areas; management and rehabilitation of quarries, community development, etc.

On the part of the University of the West Indies: the Principal of the University of the West Indies, St.Augustine Trinidad Campus has stated that the Northern Range assessment is relevant to its present agenda to rationalise its environmental and sustainable development programmes, to encourage more inter-disciplinary study, to establish a biodiversity centre with a focus on small islands, and to make its activities and expertise relevant to the needs of the society which it serves. The fact that the University is one of the sponsors, and that a good number of its faculty are involved in the working groups of the project, should enable these needs to be met.

We hope that this assessment of the Northern Range based as it is on a collaborative dialogue between several stakeholders to assess what is known along with the effectiveness of past actions as a rational basis for providing options for future responses will become the norm for our country.

Dr. John Agard
CHAIRMAN

REPORT OF AN ASSESSMENT OF THE NORTHERN RANGE OF TRINIDAD, TRINIDAD AND TOBAGO

'PEOPLE AND THE NORTHERN RANGE'

Project Sponsors:
The Cropper Foundation
The University of the West Indies
The Environmental Management Authority
The Tropical Re-leaf Foundation
The Trust for Sustainable Livelihoods

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In January 2002 the Board of the Millennium Ecosystem Assessment (MA) decided to support some aspect of the work of The Cropper Foundation, as a tribute to the late John Cropper. This decision led to a meeting between the Director of the MA and several colleagues who had been involved with John Cropper in his efforts between 1996 and 1998 to "regreen the Northern Range." Dr. Walter Reid, Director of the Millennium Ecosystem Assessment (MA), having examined the documents left by John, enthusiastically encouraged us to develop that initial interest as a sub-global assessment of the Millennium Ecosystem Assessment. The project began in March 2003 and continued to receive valuable support from the MA in the form of financing, conceptual and methodological guidance from its collaborators, and technical and administrative assistance from its staff. We convey appreciation to all of them.

The project was carried out by a large number of colleagues in Trinidad and Tobago, drawn from the sponsoring organizations and others, who contributed their services *pro bono*. It also had the benefit of advice from a group of colleagues, operating in their personal capacity, who function within the public sector. We are most grateful to all of them.

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This report is a contribution to the Millennium Ecosystem Assessment prepared by the Northern Range Assessment Sub-Global Assessment Team. The report has been prepared and reviewed through a process approved by the MA Board; but it has not been necessary for the MA Assessment Panel or Board to approve Reports of the Sub-global Assessments.

TABLE OF CONTENTS

LIST OF BOXES

LIST OF FIGURES

LIST OF TABLES

FOREWORD

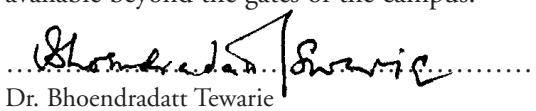
The Northern Range is undoubtedly one of the most important ecosystems in Trinidad and Tobago. Occupying nearly twenty-five per cent of the land area of Trinidad, and so close to the main urban areas, we are reliant on the Northern Range in many ways, ranging from space for residential development to recreation and education to a variety of invisible but vital environmental services. However, there is noticeable degradation of the Northern Range especially in its south-westernmost regions. It is evident that this degradation is now spreading both eastward and northward, expanding into many of the main valleys along its southern flanks. Some consequences of this degradation are readily evident in loss of forest cover and flooding of the city and plains, but appreciation of the full consequences depend on a deeper understanding of the range of services–the benefits which we enjoy–which are provided by ecological systems.

Such understanding can only come from a more systemic, science-based, and systematic approach to the way in which we organize and manage our ecosystems. At present, and as the Northern Range Assessment indicates, there is a general paucity of scientific data and information which can be used to inform policy. At the same time, the assessment illustrates the importance of having a holistic approach and sound science-based analysis on which to base policies.

Moreover, a framework for better co-ordination of public policy and management of interventions that affect the sustainability of the services of the Northern Range does not exist. Such coherence in policy and action will not be achieved without harmonious, in-depth collaboration among public agencies; between public agencies and research institutions; and with civic society organizations and communities. The assessment itself has demonstrated that such collaboration is possible: it represents an unusual and welcome combination of interests and resources from the sponsoring organizations (reflecting academic, public, and civic entities), as well as from colleagues in the public sector (albeit contributing in their personal capacities). How can we build on this example to make such an approach a way of operating within the society? It also represents fruitful collaboration between local and global entities and activities, in a synergistic and mutually supportive way. It is salutary to see that we have also contributed to global issues and processes through this local assessment, and that we do not have to be takers all the time.

The assessment makes a compelling case for new approaches in order to move towards sustainable development: for integrated planning based on a holistic appreciation of the problem, for co-ordination among the various entities whose activities affect the Northern Range, for more effective enforcement of policy and regulation, for public participation in the process of policy planning, for involvement of communities in management and care of their physical space, and for widespread public education about the relationship between our natural assets and our well-being.

The University of the West Indies is very proud to be a sponsoring organization of the Northern Range Assessment. I am gratified that so many of my colleagues here at the University, including five Professors Emeriti, were involved in the process. The assessment has identified the way in which the University's research agenda, including its student research activities, might contribute more directly to science for public policy analysis. Efforts are already underway at the University to encourage more integrated and inter-disciplinary research, to work collaboratively with civic and community-based organizations, and to make the intellectual resources of the University available beyond the gates of the campus.



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Executive Summary

1.0 Introduction

The Northern Range covers approximately twenty-five per cent of the landmass of the island of Trinidad. As an ecosystem it is very significant to the environmental, economic, and sociocultural life of the island, and the country of Trinidad and Tobago, because of the range of services–the benefits that the society enjoys–from its various functions and resources. Some of these services are visible and tangible, and are directly and consciously used or consumed by citizens. Others are invisible and intangible, and they contribute in indirect ways to meeting environmental and human needs, and thus to overall well-being of the society. (See page 11 of this Report for a diagram of the constituents of human well-being used in this assessment.)

The Northern Range meets needs of the society in a variety of ways:

- It provides space for housing and agriculture;
- It contains forests which cleanse the air, contribute to water retention and mitigate flooding, provide habitat for birds and animals, yield timber and non-timber materials;
- It is the major source of the freshwater resources for the island;
- Its coastal resources allow safe harbour, artisanal fishing, tourism enterprises, coastal protection;
- It is biologically diverse as it bridges Continental and Antillean systems;
- It is high in amenity value from land and marine resources, which underpins economic, cultural, and educational activities.

In this assessment, these benefits are categorized and described as provisioning, regulating, supporting, and cultural services of the ecosystem.

This is a very complex ecosystem, especially given the range of influences on its natural functioning as a result of the variety of human uses, and abuses, to which it is subject. Many factors-the driving forces-interplay to affect the resources and integrity of the functioning of this ecosystem. They include economic, demographic, institutional, natural, behavioural, technological, policy, and regulatory influences. Understanding its natural complexity, analysis of the driving forces which impact on the ecosystem as a whole and its individual functions, and evaluation of effectiveness of policies and management that are directly or indirectly relevant, are essential for sustaining the services of the Northern Range and consequently the well-being of the society. (See page 10 of this Report for a diagram of the conceptual framework for the assessment.)

This assessment seeks to catalyse such an effort towards better understanding and management. Its objective is to enhance understanding, analysis, and evaluation and thereby contribute to the process of public policy formulation, and to appropriate management for sustaining the Northern Range and the variety of services it provides.

In doing so the assessment has undertaken no new research. It has drawn on published scientific literature, supplemented by professional judgement and community perspectives. It seeks to

explore and illustrate links between the Northern Range and human well-being. Data required for such analysis are patchy in relation to certain resources or services or ecosystem/human well-being relationships, scant in relation to some, and non-existent in relation to others. Nevertheless, it is felt that the composite body of scientific knowledge, professional judgement, and community perspectives assembled in this assessment reveals condition and trends which justify a special and urgent effort, so that the integrity of this ecosystem is not further compromised and the well-being of the society that derives from its resources and functions is assured into the future.

The assessment defines the Northern Range as bounded on the north by the coastal strip, on the south by the Eastern Main Road, and including the city of Port-of-Spain and the western offshore islands.

The assessment is organized on the basis of three components, each a subsystem of the Northern Range: forest, freshwater, and coastal resources. These components interrelate and affect one another and the ecosystem as a whole. Biological diversity is inherent to each of the three subsystems and land use affects them all, adding to the complexity of the ecosystem and its subsystems. Biodiversity and land use are thus presented as cross-cutting themes. Each subsystem, while offering its own amenity value, contributes to the total amenity value of the ecosystem as a whole. This dimension thus overlays the entire assessment. Consequences of these findings about condition and trends in the Northern Range for well-being of the society are explored in the Report.

Responses–policies, legislation, regulations, programmes, and management–are expected to be sensitive to these dynamics. The assessment provides a broad sweep of the responses to date that have been specifically or indirectly related to the Northern Range, and offers a set of further response options for consideration.

2.0 Summary of Findings on Condition and Trends

2.1 Overview

1. It is evident that the Northern Range is being affected by a range of driving forces:
    a. Demographic: urbanization and pressure for housing space.
    b. Economic: search by some groups for livelihoods and housing space; increasing incomes by others and therefore demand for superior housing sites, facilitated by technology and mobility.
    c. Land use: permitted land use inconsistent with land capability studies and characteristics; unauthorized housing and agriculture; slash-and-burn method of land clearing.
    d. Institutional: lack of rules or lack of their rigorous application in planning and authorization of activities.
    e. Cultural: increased demand for recreational opportunity; misuse of environment; lack of understanding, care and sensitivity by users.
    f. Environmental: increasing variability in weather patterns.
    g. Public policy: lack of holistic planning; absence of co-ordination; ineffective management; no monitoring or accountability for impacts.
2. It is evident that the western section has been seriously degraded and that this pattern continues; that the eastern section is not as disturbed but that pressures are increasing; that freshwater sources are being depleted and waterways contaminated; that soil loss and flooding are exacerbated by forest clearance for housing, agriculture, and timber; and that

downstream impacts of this pattern of use and misuse are widespread, increasing in frequency and intensity, and generating high costs for compensation and correction.

3. Though it may be less evident from empirical evidence and scientific studies, it is highly probable that the above driving forces and patterns of use and misuse would lead to reduction of biodiversity through loss of species and change in habitats, and eventually to reduction in the invisible but essential supporting services the Northern Range provides.
4. The impacts and implications for the well-being of the society–of economic, cultural, health, security, and recreational significance–are definite and perceptible even if not measurable or quantifiable on the basis of existing data.
5. Given its geology, the Northern Range is very vulnerable from land use that is inappropriate to contour and slope characteristics.
6. It is foreseeable that conversion, degradation, and decline in its services will continue unless appropriate policies and management approaches and measures are applied.
7. There is a low level of popular understanding of the relationships between ecosystems and human well-being. Intensive public education is required if the society as a whole is to take responsibility for sustaining the Northern Range and the human well-being to which it contributes.

2.2 Forest Component

1. There is very little, up-to-date, organized, reliable data on the extent of forest cover in the Northern Range and it is not possible to give a precise account of the current extent of forest cover. **However, it is evident that forests have declined in extent and quality of cover, especially in the western section, and the eastern section is now under threat from use of land space for housing and agriculture.** Unauthorized agriculture is increasing in the eastern section. Past and continuing land use for housing, including high-income housing, is the dominant cause of conversion of the southern slopes in the western section. Although regulations prohibit building on gradients greater than 1 in 6, these are not enforced.
2. **Forests are being increasingly used for recreational and educational purposes.** The Northern Range is important as a recreational and tourist site (Table 11 of this Report), and the number of visitors to some of its sites exceeds the total for all sites in other parts of Trinidad.
3. Forest cover is closely associated with watershed management and surface-water quality and quantity. **Loss of forest cover is associated with exacerbated soil erosion and flooding.**
4. Forest fires are also a source of forest degradation. **Over the last fifteen years, there has been no steady increase in the extent of land in Trinidad affected by fire (Fig 27), but the Forestry Division has noted increasing threat to primary forests within the valleys of the Range by fires due to inappropriate agricultural practices.** The highest proportion of forest fires occurs in the Northwest Conservancy in the areas that are most heavily settled (Annex 5).
5. **One of the factors that contributes to the degradation of forest resources is the lack of capacity to monitor activities and enforce legislation even where it exists.** One response to this has been the establishment of a system of honorary game wardens by the Wildlife Section of the Forestry Division, which enlists the help of volunteers to monitor illegal hunting of wildlife in Trinidad's forests. However, this system has not achieved its main objective mainly because of threats to personal safety.
6. The geology of the Northern Range makes it prone to land slippage, with consequent soil loss. **This underscores the importance of the forest cover of the Northern Range, as**

natural forests seem to be most effective in helping to control downstream effects such as flooding and sedimentation (Table 10).

7. The economic returns from timber and wildlife harvesting from the Northern Range are not high (Table 8). **The value of its regulating, supporting, and cultural services, as well as its amenity value and the potential for economic activities based on such amenity value, could be considerably higher.**
8. Appropriate planning will be required to ensure that the forests of the eastern section of the Northern Range, together with the biodiversity and freshwater resources which it encompasses, remain intact so that all its services can be sustained. **Zoning of the eastern section of the Northern Range for conservation purposes and appropriate but prescribed activities, and strict enforcement thereof, would be the single most effective intervention that can be made.** This would provide the planning framework for numerous other responses that are required in relation to other ecosystem services.

2.3 Freshwater Component

1. **The watershed areas of the Northern Range are the most significant contributor to fresh water supply for the island of Trinidad.** Of the surface freshwater sources exploited in Trinidad and Tobago, 80% comes from the Northern Range (WRA 2002). On the south-facing slopes, several major tributaries contribute to the Caroni River above the intake of the Caroni-Arena Water Treatment Plant, which is estimated to supply about fifty-one percent of Trinidad's potable water. The eastern section of the Range contributes more than the western section. **There is evidence to suggest that rivers flowing from primary forests release twice as much water halfway through the dry season, and between three and five times as much at the end of the dry season as do rivers flowing from cultivated land.**
2. Impacts on quality of freshwater resources can be a result of activities at the watershed level (e.g., land-use change) or in-stream activities (e.g., channelisation, pollution). **The Northern Range watersheds are becoming more degraded due to deforestation for agriculture on steep slopes, housing and associated infrastructure, road construction, squatting, quarrying, and forest fires.** The area of forest cover has declined (even with reforestation through the Northern Range Reafforestation Project) resulting in disruption to hydrological processes and negative impacts on health of the aquatic ecosystems. Watersheds are being affected by a decrease in water retention through loss of forest cover, and water courses are being affected by pollution from human use and sedimentation from soil erosion.
3. **For Trinidad, supply of freshwater currently exceeds demand, but this is projected to be more closely balanced by the year 2025, especially during the dry season (Tables 13 and 14). The recent discovery of deep bedrock megawatersheds in the islands of Trinidad and Tobago is significant for meeting the country's demand for freshwater in the future.** The country's long experience in petroleum drilling could make it well placed to exploit these deep ground-water resources. It should be noted, however, that such deep ground-water is not a renewable resource (except over an extremely long period). So it would be necessary to protect and conserve both surface-water sources and deep-water resources. While appropriate watershed management could protect and conserve surface and aquifer water, deep ground-water resources are not rechargeable through surface watershed management. If accessed, this body of water will need to be harvested conservatively to prolong its availability.

- **An indicator of the high economic value of surface and aquifer freshwater provided by the Northern Range may be provided by a rough estimate of the cost of substituting this water with desalinated water:** it is estimated that 80% of the surface water sources in Trinidad and Tobago exploited by WASA comes from the Northern Range. It is also estimated that WASA currently spends about TT $13.4 million per month to buy 10% of its water supply from a local desalination plant. If WASA had to substitute the surface water supplied by the Northern Range with desalinated water at this price, it would cost in the order of TT $107 million per month (or TT $1,286 million per year).

4. **It is speculated that about fifty to sixty per cent of the island's water supply is lost after harvesting and treatment because of old and faulty distribution infrastructure.** Much saving of water and cost could be realized through investment in renewing water-delivery infrastructure.
5. Though not as important to well-being as the provision of freshwater for domestic, agricultural, and industrial activities, the freshwater resources of the Northern Range also provide fish for food. **There is a declining trend in freshwater fish catch for the country as a whole. Since most of the rivers are located in the Northern Range, the same conclusion might be made for freshwater fish catch from the Northern Range.**

2.4 Coastal Component

1. **The Northern Range includes a range of coastal habitat types–wetlands, beaches, seagrasses, algal communities, and coral reefs.** While their significance for ecological functions and amenity value are known, there is very little information on the condition and trends in the services derived.
2. **However, it is evident that coastal resources are under threat from land-based and coastal activities, including intensive use for recreational purposes. Major causes of disturbance are coastal development, land-based activities which contribute to pollution and eutrophication, over-exploitation of coastal resources, and natural disasters.** There is evidence of increased levels of pollution in some coastal areas after intensive use for recreation. Studies indicate that the purification capacity of coastal waters is often exceeded in popular recreational waters. The western section of the North Coast is noted as one of the most fished areas in Trinidad. Soil erosion combined with flooding lead to sedimentation of coastal waters with negative consequences for uses of the coastal strip and functioning of coastal wetland resources.
3. **Coastal resources are being heavily used and coastal waters contaminated from a variety of practices.** High and growing demand for the use of the coastal resources for recreation, tourism enterprises, fisheries, anchorage and sea transportation, and conflicts among these activities for use of limited resources, have implications for sustainable management. **The trade-offs among these are not being actively examined and managed.**
4. **The protected Chaguaramas Bay in the north-west peninsula of Trinidad provides safe anchorage for boats and yachts, especially during the hurricane season. This has spawned intensive use of this section of coastal waters.** The most recent example of this is the movement of yachts within the Caribbean to the Chaguaramas peninsula during Hurricane Ivan in September 2004. The activities spawned by this safe anchorage service generate jobs and income, but also contribute to pollution of these coastal waters.
5. Comprehensive data on fisheries are not available, although it is reported that for the Caribbean Sea as a whole, **catch per unit of effort is declining and fishing is lower down the food web. The same trend can be extrapolated for Trinidad and Tobago.**

2.5 Biodiversity

1. Given the origins of the island of Trinidad, it represents a dividing line (an ecotone) between Antillean and Continental species, and makes the island rich in species diversity. **Many of the species recorded for the islands of Trinidad and Tobago are found in the Northern Range (Table 5). This gives the Northern Range a very special character in terms of biological diversity.**
2. A deep understanding of the species diversity of the Northern Range–its links with human well-being; detailed knowledge about the condition and trends in the abundance, diversity, and distribution of species; and how these are affected by driving forces-is constrained by data and information paucity. Several species have not been reflected in the current assessment for this reason. **Lack of scientific information results in not knowing how critical the role of any species is within the ecosystem and therefore the precise ways in which they contribute to ecosystem services.** We can only speculate, based on general scientific principles, about the ecological value of species found in the Northern Range.
3. **A few species are endemic to the Northern Range because of the special climatic and edaphic conditions which exist especially at higher altitude,** e.g., the golden tree frog *(Phyllodytes auratus)* and the luminous lizard *(Proctoporus shrevei)*. Several plant species currently considered to be endemic are noted.
4. **Species diversity is linked to genetic diversity, but very little information exists about the genetic diversity of Northern Range species, except for cocoa,** which has been cultivated in the Northern Range and elsewhere in Trinidad as a commercial crop.
5. **Several species have demonstrated economic value (Table 4).** For example, the lappe, agouti, and deer are prized hunting game species. Species like the Pawi and marine turtles generate revenue through eco-tourism activities. **The amenity value of species diversity, especially birds, is high but the economic potential of this is not significantly realized.** Some species, like the howler monkey *(Alouatta seniculus)*, which is known to be a carrier of the Yellow Fever virus, have also been identified as potential species for medical research. Species which are not known to be or are not currently of economic value, and for which information does not currently exist, may be potentially important for medical research and for maintaining integrity of the ecosystem, as well as for their use for recreational and educational purposes.
6. **The main threats to the biodiversity of the Northern Range are habitat destruction (including fragmentation) resulting from forest fires, logging, clearing for housing and agriculture, and over-exploitation of wildlife species. Ineffective or lack of enforcement of existing regulations allows unmanaged harvesting of wildlife species to occur.** Information about the pattern and frequency of such threats indicate negative consequences for distribution and abundance of species in the Northern Range, especially for specialist species like the Pawi, oilbirds, golden tree frog, and other forest interior species like the ocelot and lappe. The species most under threat include the Pawi (which has been recommended to be formally designated as an Environmentally Sensitive Species), the ocelot and the river otter.

2.6 Land use

1. The northern slopes of the Northern Range are generally not under intense pressure for human settlement mainly because of their inaccessibility, given the rugged terrain and the sea cliffs along the North Coast. Early settlements have concentrated mainly along the foothills of the southern slopes and the accessible valley areas. **Recently, however, there**

has been movement up the slope in a number of the valleys. This is usually done in non conformity with land capability and proper land-use management.

2. Slopes of the Northern Range are very attractive for high-income homes. This pattern of land conversion for housing is facilitated by the current wealth of the country and by modern architecture, engineering, and means of mobility. **The Northern Range is thus affected by authorized high-income housing as much as by unauthorized low-income settlements.**
3. **The lower reaches of fertile valleys in the western section are now converted from agriculture into housing.** The exception is Tucker Valley in Chaguaramas which is State owned and used as a farm for producing seed for various crops. At the same time, unauthorized agriculture on the upper slopes of these valleys is quite common, though in small pockets. A pattern of small-scale, unauthorized and inappropriate agricultural crops and practices is now observed in the valleys and slopes of the eastern section of the Northern Range, including within Forest Reserves.
4. **No timber is now officially harvested from natural forests in Forest Reserves because over-exploitation in the past has resulted in depleted reserves.** However, in recent years there has been a trend of old family-owned estates being sold and their commercial timber being removed.
5. **The Northern Range is the main source in the country of deposits of blue limestone and other non-hydrocarbon construction materials. Lack of implementation of the Mining and Minerals Act, 2000 allows quarrying to proceed in an unregulated manner, with many negative impacts and nuisances, and without restoration of sites.**
6. **Land-based sources of pollution (from quarrying, agriculture, waste disposal and malfunctioning sewage-treatment plants) pose a major threat to the Northern Range freshwater resources and thus to coastal environments,** as the coastal zone receives water from rivers and drains and is therefore the ultimate sink for effluents generated from land-use activities.
7. **Numerous bush fires which ravage terrestrial vegetation during the dry season take their toll on coastal vegetation during the rainy season, as exposed soil runs off into the sea, smothering coastal systems like seagrass beds.**
8. **Deforestation on Northern Range slopes leads to increased sedimentation in rivers, especially in the rainy season.**

2.7 Amenity Value

1. Amenity value of the ecosystem of the Northern Range contributes to human well-being through recreation, education, religious practices, and tourism. **Amenity sites in the Northern Range are numerous and varied and are major contributors to the interests of residents and visitors.**
2. The forests, rivers, and coastal zone of the Northern Range offer many opportunities for recreation and cultural activities. **Though there is little systematic documentation of the flows of visitors and monetary value of these activities to the national economy, their importance to national well-being and eco-tourism is growing. However, the amenity value of these resources is threatened by incompatible uses, exceeding carrying capacity, absence of facilities, and misuse.**
3. **At the same time, demand for these services is growing** due to increasing accessibility, mobility, leisure time, and wealth of users.

4. **The forests of the Northern Range and their biota have supported significant international research in a variety of fields for almost 100 years.** Scientific research conducted on the Northern Range has always included some coverage of the rivers and other aquatic ecosystems.
5. **The economic potential of the amenity value of the Northern Range may well exceed the returns from forestry, agriculture, mining, and wildlife harvesting which the ecosystem supports.**

2.8 Summary of Condition and Trends

Based on the assessment made from both quantitative data and professional judgement, the table below summarizes conclusions about trends for most services derived from forests, freshwater, and coastal resources of the Northern Range. These conclusions relate to trends in the capacity of these components to deliver their services and not to the human demand for use of those services.

Summary Table: Assessment of Condition and Trends

Northern Range ecosystem service	Service type - Provisioning/ Regulating/ Supporting/ Cultural	Condition	Trend	Certainty level
Forest ecosystems				
Timber and non-timber forest products	Provisioning	Fair	Declining	Medium
Land space	Provisioning	Fair	Declining, especially in the south-western regions of the NR	High
Minerals	Provisioning	Good	Decreasing	High
Runoff regulation and retention	Regulating	Fair	Significant decline especially in the Western NR	Medium
Soil conservation	Regulating	Fair	Declining	Medium
Water cycling and replenishment	Supporting	Fair	Declining	Medium
Amenity value	Cultural	Good	Declining, especially in the south -western regions of the NR	Medium
Freshwater ecosystems				
Water resources	Provisioning	Fair	Declining, especially in the south-western regions	High
Fisheries, aquaculture	Provisioning	Fair	Declining	Low
Waste disposal, assimilation, and treatment	Regulating	Fair	Declining	Medium
Flood regulation, water storage	Regulating	Fair	Declining, especially in the south-western regions of the NR	Medium
Amenity value	Cultural	Fair	Declining, especially in the rivers on the southern flanks	Medium

Northern Range ecosystem service	Service type - Provisioning/ Regulating/ Supporting/ Cultural	Condition	Trend	Certainty level
Coastal ecosystems				
Fisheries	Provisioning	Fair	Declining (as evidenced by the increase in effort per unit catch)	Low
Safe anchorage	Provisioning	Good	Stable	High
Waste disposal, assimilation and treatment	Regulating	Fair	Declining	Medium
Amenity value	Cultural	Good	Declining, especially in the south-western region of the NR	Medium

Given the constituents of human well-being (Fig 5) and their linkages with ecosystem services (Table 2), overall consequences for the well-being of Trinidad and Tobago citizens of the condition and trends presented can readily be inferred, although it is not possible to assess quantitatively consequences associated with a given ecosystem change.

Our demands on these three components of the Northern Range, especially for their amenity value, have been increasing. More purposeful management strategies are required to ensure that user demand as well as ecological functions can be satisfied. **Fortunately, maintaining amenity value to satisfy user demands would at the same time sustain capacity for the regulating and supporting services, which these components provide. This positive relationship is very relevant to policy decisions about management and use of these resources in the short and long term.**

3.0 Responses and Response Options

3.1 Assessment of Responses to Date

Based on an assessment (Section 9) of a range of responses (policies, legislation, regulations, programmes, projects) undertaken by official public entities as well as the civic and corporate sectors, the following conclusions have been made:

1. It is evident that there are many policies and plans within the public sector that have implications for the country's ecosystems generally, and for the Northern Range specifically. **Altogether the range of policy instruments that might generally or specifically affect the Northern Range reveals awareness of the issues and declarations to address them.**
2. **But this array of policies and plans is not being systematically or adequately translated into action and effectiveness. While links between ecosystems and human well-being are embodied in many documents, these links are not made explicit; nor are targets for, and impacts on, the ecosystem or human well-being enunciated.**
   Given the assessment of condition and trends, it is apparent that these policy instruments are not effective in achieving their objectives. This is the result of a general lack of follow through on many policies; consequently implementation is patchy, and enforcement of the stipulations of the policies is not rigorous.
3. **Moreover, where these links are pursued they are done on a very sectoral basis, and not cross-referenced to, or co-ordinated with, policies or activities of other sectors.**

The highly sectoral organization of the public administration system, in which responsibilities that have implications for the Northern Range are distributed among many government departments and statutory authorities, inhibits systemic application of these official policies.

4. Despite this fractured system, **there is no co-ordinating mechanism to ensure that all agencies are operating consistently with these policies,** or to make use of synergies or manage the trade-offs among their objectives and activities.
5. **Understanding of the links between the natural environment and human well-being is at a very low level within the society. But there is evidence that such awareness is beginning to take root among small groups and within a few communities.** Many small community-based initiatives are underway and many special-interest groups are organized as nongovernmental organizations. While their impacts are localized and limited, their special initiatives are considered useful in taking responsibility, showing leadership, motivating and mobilizing people and resources to address particular issues. They have been at the forefront of advocacy and public education for environmental management and resource conservation. However, they have not yet attained critical mass to make a significant difference; especially as the major driving forces or potential for responding are outside their influence or capability, and their activities are not undertaken within an overall planning framework for the Northern Range.
6. **A practice of evaluating effectiveness of policies and implementation of plans, rules, and regulations; or of monitoring and evaluating outcomes and impacts of activities, is not established within the public sector.** Thus there is no feedback into successive rounds of policy-making.
7. **There is a range of international and regional treaty law and agreements to which the country subscribes that have implications for natural resource management and sustain able development, which would by extension be relevant to the Northern Range.** These are sometimes reflected in the national legislative and policy framework, more often they are not so reflected; and **a poor track record of implementation implies that these agreements do not significantly affect the matters that are their subject.**

3.2 Options for Further Responses

Responses are required that are sensitive to the dynamics of the Northern Range as an ecosystem, to the driving forces which affect its integrity and its functioning, and to the human well-being that is directly and indirectly associated with its services. Some options for consideration are examined in the Report in two categories, although there is no watertight separation between them:

- Framework responses, which relate to the overall system of policy and public administration, to governance and public involvement, and responses which are capable of achieving multiple outcomes;
- Specific responses, targeted to issues and needs within each of the three components of the Northern Range assessed (forests, freshwater, coastal resources) as well as relevant to the cross-cutting themes of biodiversity, land use, and amenity value.

No response options specifically dealing with human well-being are presented: the contribution to human well-being made by the Northern Range will accrue and be sustained to the extent that appropriate responses are made to arrest declining trends and to sustain its services.

3.2.1 Framework Responses

3.2.1.1 Implementation of Policy; Enforcement of Regulations

1. **Implementation of existing policies and plans, suitably revised in the light of this composite assessment, would be the most immediate response that might be considered.** Policy implementation takes place mainly through projects which channel funds to stated objectives. The various policies depend upon development and funding of projects through which they could be applied. But such projects do not automatically follow the formulation of policies, as projects have to compete for funding within the Public Sector Investment Programme or funded by an external agency. This approach to public-sector investment is a major limitation to policy implementation. One option is for decision-makers to require that proposed policies be accompanied by proposed implementation plans. Another is for policies of specific relevance to the Northern Range to be accompanied by commitment of dedicated funds to implement projects as a means of ensuring implementation of the policies. This would be only one aspect of clearly defined implementation plans. **Similarly, there is a considerable body of legislation and regulation which is not well enforced.** Noncompliance with existing policies and legislative provisions occurs within public agencies and by citizens.
2. **But implementation also requires appropriate human capabilities and administrative arrangements, as does enforcement.** While the size of the public service is relatively large, whether there are suitable competencies at the appropriate levels required for implementation and enforcement is a question to be addressed. Enforcement of regulations relating to the Northern Range might be better achieved if there is clear location of responsibility and accountability with the necessary resources being provided to enable effective enforcement.

3.2.1.2 Integrated Planning; Co-ordination and Collaboration

1. **Comprehensive planning for the Northern Range might be undertaken with the following core elements:**
    - **Zoning of the eastern section of the Northern Range for conservation purposes,** while there is still time, to avoid the pattern of land conversion and use that characterizes the western section;
    - **Revised contour and slope limits to construction of housing in the western section,** in light of cumulative downstream experience to date, with strict enforcement of stipulations;
    - **Urgent executive and legislative action on proposals for Environmentally Sensitive Areas and Species,** with the required management authority and arrangements clearly established and resourced;
    - **Local area physical development plans (required by the Town and Country Planning Act 1968) compatible with the overall plan for the Northern Range.**
2. **Recognizing that Northern Range related activities cut across various sectors and ministries, one option is to consider planning and decision-making for the Northern Range as a single ecological and socioeconomic system,** given the significance it has for the country as a whole. This could then lead to designation of political and technical leadership, and to setting up the public administrative mechanism/s that would be required for oversight, coherence, and co-ordination. **One approach to this is a sustainable development council for the Northern Range, which would be charge to**

oversee the Hillside Development Policy, revised to embrace the whole of the Northern Range, and to co-ordinate activities in the Northern Range relating to housing, infrastructure, tourism, water/forest/coastal resource management, mining, agriculture, and community development. These all have to be compatible within an approach to the Northern Range that seeks to identify and manage trade-offs among the environmental, economic, and social aspects of development.

3. **Increased collaboration among all sectors–academic, public, civic, community–would also contribute to better co-ordination of initiatives.** An alternative to a sustainable development council for the Northern Range might be to set up a Cabinet-appointed Northern Range co-ordination mechanism under the Ministry of Planning and Development.

3.2.1.3 Governance Arrangements

1. **One immediate response given the country's highly centralized governance system would be for policy, implementation and enforcement, and management to be devolved to the various Regional Authorities into which the Northern Range falls.** This would allow for local area development plans to emerge, and would make possible a framework for local community involvement in joint management of Northern Range resources. Devolution of authority and decentralization of services to local authorities could have many positive consequences, including planning and managing development for, and with, communities. But local authorities will require adequate staff with appropriate expertise and experience, in keeping with expanded authority and responsibility, as accountability would require resources necessary for carrying out the functions.
2. **One option to compensate for lack of public sector capacity for planning, implementation, and enforcement would be to devolve management for natural resources and assets to communities, within the framework of local government authorities, and in the context of clearly articulated national policy.** This option is predicated on compatible and facilitative local government arrangements, on effective education and training, and on easy and continuing access to technical support, to equip local government authorities and communities for this role. Community motivation and engagement would be more likely to occur if communities were involved in a consultative process about policies that would affect them or their space, and if benefits from such involvement are evident. There need not be total devolution of management responsibility at once or in all situations; and government's role in implementation could be designed to decrease in tandem with an increase in competencies of the local authorities and civic/community sector.
3. **Early involvement of the private sector is also likely to affect conformity positively with official policy.** Its decisions and actions are of central importance in an overall societal approach to sustain ecosystem services and to assure continuous progress in human well-being.

3.2.1.4. Public Responsibility and Public Education

1. It would appear that public understanding of how natural resources are related to the long-term development of the country and to the well-being of the society is quite superficial. **Processes for open discussion, better public understanding of the rationale for policies and regulations, and transparency in public decision-making could positively affect attitude and behaviour of the public.** Public responsibility

depends on awareness of the issues and understanding of how they matter to human well-being. This in turn requires intensive and systematic public education.

2. While there are pockets of public education effort initiated by civic organizations, they are scattered and discontinuous and have not attained critical mass. Financial support for these activities from public sources would strengthen and sustain them. This would capitalize on their initiative, energy, and expertise and would complement the rudimentary efforts possible within the formal education process, given an overloaded formal education curriculum. **Public education could be accelerated through a national sustainable development education strategy and action plan, designed to incorporate existing initiatives and actors, and supported as necessary by materials and technical assistance.**

3.2.1.5 Financing Management of Natural Resources

1. **More attention to the use to which funds are put, rather than to availability of funds, may be useful.** Where the question of availability of funds persists, the policies and responses that are being considered need to be designed to be more financially autonomous. Arrangements need to be built-in to decrease dependency on government's central funds and therefore on the vagaries of political will for policy implementation and enforcement. In this regard, the transparent activation of the Green Fund is long overdue.
2. **User fees, and fines for noncompliance with site regulations would be a source of financing for specific amenity sites** and for developing desirable habits in relation to the use of sites.

3.2.1.6 Research and Documentation

1. **Research organizations might consider a series of possible responses to the need for the type, range, and continuity of data required for continuous monitoring and evaluation, and for periodic assessments of this kind:**
   - Linking research resources with public interest issues and public policy needs
   - Developing a research ethic that embodies sustainable development principles
   - Designing research that is interdisciplinary and multi-sectoral
   - Collaborating in research with other entities, including communities.

   The University of the West Indies at St. Augustine could take a leadership role in reflecting the above characteristics in its research approach and agenda.
2. **It would greatly help future assessment activities of this kind if research results relating to the Northern Range held by various government departments from consultancies, along with those from the University and other research organizations, could be available in a central location in hard copy and also via the Internet.** If processes for public involvement are to be effective, transparency and freedom of information will be required.

3.2.1.7 Monitoring and Evaluation

A systematic approach to monitoring and evaluation of impacts of policies and programmes on the Northern Range is required, which would provide necessary feedback into successive rounds of assessment, research, and policy formulation. Better practice here might be attained in the wake of clear designation of responsibility and accountability for implementation.

3.2.2 Multi-purpose and Specific Responses

A summary of response options for multi-purpose or specific issues relating to the Northern Range can be found on pages 113 to 115 of this Report. They relate to cross-cutting themes as well as specific ecosystem services. It will be readily seen that the measures identified would be symbiotic, and can be expected to be most effective if undertaken in the context of the Framework response options discussed above.

ACRONYMS

AWNC	Asa Wright Nature Centre
CARE	Citizens in Action to Restore the Environment
CAREC	Caribbean Epidemiology Centre
CARICOM	Caribbean Communities
CARSEA	Caribbean Sea Assessment
CBD	Convention on Biological Diversity
CIDA	Canadian International Development Agency
CITES	Convention on International Trade in Endangered Species
CSO	Central Statistical Office
EMA	Environmental Management Authority of Trinidad and Tobago
ENRP	Eastern Northern Range Plan
ESA	Environmentally Sensitive Area
ESS	Environmentally Sensitive Species
EVI	Environmental Vulnerability Index
FAO	Food and Agriculture Organization of the United Nations
FRIM	Forest Resources Inventory Management Unit (of the Forestry Division)
GDP	Gross Domestic Product
GIS	Geographic Information Survey
GoTT	Government of Trinidad and Tobago
GRANTA	Grande Riviere and Nature Tourguide Association
IMA	Institute of Marine Affairs
IGBP	International Geosphere–Biosphere Programme
IHDP	International Human Dimensions Programme on Global Environmental Change
IPCC	Intergovernmental Panel for Climate Change
IUCN	International Union for the Conservation of Nature

MA	Millennium Ecosystem Assessment
MALMR	Ministry of Agriculture Land and Marine Resources
MARPOL	Marine Pollution Convention
MCM	Million Cubic Metres
NEP	National Environmental Policy
NR	Northern Range
NRHDP	Northern Range Hillside Development Policy
NRRP	Northern Range Reafforestation Project
PVA	Population Viability Analysis
SAD for Toco	Stakeholders against Destruction for Toco
TIDCO	Tourism and Industrial Development Company
T&T	Trinidad and Tobago
T&TCAN!	Trinidad & Tobago Citizens Agenda Network
TT $	Trinidad and Tobago Dollars
TTMS	The Trinidad and Tobago Meteorological Services
UN	United Nations
UNDP	United Nations Development Programme
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UWI	The University of the West Indies
UWI/SEDU	The University of the West Indies / Sustainable Economic Development Unit
WASA	Water and Sewerage Authority
WRA	Water Resources Agency
WRI	World Resource Institute
WRMU	Water Resources Management Unit
WTO	World Trade Organisation

1.0 Introduction

1.1 Rationale

Ecosystems provide many services from which humanity benefits and which are vital to human well-being. The capacity of ecosystems to provide these benefits is affected directly and indirectly by many driving forces, most of which originate in the human sphere through economic, social, and technological patterns; through population dynamics; and through cultural attitudes and behaviour. The Northern Range is a major ecosystem in the island of Trinidad, and it provides a range of benefits for residents of this island, for the national population, and for visitors to the country. It is evident that rapid changes are taking place in the Northern Range, and it is imperative that the society understands and manages these changes, so that the future well-being of people, as well as other species that depend on this ecosystem, are not undermined.

The assessment therefore seeks to present a holistic understanding of the ways in which natural, institutional, and human forces are impacting on the Northern Range and its capacity to continue to provide these services indefinitely. It seeks to illuminate the precise ways, direct and indirect, in which these services contribute to the well-being of the society. It also seeks to explore ways in which the society might respond to the condition and trends which are found in the ecosystem, to minimize negative impacts on its capacity and functioning as a natural system while the society makes use of what it offers to enhance its well-being.

The intention is to seek to influence the direction and content of policy, and the quality of management and enforcement of measures directed to the goal of sustainability of these services, by providing an analytical context and diagnosis. The assessment will also establish a baseline for information and understanding about the Northern Range as an ecosystem, based on existing scientific data and knowledge, and on professional and community perceptions and understanding, which might engender continuing monitoring and assessment of impacts, and consequences for communities and the nation as a whole. It is hoped that the exercise would also catalyse similar undertakings for other natural resource systems in the country, to build an appropriate approach and model for planning and decision-making about use and management of those resources.

The emphasis is on understanding the interlinkages among the various functions which the Northern Range as an ecosystem provides, as well as the links with aspects of the well-being of the society, including an understanding of how these relationships affect communities that are located within the Northern Range. For this purpose, three watersheds were selected for on-the-ground exploration with their communities, a process which made possible a blending of scientific knowledge and opinion with community experience and understanding.

The assessment seeks to carry forward the following two initiatives:

- The antecedent work of the late John Cropper, undertaken during the period 1996 to 1998 under the aegis of UWI/SEDU, to motivate, guide, and support some selected communities to engage in 'regreening the Northern Range' as a way of contributing to their livelihoods and to restoration and maintenance of the services provided by the Northern Range;
- The concerns of the Sustainable Development Network, a group of concerned professionals initiated by The Cropper Foundation in 2001, whose Statement of Purpose reveals its concern about the lack of application of, and compliance with, planning frame works and processes in the country, as well as about the lack of opportunity for civic society to contribute to the policy-planning process. (This network of persons has served as the Steering Committee for the assessment.)

The main audience for this assessment is, therefore, the groups of people–within central and local government authorities, communities, businesses, and nongovernmental organizations–who take decisions and undertake actions that have direct impact on the Northern Range. But it is also intended that the findings of the assessment will be used to promote general public awareness of the links, in particular, between the Northern Range and the well-being of the society, as well as of the links, in general, between the country's environmental resources and its well-being.

This report summarizes the assessment that has been made of:

(i) The current condition of selected 'services'–benefits that humans derive–provided by the Northern Range which are directly related to the well-being of the society (e.g., biodiversity[1] , freshwater, recreation);
(ii) The forces which explain this condition;
(iii) The 'responses' the society has made, that is to say, policy, programme, and legal and regulatory provisions that are intended to alter directly or indirectly, or avert a worsening of, the condition;
(iv) Further options that may be considered for responding to the issues identified, to sustain the services of the Northern Range as an ecosystem, and thereby secure the contribution to the well-being of the society which it makes.

1.2 The Northern Range Assessment in a Global Context

The Northern Range assessment is one of thirty-three sub-global assessments undertaken as a part of the Millennium Ecosystem Assessment (MA)[2]–a global initiative intended to provide a comprehensive assessment of the state of scientific knowledge concerning the consequences of ecosystem change for human well-being and options available to enhance the conservation of ecosystems and their contributions to meeting human needs. The MA conceptual framework[3] and methodology, developed at the global level, provide the basic approaches for these sub-global efforts, all of which contribute, as appropriate, to the findings and insights of the global programme.

[1]Biodiversity - a contraction of Biological Diversity.
[2]For more information on the Millennium Ecosystem Assessment, see the Millennium Ecosystem Assessment website - www.millenniumassessment.org.
[3]The MA Conceptual Framework Diagram is shown in Figure 4. For a full presentation of the approach of the MA, see Millennium Ecosystem Assessment, Ecosystems and Human Well-being, Island Press, 2003.

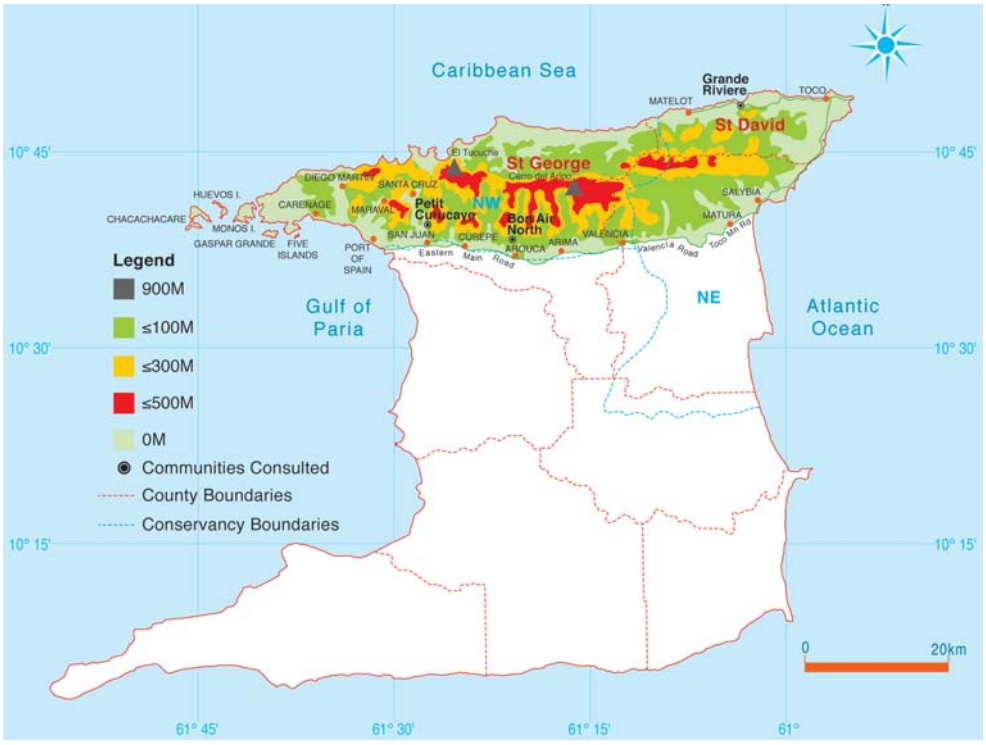
2.0 Description of the Northern Range

2.1 Definition of the Northern Range

The Northern Range is the most dominant relief feature on the island of Trinidad, one of the two islands which make up the Republic of Trinidad and Tobago. The Range stretches across the entire width of Trinidad, a distance of approximately 96 km (60 miles), between the Chaguaramas peninsula in the west and Toco in the east, and is about 16 km (10 miles) at its widest point. It extends from the north coast of the island, southwards to the Caroni Plains, and includes the capital city Port-of-Spain (Fig. 1).

For the purpose of this assessment, the Northern Range is defined by the entire north coast of the island, from Galera Point in the east up to and including the islands at the western tip of the Chaguaramas peninsula (which are the Five Islands, Carrera, Kronstadt, Gaspar Grande, Centipede, Monos, Huevos, and Chacachacare). To the south, the range is bounded by the coast from Chaguaramas to Port-of-Spain, and by a road artery that generally traces the southern extent of the foothills of the Range (the Eastern Main Road) from Port-of-Spain to Valencia, the Valencia Road to where it meets the Toco Main Road, and the Toco Main Road to Salybia[4] (Fig. 1). The definition used includes the coastal zone. Though by some definitions the entire island of Trinidad would be considered coastal, for the purpose of this assessment the MA definition is used (MA 2005b): Systems containing terrestrial areas dominated by ocean influences of tides and marine aerosols, plus near-shore marine areas. The inland extent of coastal ecosystems is the line where land-based influences dominate, up to a maximum of 100 km from the coastline or the 100-m elevation (whichever is closer to the sea); the outward extent is the 50-m-depth contour.

Fig. 1: Northern Range: Topography and Boundaries



Salybia (Matura)
Compiled from: EMA (1998a); Kenny (2000); www.mapscd.com/trinidadytobago_illustrator.html

[4]Adapted by Faizool (2002) and agreed at the Northern Range Working Group meeting, 9-10 May, 2003.

The assessment is based for the most part on existing reported data and information. It is important to note, however, that in the literature there are several units of analysis and recording of data–conservancy, county, constituency, regional corporation-with no formal process of relating and reconciling the various data sets they yield. Although Trinidad and Tobago is now organized according to Regional Corporations, data collection has not been adjusted to these new administrative boundaries. The definition of the Northern Range as an ecosystem does not conform to any of these units of recording. In the case of forests, for example, historically data have been recorded on a conservancy basis, that is, a management area set up by the Forestry Division. Forest fires are also recorded on this basis; other data on a country-wide basis. Thus data for forests are approximate because the boundaries of the conservancies do not exactly coincide with the boundaries of the Northern Range when defined as an ecosystem in this assessment. The area covered by the Northwest and Northeast conservancies include all of the Northern Range as defined in this report but extend beyond the southern boundary.

Counties: The three counties that constitute the Northern Range are the St. George county, which lies to the west; the St. David county, which is in the north-eastern section of the Northern Range; and the county of St. Andrew, which lies to the east. While the county of St. David lies entirely within the Northern Range, the southern boundaries of the counties of St. George and St. Andrew extend south beyond the southern boundary of the Northern Range.

Eastern/Western Northern Range: The Northern Range has conveniently been divided by the Blanchisseuse Road into eastern and western portions (ENRP 1991). This subdivision was especially important for the concept of developing an Eastern Northern Range Plan which sought to address the environmental degradation occurring in the eastern section of the Northern Range. The official demarcation into eastern and western Northern Range is used with exact application in the assessment.

2.2 Physical Characterization of the Northern Range[5]

The Northern Range is a continuation of the Coastal Cordillera of Venezuela and is the major topographic defining feature of the island of Trinidad consisting of an east-west spine or watershed with an average elevation of approximately 450 m (1,500 ft). Most of it lies between the 90-m (300 ft) and 450-m (1,500 ft) contours, but elevations well over 600 m are attained in some areas. The highest peak is Mt. Cerro del Aripo at an elevation of 940 m. The Range is characterized by rugged topography with very steep slopes, and it forms part of the regional system of coastal ranges which are characteristic of much of the neighbouring South American continent (Faizool 2002).

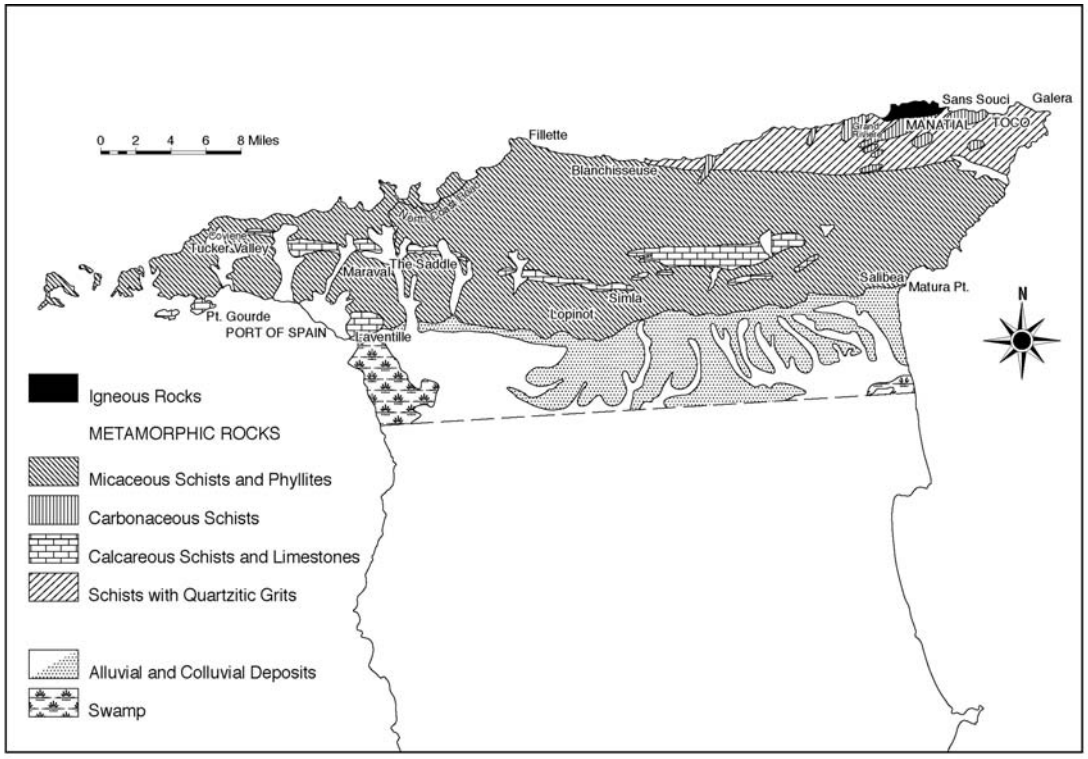
The main East-West divide spanning the Range is located closer to the North Coast, towards which the land for the most part falls in a succession of steep, narrow, gorge-like valleys, interrupted by an occasional strip of coastal plain with scenic beach front. The south-facing slopes are generally less steep and are dissected by a series of north-south oriented valleys. Valley profiles range from youthful V-shaped to well-developed, mature U-shaped valleys. More than 80% of the slopes have a gradient of 20° or higher; of this percentage a substantial part is made up of slopes greater than 30°, which are considered critical for soil and water conservation (Faizool 2002).

Geologically the Northern Range forms part of a series of sediments deposited far to the west and transported and uplifted by the eastward moving Caribbean plate where it scrapes past the South American plate to the south. It is the oldest geological formation in Trinidad (Kenny 2000).

[5]Much of the information in this section is drawn from Faizool (2002).

Structurally it is regarded as a broadly homogeneous system. However, its lithologic units are heterogeneous both in mineralogy and age, ranging from very old limestone to younger limestone, shaley phyllites, shales, and quarzites, in alternating bands (Fig. 2).

Fig. 2: Geology of the Northern Range



Salibea (Salybia, Matura)
Source: Brown and Bally (1966)

A detailed description of the geology of the Northern Range is given in Annex 1. The predominant rock types are metamorphic rocks dating to the Jurassic more than 100 million years old, of which the micaceous schist and phyllites are the most abundant. The southern boundary of the Range coincides with the El Pilar/Arima fault system and is identified with an area of tectonic disturbance and deformation, resulting in intricate patterns of folds and faults, which have considerably displaced the axes of previous structures (Faizool 2002).

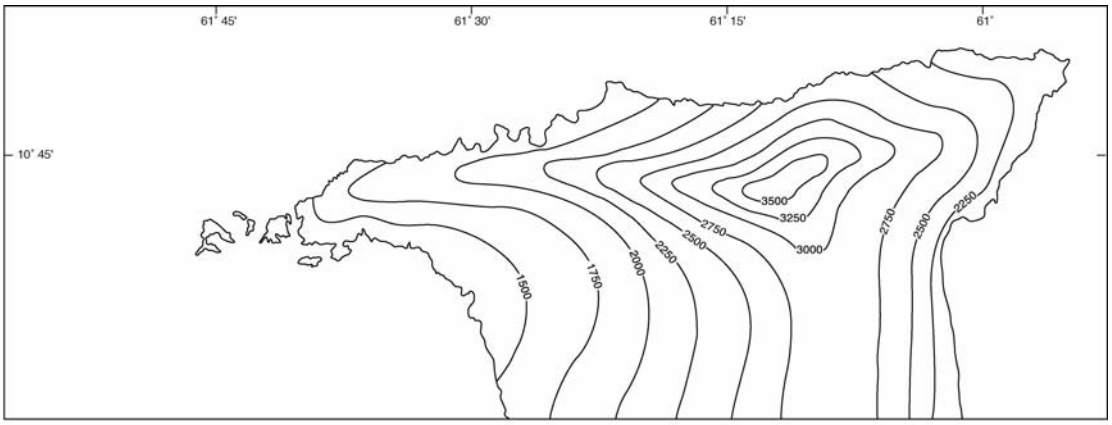
A detailed description of the soils of the Northern Range is given in Annex 1. About 90% of the Range consists of high upland soils with free internal drainage. Most of this occurs in the Maracas and Matelot sandy clay loam series consisting of micaceous phyllites. Other areas consist of the deep alluvial soils with free internal drainage (known as River Estate Soils). These occur in the Tucker, Diego Martin, and Santa Cruz valleys. This soil type consists of a fine sandy loam derived from river alluvium and, along with the Maracas and Matelot sandy clay loams of the uplands, constitute the only soils of good drainage in the country (Faizool 2002). Other soils found in the Northern Range are small patches of Acono Sandy Loam, and St. Augustine Loam in some of the valleys and on the foothills close to the Eastern Main Road. These are lower in agricultural capability than the River Estate Soils, but also support a similar range of crops (FAO 2001).

The characteristics of the geology and soils of the Northern Range, as detailed in Annex 1, combine to render the hillsides prone to soil erosion and land slippage. This fragility is

exacerbated on steep slopes, where vegetative cover has been removed or reduced, where inappropriate hillside building or farming practices occur, and when very heavy rainfall occurs.

The climate of the Northern Range is typically seasonal tropical regime with generally a dry season from January to May and a wet season from June to December. Long-term rainfall records indicate the highest annual precipitation levels in the north-east of the Range (3,048 mm) decreasing westwards and southwards (to 1,524 mm; Berridge 1981). However, a more recent isohyetal map for Trinidad (Fig. 3) shows that the highest rainfall occurs in the north-east and at the highest elevation, from which point it decreases eastward, westward, and southward. Temperatures are generally equable, but slight decreases at higher altitudes and within shaded valleys are not uncommon (Faizool 2002; Berridge 1981).

Fig. 3: Isohyetal Map of the Northern Region of Trinidad



Source: Piarco Meteorological Office (unpublished; pers. commun., 2004)

The Northern Range was originally clothed in dense forest cover in pre-Columbian times (Chalmers 1981). Vegetation formations varied according to temperature and moisture gradients associated with altitude and rainfall patterns. Since European colonization, however, forest cover has given way to tree-crop estates, especially cocoa *(Theobroma cacao)*, throughout the range, and more recently to urban development primarily in the western regions nearer the sheltered Gulf of Paria and the capital city, Port-of-Spain. Urban centres have expanded rapidly as a result of the shift from an agriculture-based economy to a commercial and energy-based economy. Periods of economic windfalls derived from oil revenues within the past 30 years have fuelled such recent changes.

2.3 Description of the Northern Range Communities Consulted [6]

To have an understanding of the perceptions and concerns of communities located within the Northern Range, their perspectives about it, and their relationship with the services it provides, three communities were included in the assessment. This was an attempt to 'ground-truth' assumptions and judgements in the absence of local scientific information, to have inputs of citizens about their relationship with their immediate environment, to bridge scientific information with community understanding and experience, and to consider what might be options for community-level responses to sustain the ecosystem and enhance their well-being.

[6]Throughout this report points of view of the residents of the three communities consulted in the assessment are cited.

These three communities (Fig. 1) were chosen on the basis of various criteria developed by the project Steering Committee.

Petit Curucaye, the most westerly of the three communities, is located in the Santa Cruz Valley on the banks of a river. There are 318 households located at a height ranging between 45 m and 180 m above sea level. This community grew out of the need for housing space within easy access of employment and amenities in the city and nearby towns. The slopes of Petit Curucaye are sparsely covered with trees. Some houses in the settlement received electricity service in 2002, and the sentiment within the community is very much of neglect by the authorities.[7] This watershed reveals a high degree of land conversion.

Bon Air North is a squatter[8] community located on State land on the gently undulating southern foothills of the Northern Range in the constituency of Arouca North. Like Petit Curucaye, Bon Air North grew out of the need for housing space within easy access to employment and amenities in nearby towns, but there is a lack of social services and public utilities as in most squatter communities.

There were several waves of immigration into the community which residents have claimed started as early as 100 years ago with a few farmers. This was followed by a slight increase in the early 1940s by former residents of Caura Valley who were evacuated for the construction of a dam. Then there was a slow but steady stream of immigration in the 1970s and 1980s from neighbouring areas as well as from nearby Caribbean countries. The most rapid growth period was in 1997 when people sought to occupy land space before the State Land (Regularisation of Tenure) Act No 25 of 1998 would come into effect. This Act would allow residents who occupied State lands before January 1st 1998 to apply for a Certificate of Comfort, which would grant them a few years leeway to purchase the land that they currently occupy. In 1993 there were 60 houses according to a National Housing Authority (NHA) survey and this grew to about 250 in 1998 [Land Settlement Agency (LSA) survey]. A house-to-house, interview-based survey conducted by the residents in August 2004 revealed that there are about 400 houses. Only 25% of these 400 households are in possession of Certificates of Comfort granted by the LSA and another 17% have approval by the NHA for vacant lot occupation.

The survey also revealed that the community is inhabited by 1,136 people of whom 512 are adult females, 624 are adult males, and 242 are minors (younger than 16 years according to the Central Statistical Office). The community has a young population with an average age of 24. About 70% of the adult population is employed and of this figure, about 60% work outside of their home. The average annual household income is in the TT $10,000.00 to TT $15,000.00 category. Most people are employed in the East-West Corridor while a few are engaged in farming in an area of the community called the “greenbelt” which also includes parcels of forested land.

Grande Riviere is a coastal village containing 116 households on the north-east coast of Trinidad. There is perennial cover of greenery even in the dry season due to the very heavy rainfall in this area. The village hosts a health centre, a primary school, a community centre, and a fishing depot. This village has experienced periods when cocoa growing and then fishing were dominant economic activities. With their decline as sources of employment and income, it now exploits its natural assets for eco-tourism. Leatherback turtles *(Dermochelys coriacea)* nest on the village beach between the months of February and August, and the endangered species *Pipile pipile*, popularly known as the Pawi or the Trinidad piping guan, reported to be endemic to Trinidad,[9] is found in the forest south of the village. Two small hotels on the beach and other guest accommodations are available for visitors.

[7]S. Maharaj (pers. commun., 2003).
[8]Person who is in actual occupation of State land without probable claim or pretence of title thereto.
[9]Genetic research is now underway to determine the endemism of this species.

3.0 Data: Sources and Limitations

The assessment relies on results of previous scientific work as well as community inputs obtained through extensive dialogue with individuals and groups on the basis of questionnaires and focus groups. As a scientific assessment it is therefore constrained by limitations in data and understanding as no scientific assessment has been undertaken for the Northern Range as an ecosystem; nor have the driving forces which impact this ecosystem, and the links with human well-being, been the subject of scientific study. Sporadic scientific data and analysis exist, but are not comprehensive of all the ecosystem services and interactions that need to be understood. There is a large data and information gap, in scientific terms; though much opinion is presented in a range of documents–such as planning and policy documents, project reports, consultants' reports, graduate theses–all of which will not have been subject to the peer review process. It follows that time-series data are also not available, except in the case of a few ecosystem services.

Thus the quality and quantity of data available for each ecosystem service being assessed are highly variable (see Annex 2). Some data about services such as freshwater, timber and other forest products, minerals, and food exist. Data about some functions that are less tangible and visible (e.g., the underlying regulating and supporting functions of the ecosystem) are sparse to nonexistent, making scientific assessment and firm conclusions about changes in ecosystem capacity and functioning difficult. Similarly, discussion of functions that are difficult to value quantitatively (e.g., amenities that are a source of aesthetic, cultural, or spiritual satisfaction) is possible only in qualitative terms.

The quality of the data is also highly variable due to the variety of sources, ranging from unpublished undergraduate reports to Ph.D. theses and a few relevant published manuscripts. Given the knowledge that many studies are often constrained by limited resources, which may be reflected in the methodology and data collection, data used were treated with caution. For example, data collected by the Forestry Division on the loss of forest area, due to squatting, only take squatting on State land into consideration thus leaving the proportion of squatting on private land unaccounted for. One would then expect that deforestation rates would be underestimated. Inconsistencies among various sources in the changes in forest cover for Trinidad also highlight the questionable nature of the available data.

Additionally, an accurate assessment of data sets rests heavily on an appreciation of the methodologies and data-collection techniques used. For example, in the case of land use in Trinidad, two maps–one generated in 1980 based upon aerial photography and the other by satellite imagery in 2001–show some inconsistencies in the information presented. In this case it cannot be assumed that the changes represent the historical trends in land use. Rather the differences may be attributable to the margin of error inherent to the methodologies used. Or, for instance, two studies on the avian fauna of the Northern Range–one conducted using species counts, the other using mist netting-provide very different accounts of species diversity and abundance. Additionally, where the number of recorded species is noted, this should not be interpreted as the absolute number of species in existence. Where these inconsistencies arise within the literature, the data and information sets are presented and methodological variances are noted.

Another major consideration was the delineation of the boundaries for available data sets: in some cases national, conservancy-level, or county-level data alone were available which only to a limited extent could be extrapolated to the area under study.

As everywhere, scientific research has traditionally been within the bounds of a single discipline, while the conceptual framework used as well as contemporary approaches to resource management require an appreciation of the interrelationships among different parameters. It follows therefore that data even where they exist from past research are unlikely to be illuminative of those relationships. Moreover, a conceptual framework that seeks to assess relationships among the economic, environmental, and sociocultural aspects breaks new ground, vis-à-vis the established pattern of scientific research. Trying to reveal the connections between changes in ecosystem services and human well-being over space and time is a further layer of complexity. The gap therefore between what needs to be known and understood and the information that exists is wide. It is expected that the process of the assessment itself will therefore be useful to identify and orient the nature and scope of research required to equip us in due course with the quality and continuity of information required for further assessments of this kind, and for management that sustains the natural ecosystem and secures human well-being.

Nevertheless, there is a considerable bank of learned opinion–professional, practitioner, and community–that exists. What is remarkable is the commonality of insight within it: that the Northern Range is evidently being rapidly degraded; that there are observed or expected consequences for various constituents of well-being; that there is sufficient knowledge and understanding to warrant a precautionary approach, and to underpin holistic policy and planning to recover some ground, to restore some of its condition, and to resist further degradation.

This assessment is therefore a starting point: to assemble what we know with reasonable confidence as well as what is hypothesized; to draw upon scientific theory and examples of research from elsewhere; to reflect a range of professional and community observations and opinion; to indicate issues and questions that require research and analysis if we are to know more and understand better; and to establish a framework for policy analysis and policy consensus, and decision-making and action. It is offered to engender awareness of, and collective responsibility for, the condition of the Northern Range, now and in the future, and to inform and assist the public process for responding.

4.0 Services of the Northern Range and How They Contribute to Human Well-being

4.1 The Conceptual Framework

This assessment of the Northern Range draws upon the MA conceptual framework. Figure 4 shows the MA Conceptual Framework diagram. This framework 'places human well-being as the central focus for the assessment while recognizing that biodiversity and ecosystems also have intrinsic value and that people take decisions concerning ecosystems based on considerations of both well-being and intrinsic value. It assumes that a dynamic interaction exists between people and ecosystems; with the changing human condition serving to both directly and indirectly drive change in ecosystems, and with changes in ecosystems causing changes in human well-being. At the same time, many other factors independent of the environment change the human condition, and many natural forces influence ecosystems' (MA 2003, 26). The MA also emphasizes the usefulness of a multiscale approach in conducting assessments stating that 'a full assessment of the interactions between people and ecosystems requires a multiscale approach, as this better reflects the multiscale nature of decision making, allows the examination of driving forces from outside particular regions, and provides a means of examining the differential impact of ecosystem change and policy responses on different regions and groups within regions' (MA 2003, 26).

The involvement of three communities was an attempt to assess relationships between driving forces, ecosystem change, and human well-being according to two scales (national and local, i.e., community). The MA conceptual framework guided the identification of the range of ecosystem

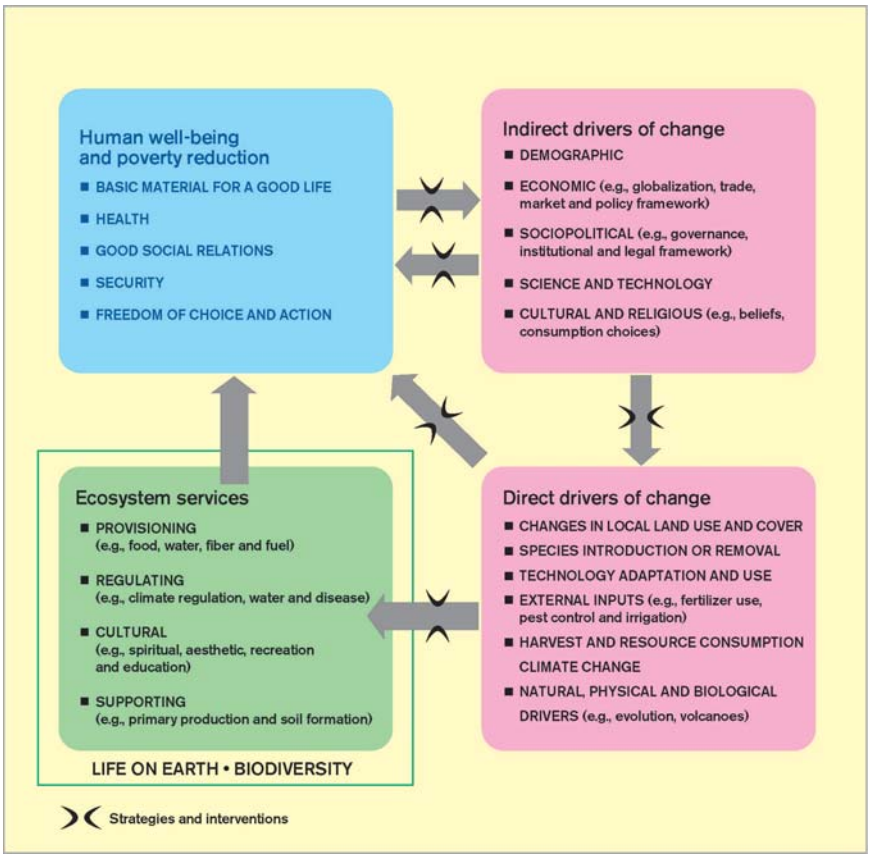
services of the Northern Range. Selection of those included in this report was guided by empirical information applicable to the national level. A scale dimension, however, does not emerge as an important factor in this assessment. The services assessed appear to be as significant for the island as a whole as for the communities. This may be explained by a number of factors:

- The small size of the island
- The identity between driving forces for national and community levels
- The lack of distinctiveness as between community and national approaches to use, impacts, and responses
- The absence generally of community-based governance and decision-making that have consequences for the Northern Range or any of its services
- Responses required to address the driving forces impacting on the Northern Range are required primarily at the national level.

It may also be explained by the absence of a clear methodology for applying a scale dimension in the assessment. However, because of the above factors and given the results of the community engagement, the incremental value of a scalar organization of this assessment was not evident.

Thus, the assessment as a whole proceeds largely on the national level, though the inputs of the three communities involved are drawn upon to help illuminate some of the issues 'on the ground' and to help identify some responses at the community level which may be appropriate for meeting the needs of these communities, as well as helping to secure the sustainable use of the resources of the Northern Range.

Fig. 4: Millennium Ecosystem Assessment Conceptual Framework Diagram

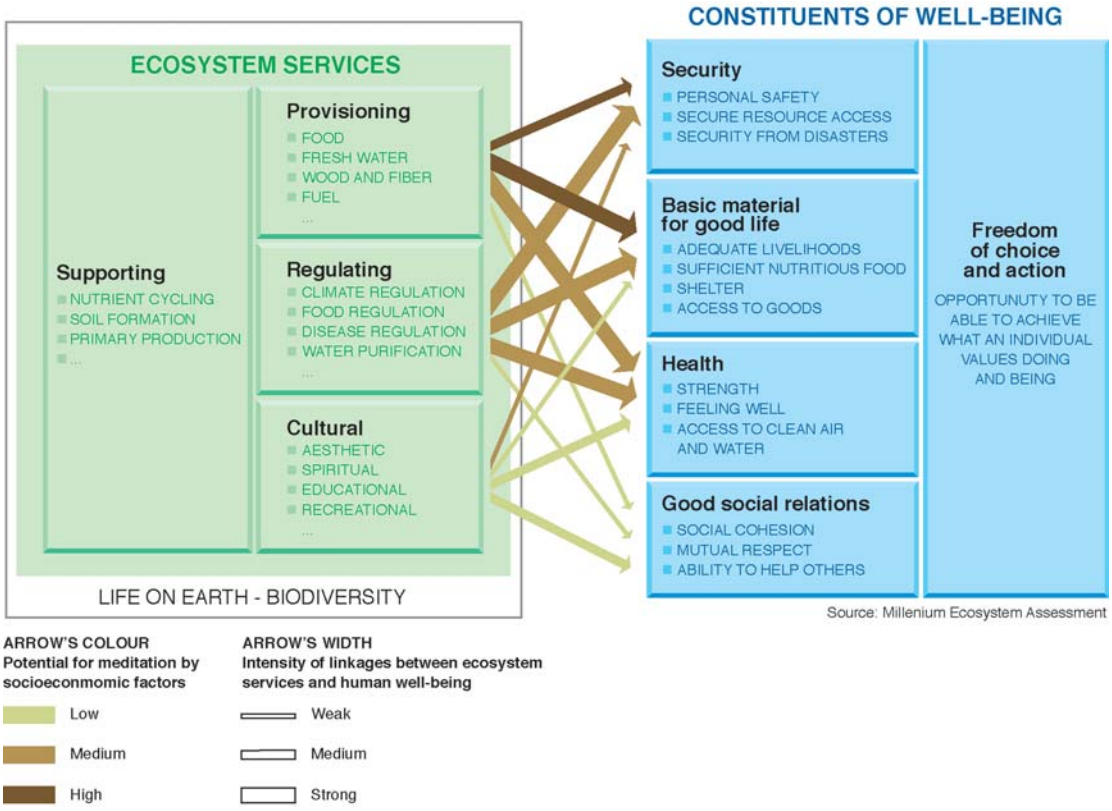


Source: MA (2005a, in press)

4.1.1 Ecosystem Services

Ecosystem services are the benefits that humans derive from ecosystems and may be classified into four categories: provisioning, regulating, cultural, and supporting services (MA 2003). While some ecosystem services, such as the provisioning services, may be tangible and material, and thus more easily identifiable and quantifiable, others (such as the supporting and regulating services) are underlying functions that are invisible, less easily quantified, and that are enjoyed collectively as a society, rather than on an individual or community basis (Fig. 5). However, the focus of the assessment is not just on what services are provided, but how these services contribute to human well-being. Thus Figure 5 also presents various dimensions of human well-being to provide an analytical framework for tracing the relationship between the ecosystem and people.

Fig. 5: Links between Ecosystem Services and Human Well-Being



Source: MA (2005a, in press)

4.2 A Framework for the Northern Range Assessment

Table 1 seeks to interpret the analytical framework about ecosystem services and human well-being presented in Figure 5 to the case of the Northern Range by indicating the variety of ways in which people make use of, or directly/indirectly benefit from, the assets and functioning of the Northern Range.

Table 1: Northern Range Ecosystem Services[10]

Northern Range component	Provisioning services	Regulating services	Supporting services	Cultural services
Forest	* ***Timber and non-timber forest products*** (including wildlife, handicraft, and medicinal plants) * ***Land space*** for housing and agriculture * ***Minerals*** *(stone for construction)*	* ***Water runoff regulation and retention*** ***Biodiversity services*** (population regulation, habitat, and species diversity) ***Soil conservation;*** ***Soil formation and fertility;*** ***Climate and microclimate regulation;*** ***Atmospheric composition regulation***	* ***Water cycling and replenishment*** of surface and ground-water resources ***Biodiversity support*** (pollination, germination, dispersal, food webs, productivity, terrestrial/aquatic ecosystem interface) ***Nutrient cycling and transport***	* ***Amenity value*** (recreation, agro-tourism, eco-tourism, spiritual and religious practices and values, aesthetics and inspiration, cuisine) * ***Education*** : scientific research and teaching
Freshwater	* ***Water resources*** * ***Fish, aquaculture***	* ***Waste disposal, assimilation and treatment*** * ***Flood regulation, water storage*** ***Biodiversity services*** (population regulation, habitat, and species diversity)	***Biodiversity support*** (food webs, productivity, terrestrial/aquatic ecosystem interface) ***Nutrient cycling and transport***	* ***Amenity value*** (recreation, river 'lime,'[11] spiritual and religious practices and values, aesthetics and inspiration) * ***Education*** : scientific research and teaching
Coastal	* ***Fish*** (including other marine products) ***Safe anchorage***	* ***Waste disposal, assimilation and treatment*** ***Biodiversity services*** (population regulation, habitat, and species diversity) * ***Physical processes*** (sediment dynamics, coastal protection)	***Biodiversity support*** (food webs, productivity, terrestrial/aquatic ecosystem interface) ***Nutrient cycling and transport***	* ***Amenity value*** (recreation, beach 'lime,' spiritual and religious practices and values, aesthetics and inspiration) * ***Education*** : scientific research and teaching

Note: The services for which data are available (indicated in the table by *) are prioritised for assessment.

These services were identified in workshops with collaborators and assessed, based on published material, on expert knowledge of the situation and on information collected from the communities consulted. Forests, freshwater, and coastal resources were identified as the major components of the Northern Range providing services to communities and the nation.

Two of these services, land space and biodiversity, which are treated as cross-cutting factors, require special mention, however. Given the small size of Trinidad, land space was considered an important provisioning service since all other services were in some way dependent upon, or influenced by, the dynamics of land use. In the case of biodiversity, species diversity (and by extension genetic diversity) occurs within each of the components of the Northern Range selected for assessment, and species (and genetic) diversity contributes to many of its services. For example,

[10]The provisioning services–timber and non-timber forest products, and fish from both freshwater and coastal ecosystems–are predicated on the extent of biodiversity.
[11]'Lime'-Local term for passing time with friends

the timber industry rests on the diversity of trees available in the forest; the amenity value of the forest depends largely on the diversity of plants and animals; coastal fishing depends on the diversity of coastal species available. Biodiversity is thus treated as an overarching service, and to prevent repetition in the assessment of the aspects of biodiversity within the three components, a general introduction to the biodiversity of the Northern Range is given at the beginning of the section on Ecosystem Services (Section 6.0), and the biodiversity aspects specific to each component are then dealt with in each subsection. The Northern Range offers land space for housing, infrastructure, and agriculture, and in this assessment land space is considered a 'service' in its own right, which is accessed by the way in which we make use of that space. Thus land space is considered in the context of the discussion on land use as it relates to the Northern Range (see Section 5.2.3).

4.2.1 Human Well-being

As can be seen from Figure 5, the MA identifies five key components of human well–being-basic material needs for a good life, health, good social relations, security, and freedom and choice (MA 2005a). In the Northern Range assessment, the aspects of human well-being selected for priority attention are:

(i) livelihoods
(ii) housing
(iii) health and nutrition
(iv) recreation
(v) personal/environmental security

These were identified in workshops with collaborators, on information from both published and unpublished documents, and from perceptions of the communities involved about their well-being (Box 1 and Box 2).

Box 1: Community Perceptions of Well-being

Aspects of human well-being as perceived by the communities, and listed in order of importance to them, are:

(i) Income security, e.g., an income that is based on regular and predictable employment
(ii) Access to freshwater of good quality and quantity
(iii) Security of land tenure
(iv) Availability of affordable housing
(v) Recreational opportunities
(vi) Personal security
(vii) Sense of place

Perceptions of residents of the communities relating to personal security and sense of place are detailed in Box 2.

Box 2: Personal Security and Sense of Place as Constituents of Community Well-being

The three communities are not insulated from social issues affecting the larger society: an increase in the incidence of crime was a concern to people in all three communities. In each case residents mentioned that an observable breakdown in parenting skills contributes to this increase. In Grande Riviere and Bon Air North people explain this by the increasing trend of absentee parents who leave their children with grandparents or other relatives to find employment in the towns or other countries.

In Petit Curucaye a criminal element is said to have recently arisen from within the community. Some people said they no longer hunted or walked in the forested areas around the community because they felt it was no longer safe due to the presence of trap guns on land used for planting marijuana (S. Maharaj, pers. commun., 2003). Bon Air North residents say there is a need for a neighbourhood watch in the area. Residents of Grande Riviere feel safe in their community and this sense of personal security is an asset to life in this relatively isolated community. However, they are of the opinion that a road linking two villages on the North Coast of the Northern Range, Matelot to Blanchisseuse, would increase crime in the area because this would result in more than one route of entry to, or exit from, the village of Grande Riviere. Residents in this village appreciate the absence of crime in the area. Grande Riviere residents also appreciate their natural surroundings, and the sense of attachment to the place in which they live is strong enough to translate into some measure of protective action for its natural resources. A catch by a visitor of too many crayfish at one time is regarded as inappropriate. Along the Coast the village is reputed for its awareness of the relationship between its natural resources and its well-being, which lies behind its activities to protect nesting turtles. Two factors that may contribute to this 'sense of place' are relative isolation and the fact that residents own the land they occupy. There is one road into the village and visiting it involves a 2- to 3-hour drive from the capital city. There tends to be little and irregular contact with State services such as agricultural extension, community development; few commercial and employment opportunities within the village; and an absence of facilities such as a bank–Sangre Grande has the closest facilities for people to cash their pay cheques and consequently it is there that people spend most of their money, leading to less investment in their own village commerce and less internally generated support for those who set up small businesses there.

Children in the Grande Riviere Anglican School made drawings to illustrate what living in Grande Riviere means to them. Of 32 drawings, all depict some aspect of the natural environment: 29 focus on the sea and beach, with predominant images such as surfing, sea, boats, coconut trees, sunsets, and forests; 2 show tree stumps; and 1 an area cleared for agriculture.

Petit Curucaye residents feel a sense of place based on the isolation and neglect of their community. This feeling of neglect by government and its agencies has led to community cohesiveness in obtaining, at their own initiative, the installation of basic services such as roads, lighting, and water. Although they have made considerable achievements they feel a lack of empowerment, which is evident in their feeling of dependency on outside organizations to respond to their immediate and long-term concerns.

Bon Air North residents talk about enjoying “the clean, unpolluted air on their faces.” A strong appreciation for green spaces like the “greenbelt” is also very clear. Again, a balance is continuously being sought between a house in which to live, and green space. The desire to own land has created a sense of place in Bon Air and has resulted in residents coming together over this issue in representations to the government.

4.2.2 Links between Northern Range Ecosystem Services and Human Well-being

Table 2 infers links between Northern Range ecosystem services and human well-being based on expert and community opinions, workshop discussions, and data reviewed. These links are assessed in greater detail later in the report. The strength of the link is based on perception of the persons involved and not on quantitative assessment.

Table 2: Linking the Northern Range Services with Well-being

Ecosystem service	Link to human well-being	How strong is the link?	Factors that influence the relationship
Freshwater (including water cycling and replenishment of surface and ground-water sources)	Health and nutrition: water for domestic purposes Economic activities: water for industrial purposes and irrigation for agriculture Recreation; river liming	Very strong	Availability, accessibility, potable quality and quantity; waste assimilation capacity; capacity to recharge, pristine and aesthetic characteristics; recreational options from many rivers
Land space for housing and agriculture: authorized and unauthorized	Personal security: housing Economic security: livelihoods Material minimum: food and income	Very strong	Availability, accessibility, regularization/ ownership; proximity to urban centres; soil cover and depth
Timber and non-timber products of forest	Economic security: subsistence livelihoods from handicraft, fuel/coal; wildlife harvesting; Trade in wildlife, timber, and other building materials Personal security: housing	Fairly strong	Availability, accessibility, quantity, ownership; productive use of materials; markets
Minerals	Economic activities: building materials, non-metallic minerals (limestone aggregate, silica sand, lime)	Very strong	Availability, accessibility, quantity, ownership, technology
Fisheries (including freshwater and marine products)	Economic security/ livelihoods: income, handicraft products Health and nutrition: food	Very strong Fairly strong	Accessibility, quantity, quality, competition, foreign interests

Ecosystem service	Link to human well-being	How strong is the link?	Factors that influence the relationship
Regulation of runoff and water retention	Environmental security: risk of flooding, soil conservation Economic security: loss of property, cost of flooding; loss of freshwater availability Health: flood-borne diseases, loss of lives	Very strong	Land cover/ land use, instream flood-control mechanisms, planning controls
Waste disposal, assimilation, and treatment	Environmental security: amelioration of pollution Health: negative impacts of pollution; positive impacts of pollution reduction	Very strong	Capacity to absorb in relation to the level of waste, alteration of ecosystem to reduce capacity
Amenity value	Economic activities/ security/livelihoods: turtle-watching, eco-tourism, yachting industry Recreation: river and beach liming, eco-tourism: basis for livelihood Good social relations: cultural and religious values	Very strong	Accessibility, quality, sustainability; pristine characteristics; variety of options
Biodiversity services/ support	Economic security: wildlife sale Recreation: eco-tourism, guiding/tours Health: disease alert; medicinal plants Ecosystem functioning: species (including genetic) diversity	Fairly strong	Availability, accessibility, quality
Education: scientific research/teaching	Economic security: accommodation, field/ research stations, employment creation Opportunity to study ecosystems: training, skills development	Fairly strong	Accessibility, quality

People generally do not consciously make links between use of resources or enjoyment of benefits of a physical space and their well-being. However, in the engagement between members of the assessment team and residents of the three communities, there was evidence of an emerging awareness of the ways in which the Northern Range contributes to well-being, of the ways in which people affect the Northern Range, and the consequences for its continuing capacity to contribute those services indefinitely. Some of these relationships made by residents of the communities are reflected in Box 3.

Box 3: Watershed Assets and Community Well-being

Generally, none of the three communities reveals a high awareness of how their activities have impacted or might impact on the services of the watershed and in due course on their own well-being. A similar lack of awareness of the options offered by the natural assets for livelihoods is also apparent. But in discussing the condition of the watershed and the ways in which people use these services now (or used them in the past), the interrelatedness between the ecosystem services and the well-being of the residents began to emerge.

There is some agriculture evident in all three communities, but it is rare to find a household exclusively dependent on the land for its income and subsistence requirements.

In Grande Riviere, the oldest of the three settlements and located the furthest distance from an urban centre, the cocoa estates of the past have left vestiges of subsistence agriculture by a few households. Historically the residents of Grande Riviere fished the coastal waters and farmed the land for a major part of their diet. But currently, there is a decrease in reliance on the land for food, either for subsistence or as an income source. Grande Riviere residents own the land on which they live and land titles have passed from parents to children. Grande Riviere residents say the reason they do not farm extensively like the plantain farmers in a neighbouring village is because they know that type of farming is not good for the land. Grande Riviere residents claim to farm small crops under large trees on hillsides instead of felling the trees. One individual in the area whose main residence is in Port-of-Spain has erected "No hunting" and "No trespassing" signs on what villagers believe is State land. This is a cause of conflict.

In Grande Riviere there has been an increase in land purchases by people external to the community (both foreigners and nationals), and now the increase in the village population and the lack of available and affordable land has led villagers to be concerned about the constraints to village expansion. In 1978 the government purchased about 643 acres of private land for redistribution to residents of Grande Riviere for the purpose of agriculture. Some of this land was redistributed by the government in 1993 but the sentiment of some residents is that the allocation was politically motivated resulting in some non-farmers receiving land and this land lying vacant. Some villagers say the land that has not yet been given out should be used for village expansion.

Based on the discussion in the foregoing section, four cross-cutting factors were identified–biodiversity, amenity value, land-use issues, and human well-being. Figure 6 shows how these cross-cutting factors will be dealt with in the rest of this report.

Fig. 6: Conceptual Diagram for Dealing with Northern Range Cross-cutting Factors

Northern Range component	Cross-cutting factors				Specific responses
	Biodiversity	Amenity	Land-use issues	Human well-being	
Forest					
Freshwater					
Coastal					
FRAMEWORK RESPONSES/ MULTI-PURPOSE RESPONSES					

5.0 Driving Forces of Change in the Northern Range

5.1 Definition of Driver in the Northern Range Assessment

A driver in this assessment is defined as any natural, human, or institutional factor that directly or indirectly explains impacts on the Northern Range as an ecosystem. Land use and land-cover change are collectively considered a direct driver of change. Most of the other driving forces considered-institutional, human, or natural-are treated as indirect drivers because these influence the pattern of land use and land-cover change (through agriculture, housing, infrastructure, mining) that cause the changes evident in the Northern Range; although some human actions (e.g., pollution and over-harvesting) do have direct impacts.

Generally there is a paucity of direct discussion in the literature about driving forces and their impacts on the country as a whole, let alone the Northern Range. Drivers were identified and assessed through workshops and meetings of collaborators (Advisory Group, Steering Committee, Working Groups), and on expert knowledge. Thus the discussion of these driving forces and their interactions is largely qualitative in nature.

In the case of land-use and land-cover change, however, there is appreciable information which helps to establish the current condition and historical trends in land-use patterns and land-cover change in the Northern Range. The nature of this data is described in detail in Section 5.2.3 and in Annex 2.

Throughout the literature, there is frequent mention of links between major human activities (such as settlements, housing, and agriculture) and changes in land cover (namely, loss of primary forest), but these links are not quantified. While by deduction and general principles it is possible to trace the effect that land conversion (through deforestation) has on the Northern Range ecosystem, and the country as a whole, scientific information is necessary to prove the links, and should be addressed in future research on the Northern Range.

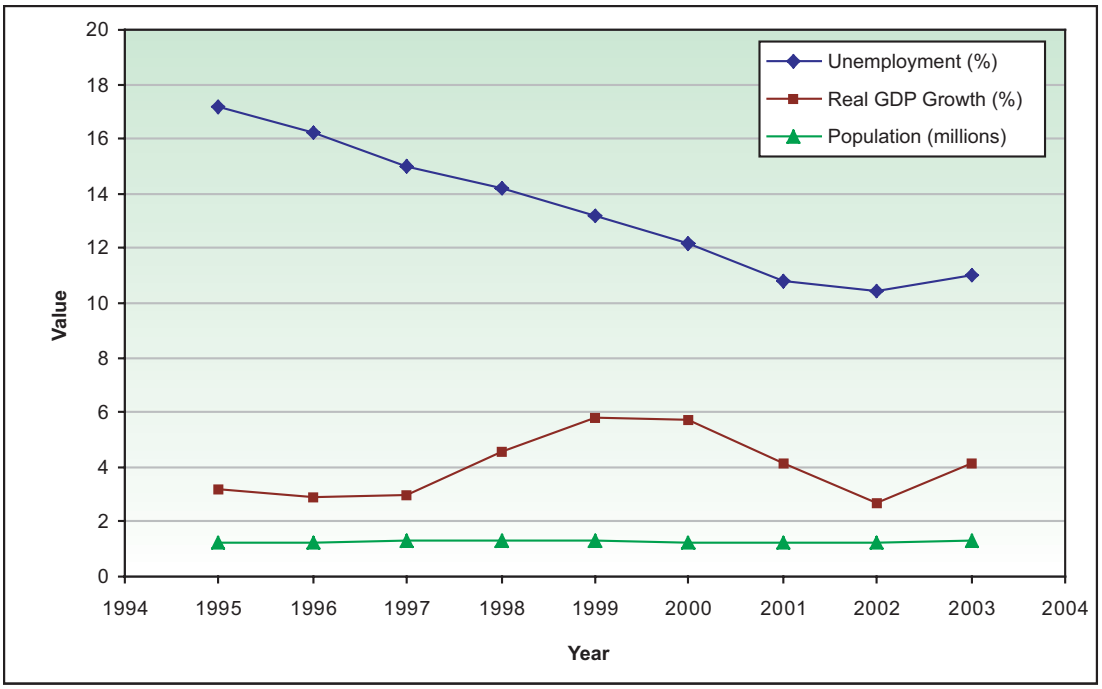
5.2 Driving Forces that Impact the Northern Range

5.2.1 Institutional and Human Factors

5.2.1.1 Economic Forces

Over the past three decades, Trinidad and Tobago has seen significant increases in economic growth which continues today. The Central Bank (2004) reported an increase in real GDP from 2.7% in 2002 to 4.1% in 2003 (Fig. 7).

Fig. 7: Demographic and Economic Statistics for Trinidad and Tobago (1995-2003)



Source: Central Bank (2003, 2004)

This growth is based on oil and natural gas resources and downstream heavy and light industries coupled with sustained high oil prices in recent years. However, disparity in income distribution is increasing and unemployment rates continue to be high (10.4% in 2002, 10.5% in 2003; Central Bank 2004). Many people, households, and communities therefore are driven to seek free or affordable living space, homestead, and livelihood opportunity (agriculture, harvesting wildlife for subsistence) on the hillsides, on the fringes of the urban centres, and along access routes into the valleys.

Trinidad and Tobago has long relied on its energy sector to fuel its economy. With a buoyant and expanding energy sector, there has been a relative reduction in emphasis on industrial or small-farm agriculture. Openness of the economy and trade liberalization also combine to provide serious price competition with domestic agricultural produce. However, small-scale and subsistence agriculture continue as a means of livelihood; and lucrative returns to growing marijuana for trade, though an illegal crop, attracts some persons to the forests of the Northern Range, which offer space as well as seclusion for this activity. There are locations in the Northern Range where unauthorized subsistence or market gardening is practised, often on slopes unsuited for the type of crop grown. This activity is exacerbated by establishment of dwellings on the agricultural sites.

There is a high level of activity in the construction sector for industrial, commercial, and housing facilities. The slopes of the Northern Range valleys are prime locations for high-income housing; and the coastal strip, especially the portion between Chaguaramas in the west and the capital city, is under heavy demand for commercial and service facilities.

5.2.1.2 Governance

Historically the country has had a very centralized pattern of decision-making. Its public administration system continues to operate on a highly sectoral and fragmented basis, with little attempt at co-ordination among various sectors, ministries, or entities even where their activities impact on the same space. There is also a poorly developed system of local government arrangements, though this system is currently receiving policy attention. Communities do not have opportunity to mature and to participate in organized, collective decision-making in their own interests. Moreover, approach to community development has been mainly through short-term employment and redistributive programmes, leading to a tendency to rely abjectly on government initiatives. Further, there is no defined or organized public-sector mechanism for the involvement of communities in management of resources. Community management of resources is in its infancy in the country. These factors account for the lack of a systemic approach to policy and management for a defined physical space such as the Northern Range, and they influence the relationship, or lack of it, which individuals and communities have with their immediate natural environment.

5.2.1.3 Demographic Factors

As indicated in Section 2.1, the population of Trinidad and Tobago, as determined by the Central Statistical Office's 2000 survey, is approximately 1,262,366; that of Trinidad alone is 1,208,282. The country's population growth rate has been decreasing within the past twenty years, and the rate of increase in 2000 was estimated to be approximately 0.5% per annum (Agard and Gowrie 2003, based on CSO 2000). About 76% of the country's population lives in the urban centres, and there is evidence of continuing rural-urban drift, with an average annual rate of increase in the urban population (over the period 2000–2005) of 0.9% (UN 2005).[12] The main effect of this insofar as the Northern Range is concerned is the demand for housing space and construction materials.

A series of forces combine to influence a drift towards the capital city, located within the boundaries of the Northern Range:

- Search for space for housing in close proximity to economic and social opportunity
- Increasing incomes for some groups leading to selection of choice hillside sites for high-income housing
- Administrative functions of the national government centralized in the city
- High-demand educational and public facilities and infrastructure located in the city
- Historical orientation of the educational system to produce skills for professional and clerical occupations which follow the public sector and corporate head-office jobs in the city
- Main locus of commercial opportunity in the city
- Lack of approved planning for many developments, ad hoc urban/ribbon sprawl, demand-driven rather than policy-driven land use.

[12]http://unstats.un.org/unsd/demographic/products/socind/hum-sets.htm. Site last updated January 28, 2005.

5.2.1.4 Increasing Demand for Recreation

Generally, as an ecosystem, the Northern Range is perhaps the most important amenity area in Trinidad. Its natural features (beaches and rivers, forest, offshore islands) and constructed facilities (such as the Hollis and Caura dams) are growing in popularity for their amenity value for nationals and visitors alike. The close proximity of many of these features to the urban centres makes them easily accessible. There is a pattern of increasing numbers of visitors to popular beach and river sites. This has been promoted by increasing demand for leisure activities, by increasing mobility of the population, by increasing accessibility from improved road networks and transport, and by recent promotion of tourism as an economic sector for Trinidad and Tobago (TIDCO 1999). It is also the result of rising awareness of the amenity value of natural assets (rivers, caves, hiking trails, beaches, bird- and turtle-watching). While this indicates increasing contribution of Northern Range assets to the well-being of citizens, these assets are threatened by overuse and abuse in the absence of management plans in keeping with their sensitive nature and their carrying capacity, and of facilities to accommodate the needs of visitors. Consequences of this growing demand are problems of waste disposal and water pollution, in a situation where no or few infrastructural facilities are provided at recreational sites, and where public education about appropriate treatment of these assets is low.

5.2.1.5 Culture and Behaviour

There is an absence of deep connection with the natural resource base and, consequently, either ignorance or lack of respect for long-term consequences of actions and activities that impact on the natural physical environment. Despite intensive use of environmental assets for recreation, for example, there appears not to be strong individual commitment by citizens to protect these assets, with some notable exceptions (e.g., turtle protection by communities). There is not a clear understanding of how pressures on the environment could lead to long-term negative impacts that undermine the very assets that are enjoyed. This driving force has been longstanding. Some positive change is perceptible due to increasing efforts in public education, but it is not yet widespread enough to alter the impacts for the Northern Range. Similarly, there has been some degree of stewardship from community and religious groups who are directly affected, and appreciation about sustainability issues is becoming more organized and articulate, but they have not yet reached a critical level of influence on the society.

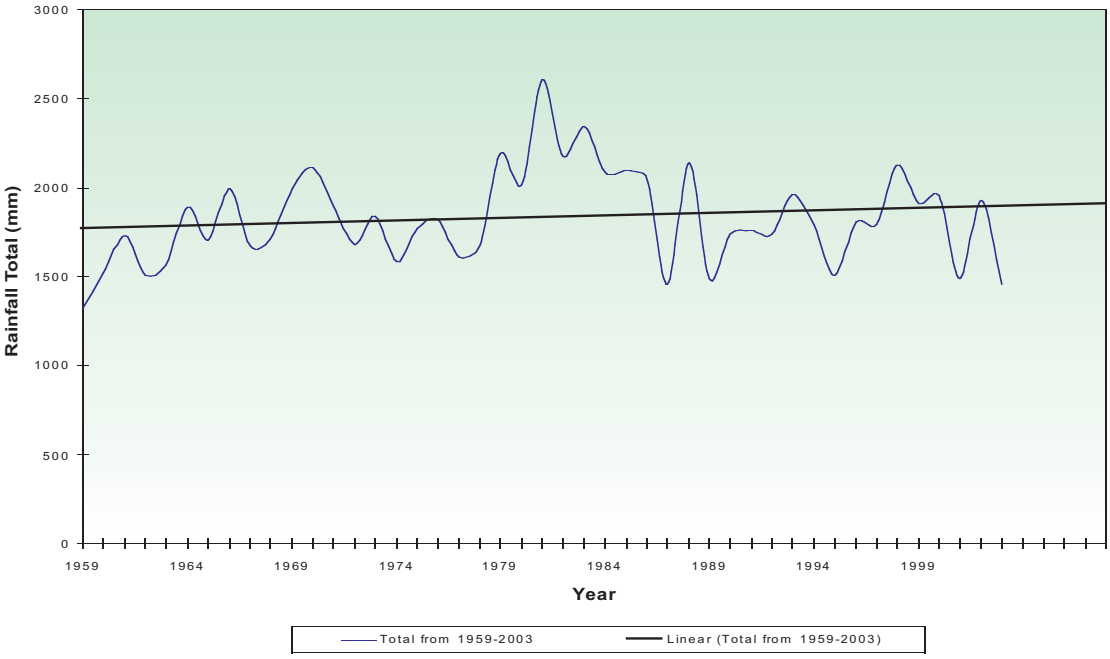
Apparently the public sees enforcement of policies and regulations as exclusively the responsibility of the public sector; and public motivation to comply is very low. Consider our driving or littering habits and the incidence of unauthorized settlements and house constructions in the Northern Range. Self-regulation is neither very evident in our social behaviour nor is public motivation to comply likely to be generated where the public perceives that there is, or can be, political override of official policies.

5.2.2 Natural Factors

5.2.2.1 Climate Variability

According to the rainfall data from the Trinidad and Tobago Meteorological Services, there is considerable variability in total annual rainfall for the period 1959 to 2003 (Fig. 8).

Fig. 8: Total Annual Rainfall (mm) at Piarco Trinidad (1959-2003)



Source: Trinidad and Tobago Meteorological Services, Piarco (pers. commun., 2004)

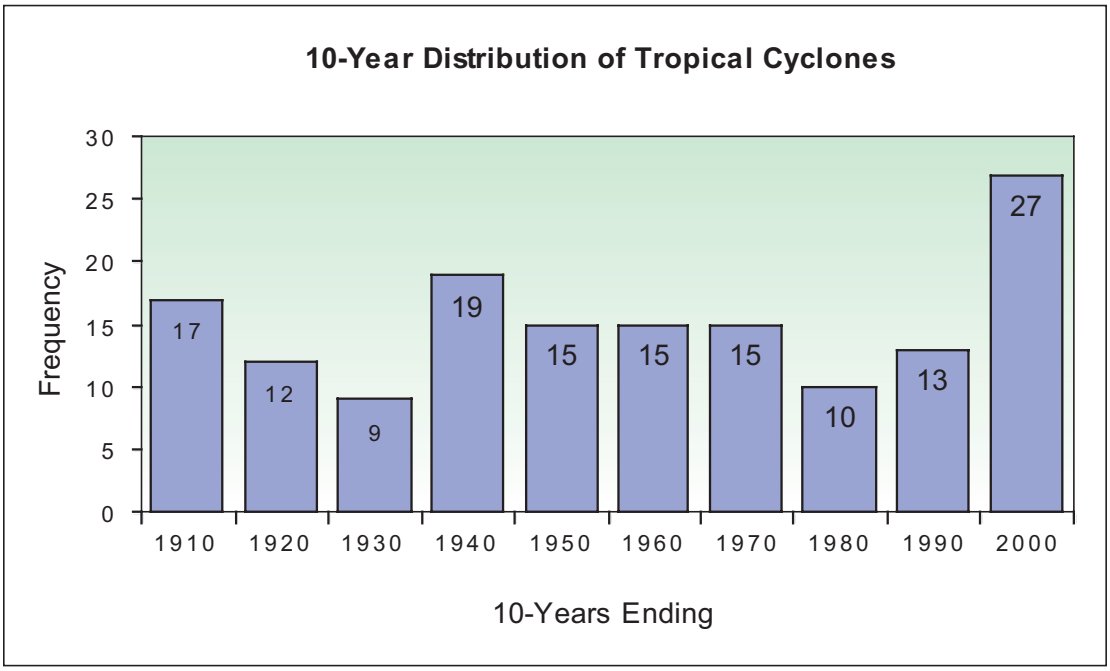
There is also a general perception of more marked variability in weather patterns in Trinidad–higher than normal dry and wet seasons and frequent occurrences of unseasonal weather. However, no clear long-term trend is evident from the data, which show that seasonal rainfall seems to be random, varying from one year to the next in a rather unpredictable way (Stone 2001; Fig. 8). This is supported by Trinidad's Environmental Vulnerability Index (Agard and Gowrie 2003), which indicates that Trinidad (and by extension the Northern Range) has slightly greater-than-average vulnerability to an increasing frequency of dry periods and average vulnerability to high rainfall events.[13]

Sea-level rise, which is reported to have increased globally between 0.1 and 0.2 m in the twentieth century (IPCC 2001 in MA 2005b), can cause loss of, or damage to, coastal areas, and this can have potential consequences for Northern Range coastal resources, especially those associated with amenity value.

Within the insular Caribbean, there is evidence to indicate variability in weather patterns (Fig. 9).

[13]Increasing frequency of dry periods-number of months over the period 1998 to 2002 during which rainfall was more than 20% lower than the 30-year average for that month.
High rainfall events-number of months over the period 1998 to 2002 during which rainfall was greater than 20% higher than the 30-year average for that month.

Fig. 9: Tropical Cyclone Activity in the Caribbean (1901-2000)



Source: Caribbean Institute for Meteorology and Hydrology (in CARSEA 2003)

For the yachting industry, this has had consequences resulting in high-cost insurance premiums which, in turn, have led to migration of private yachts for mooring from the northern Caribbean to Trinidad (which is considered a relatively safer harbour outside of the hurricane belt). Though there has been a decline in the number of yachts over the period 2004–2005, the use of the Chaguaramas area for mooring and related services continues to be intensive, spawning a range of infrastructural and other physical facilities. While this service industry yields benefits to employment and income generation, there are negative consequences for coastal waters that need to be monitored and regulated (see Section 7.2.5).

5.2.3 Land Use and Land-cover Change

According to the IGBP-IHDP[14] (1993), the term 'land cover' is used to represent broad categories of predominantly natural vegetation such as grassland, forest, wetland, or other natural features of the earth's crust. It is therefore categorized as the biophysical state of the earth's surface and the subsurface directly beneath. 'Land use,' on the other hand, represents the manner in which the biophysical attributes of the land are manipulated, and the intent underlying the manipulation. For example, forestry, grazing, agriculture, wildlife reserves, and urban development are some of the activities that can be regarded as intent (Ford 2003).[15] However, the terms land cover and land use are used interchangeably throughout the literature pertaining to the Northern Range.

Land may be regarded as one of the 'provisioning' services of the Northern Range, as it provides valuable space for housing and agriculture. However, it is not treated in this study as one of the priority services for assessment, but as a context for activities that disturb the natural vegetative cover of the Northern Range. Trinidad is a small island with consequent intense competition for

[14]International Geosphere-Biosphere Programme (IGBP) - International Human Dimensions Programme on Global Environmental Change (IHDP).
[15]Ford (2003) notes that the terms land use and land cover have different meanings across disciplines, and in some ways are used interchangeably.

land especially close to the city. As such it is a pivotal factor that influences the availability of all other ecosystem services. Forestry, agriculture, and housing are the three major types of land use, and in the Northern Range there has been loss of forest due to farming, quarrying, forest fires, housing, and squatting, and this has been linked to problems such as aggravated flooding, soil erosion, and loss of water-recharge capabilities (Kairi 1999a).

Based on the account in Box 4, many of the valleys on the southern flanks of the Western Northern Range (between Diego Martin and Arima) began to be occupied since 1834. The natural vegetation was removed and replaced by sugar estates on the flatter land, and tree crops (cocoa, coffee, citrus) on the steeper hillsides and cooler valleys. The capital city, originally at St. Joseph, was moved to Port-of-Spain, and a number of villages developed between these two main centres and eastwards to Arima. This formed the nucleus of the currently dense ribbon development known as the East-West Corridor which traces a good part of the southern boundary of the Northern Range. Urban sprawl has occurred westwards to Carenage and northwards into each of the valleys on the southern flanks of the Range, particularly those closest to the capital. The establishment of cocoa plantations between 1900 and 1920 provided some ecological benefits–namely, soil protection-and some abandoned estates have reverted to secondary forest cover. However, with the abandonment of many of these estates came their increased use for settlement and other forms of agriculture.

Box 4: Brief History of the Changes in Land Use in the Northern Range
[extracted from Chalmers (1981) and based on an original compilation by Beard (1946)]

A map produced in 1802 showed that estates granted under the Spanish Crown amounted to 10% of land area of Trinidad and were located in the mountain valleys from Diego Martin to Arima. Major developments in land settlements came in 1834 with the abolition of slavery, where many of the former slaves squatted on Crown Land forests. This reached such proportion that in 1867, it was decided to open Crown Lands for sale, and the squatters were encouraged to regularize their position by purchasing the lands they occupied.

In 1899 a plan for the management of the forests was prepared, in which areas of forest to be retained under permanent reservation and areas suitable for agriculture were demarcated. The overall programme was criticized because insufficient attention was paid to the most vulnerable part of the country–the Northern Range. The foothills between Diego Martin and Arima are now the most degraded part of the national estate, and Forest Reserves in the Northern Range cover only 13,000 acres.

At the beginning of the 1900s, cocoa plantations covered 220,000 acres and much of this was in the foothills of the Northern Range. These plantations provided soil protection but in the 1920s with increasing diseases and falling prices, the estates of the Northern Range, which were among the first to be abandoned, were gradually subjected to squatting, burning, and shifting cultivation.

Aerial photography from the 1960s shows that most of the Eastern Northern Range was under forest cover at this time, with the higher elevations covered by seasonal montane forest and montane forest, and the lower elevations covered by evergreen seasonal forest. The lowest elevations in the Eastern Northern Range (appearing as a fringe towards the boundaries of the Range) appear to be dominated by savannahs and plantations (such as teak and pine). The western section of the Northern Range (with the exception of the Chaguaramas peninsula) was notably less forested than the eastern section, and it appears to have been covered by patches of deciduous

seasonal forest, dry evergreen forest, agricultural land, burnt sites, and non-forested areas (most probably built-up areas). There is a clear emerging picture of more degradation in the western reaches of the Range than in the eastern section, and more disturbance around the edges than in the centre of the range (Fig. 10).

According to Faizool (2002), by 1988 the Northern Range covered approximately 123,100 ha (307,800 acres) of which 83,100 ha (207,900 acres) or 67.5% was under forest and 33,000 ha (83,200 acres) or 27% was under agriculture of some kind. The remaining 5.5% of the land was under built development, infrastructure, and quarrying activities.

Though it is not clear how much of the information from Forest Resources Inventory Management Unit 1980 forest-cover map was incorporated into the United States Geological Survey (USGS 2001) land-cover map (Fig. 10),[16] both maps indicate clearly that most of the forested areas of the Northern Range are concentrated in the eastern region and on the northern flanks. The western section of the Range is so fragmented that small patches of forest, where they occur, are not reflected in Figure 10. A clear pattern of land conversion has taken place on the southern flanks of the Northern Range–spreading both eastward and uphill into the Range. This change includes conversion of natural forest to built-up areas, agricultural land, and timber cultivation.

5.2.3.1 Patterns in Land-use Activities

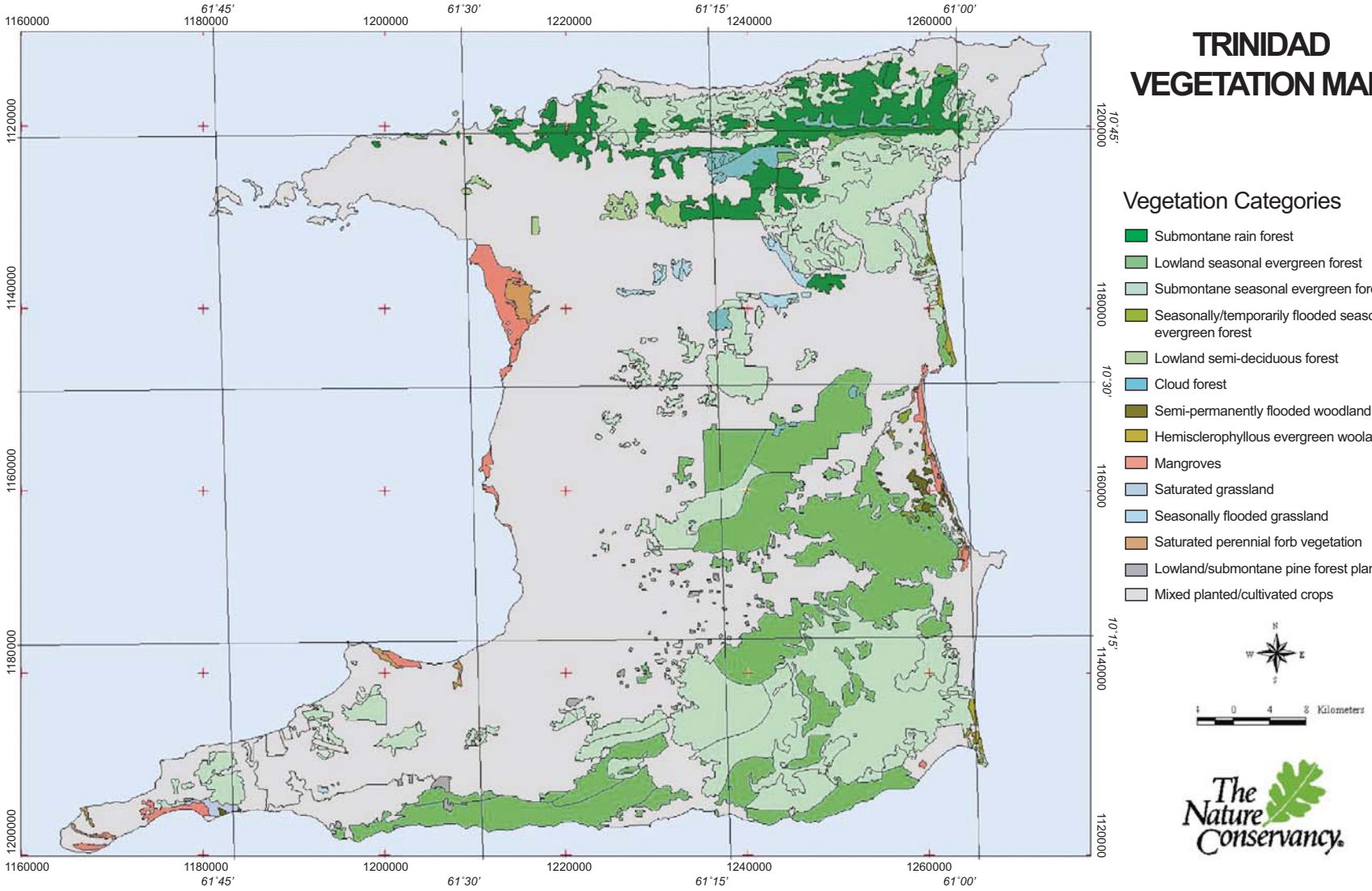
5.2.3.1.1 Residential developments (approved and unauthorized)

The northern slopes of the Northern Range are generally not under intense pressure for human settlement mainly because of the inaccessibility, the rugged terrain, and the sea cliffs along the North Coast (though there are a few pockets of housing settlements that exist, e.g., Blanchisseuse). There are some traditional fishing villages along the Coast but, especially in the north-east (e.g., areas such as Grande Riviere, Toco, Matura, and Salybia), rapid development has not occurred due to the remoteness and residents' desire to maintain the character of their surroundings. However, Faizool (2002, 7) states, "Early settlements have concentrated mainly along the foothills of the southern slopes and the accessible valley areas. In recent times, due to socio economic pressures, there has been a movement up the slope in a number of the valleys. This is usually done in non-conformity with land capability and proper land use management. Concentration of these settlement patterns though has remained mainly in the western half of the Range from Arima to Chaguaramas." "In the most urbanized sections…residential use has intensified and lands have been sold or tenanted in increasing quantities on the basis of formal sub-divisions, arbitrary excisions and other informal occupancy arrangements. There has also been a corresponding increase in the incidence of residential squatting, due to socio-economic pressures, particularly on the upper slopes overlooking these urban settlements, both on State and privately owned lands" (Faizool 2002, 8).

Kairi (1999a) notes that in the 1960s and 1970s unauthorized settlement on publicly owned land (squatting) became widespread due to migration to towns for employment opportunities, lack of affordable land for housing, weak enforcement of regulations governing land occupancy, and the political practice of providing infrastructure to households without land titles. The decline of the economy in the 1980s due to the fall in oil prices exacerbated these driving forces, leading to a noticeable increase in squatting around the urban centres of the East-West Corridor at the base of

[16]This map was compiled from various sources.

Fig. 10: Trinidad Land-cover Map



Source: USGS 2001 (compiled from various sources)

the Northern Range.[17] Some of these lower-income homes are not soundly constructed or supported on precarious slopes with inadequate infrastructure for access, drainage, and waste disposal leading to loss of aesthetics, low standards of living, and risks of disaster if exposed to extreme weather conditions. With the flat lands of the urban East-West Corridor heavily settled, squatting continues to spread upwards into the foothills of the Northern Range. Already established housing, squatting, and infrastructure in western reaches of the Northern Range lead to more intensive hillside use, which is gradually spreading eastwards along the foothills of the Range.

Box 5 highlights some ways in which these driving forces operate at the level of the community.

Box 5: Driving Forces in Bon Air North and Petit Curucaye

Two of the three communities, Bon Air North and Petit Curucaye, were established during the last few decades as people sought land space for housing within easy reach of urban centres, which offered employment opportunities. Bon Air North is a squatter community and grew from 60 houses in 1993 to 250 in 1998 due to the possibility of securing land tenure with the State Land (Regularisation of Tenure) Act No 25 of 1998. In Petit Curucaye, most people on the northern slope rent from a private landowner but there are a few squatters in this area.

In both Petit Curucaye and Grande Riviere residents lament not knowing about official development plans until implementation begins in the area. In Petit Curucaye people also speak of being affected by construction of access roads to new development areas on steep paths and are concerned about how an influx of people into their community would affect them, specifically through increased demand on the already irregular and unreliable potable water supply. In Petit Curucaye, idle estate land space that was used for sports has now been sold to a private housing developer with no alternative options for recreational opportunities within the community.

Access rights to land have become an important issue. In Bon Air North security of tenure is regarded as central to the well-being of residents, and in Grande Riviere the community is concerned about the constraint on village expansion due to exorbitant land prices being paid by purchasers external to the community who are attracted to the area for holiday homes.

Hillside slopes are also very attractive for high-income homes, as indicated in Section 5.2.1.3. This pattern of conversion for housing is facilitated by the current wealth of the country derived from the dynamic energy and petrochemicals sector (as discussed in Section 5.2.1.1). It is also made possible by technology (architecture and engineering practices making it possible for homes to be established on very steep hillsides, and by mobility from use of modern vehicles capable of reaching previously prohibitive heights with steep gradients). Intensive infrastructural facilities (roads, retaining walls) accompany such housing. Planned housing settlements have expanded in the valleys of the Northern Range such as Santa Cruz, St. Joseph, St. Ann's, and Diego Martin (due to the proximity to Port-of-Spain) and are spreading further uphill. Unfortunately these activities often occur in areas not consistent with land capability (for example, the conversion of prime agricultural lands for housing).

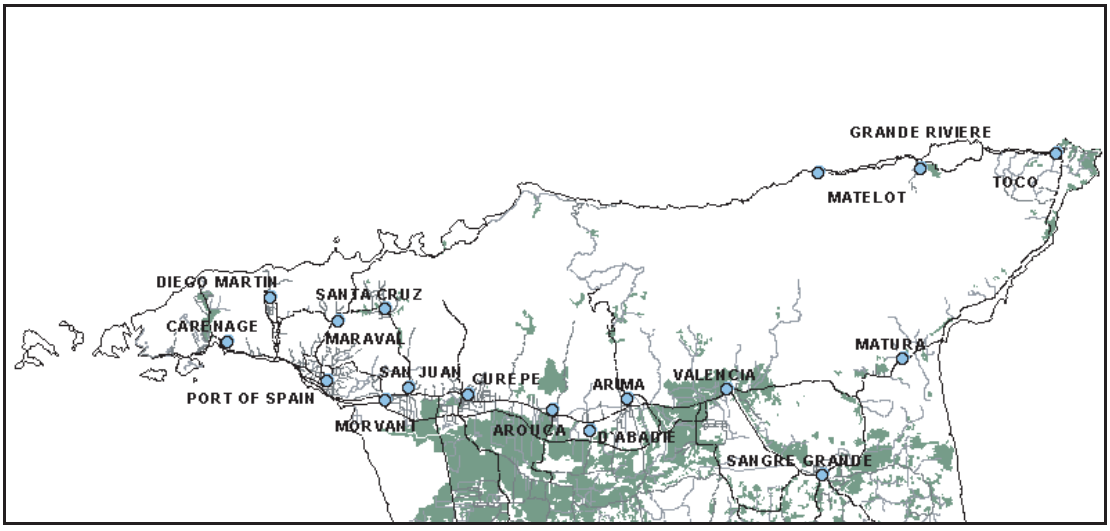
[17]Glenn et al. (1991) in Kairi (1999b) estimated that 20% of the population lived in irregular settlements in 1985, increasing to 25% by the end of the 1980s. Squatting on State lands is estimated by Cropper (1997) to be about 50,000 households nationwide.

The Northern Range is thus affected by authorized high-income housing as much as by unauthorized settlements. There is need to highlight high-income housing and land developers as often the attention falls on the poorer squatters who have more limited options. The associated road construction and the houses decrease the surface area for ground-water infiltration while increasing the pollution load on the surface and ground-water resources.

5.2.3.1.2 Agriculture and agricultural squatting

According to Faizool (2002), "Agriculture has traditionally been the mainstay of economic life in all the Northern Range Valleys, and has thrived well in the favourable conditions which exist mainly in the valley floors and adjoining slopes, but its importance has diminished significantly…." (Fig. 11). The fertile valleys in the western section (Diego Martin, Maraval, Santa Cruz, and Maracas/St. Joseph) are now converted from agriculture into housing. The exception is Tucker Valley in Chaguaramas which is State-owned and used as a farm for producing seed for various crops. In the eastern section, some small-scale farming is still evident in the Lopinot and Caura valleys. The Northern Range valleys have not escaped the effects of the relative decline of agriculture throughout the country as evidenced by abandoned or poorly maintained estates. High labour requirements for cultivating cocoa on hilly land and low product prices have combined to make this crop no longer economically viable. This has been accompanied by pressure on landowners to convert agricultural lands to housing, particularly in the valleys in the western section.

Fig. 11: Northern Range Agricultural Cover



Source: B. Ramlal and S. Surujdeo-Maharaj (unpublished; pers. commun., 2004)

At the same time, unauthorized agriculture on the upper slopes of these valleys is quite common, though in small pockets. While tree crops would be recommended in such terrain, subsistence farmers favour short-term crops. The cut-and-burn method of cultivation used has severe adverse environmental effects. Soil conservation measures are not practised, leading to a decline in soil fertility due to topsoil erosion, which then triggers movement of farmers onto new parcels of land. Loss of topsoil also results in decreased ground-water recharge (Faizool 2002). Figure 11 indicates an absence of large parcels of land in agriculture in the Northern Range. (The small parcels of land under cultivation are not captured by the technology used.) Use of agrochemicals has been linked to fish kills in the Maraval, St. Ann's, Santa Cruz/San Juan rivers (EMA 1998b).

A pattern of such small-scale, unauthorized, and inappropriate agricultural crops and practices is now observed to be prevalent in the valleys and slopes of the eastern section of the Northern Range, including within Forest Reserves. Manure which is used on agricultural land along the banks of the Caura River has been linked to fish kills, while excessive and continuous discharge of untreated agricultural and livestock wastes fed directly into the Tacarigua and Aripo rivers sometimes exceeds their capacity for biodegradation. This results in increased Biological Oxygen Demand (BOD) and subsequent overall decrease in water quality, as has been seen in the Arima River (EMA 1998b).

Agriculture in the Northern Range is subject to much of the local and international conditions that affect agriculture in the rest of the country. In an oil and natural gas based national economy, continued low wages to agriculture make the sector uncompetitive. Moreover, participation of Trinidad and Tobago in the World Trade Organisation (WTO) and in the emerging Free Trade Area of the Americas, as well as in the CARICOM Single Market and Economy, will result in our farmers having to be in open competition with other farmers from many countries. Competition will arise from two contrasting situations: from low wage economies (such as India and China) and from economies (such as the United States and Canada) with advanced agricultural technologies and well-educated farmers (and often highly subsidized agriculture). The country's agricultural sector will require that modern technology is used, farms are of economic size in relation to the crops or livestock being produced, terrain is selected to make them capable of some degree of mechanization, and that a better educated farming population is created. Viability of small-scale farms will require focus on high-priced crops, access to incentives where appropriate, and availability of competent advice through adequate and effective extension services.
Agriculture in the Northern Range will require additional specific measures: it should be confined mainly to the remaining flat areas with medium-sized farms where possible, or on sloping land, where allowed, with strict soil conservation measures in place (Gumbs 1987, 1992, 1995). Infrastructure and irrigation will need to be provided, and subsidies as appropriate. Here it will be necessary to observe WTO rules and this can be done by instituting measures to protect the environment (as is done in the United States and some European countries). Thus farmers could be offered incentives to institute soil conservation measures and to cultivate in a manner that is sustainable. (An example of this is the production of watercress in the Heights of Aripo.) At the same time, cultivation of herbaceous crops on steep slopes must be prohibited and farmers encouraged and assisted to move to forest gardening to support their livelihoods as well as conserve soil and protect the environment.

5.2.3.1.3 Timber harvesting (legal and illegal)

It is difficult to say exactly where and to what extent timber harvesting is currently occurring in the Northern Range. According to EMA (1998a), no harvesting occurs in the upper, inaccessible regions or the north-eastern regions of the Range, indicating that harvesting is more prevalent in the lower, more accessible (and possibly westernmost) regions. The Forestry Division reports that no timber is harvested from natural forests in Forest Reserves because over-exploitation in the past has resulted in depleted reserves (A. Ramnarine,[18] pers. commun., 2004). However, in recent years there has been a trend of old family-owned estates being sold and the commercial timber being consequently removed (A. Ramnarine, pers. commun., 2005). In addition, there are some unsubstantiated reports of timber being extracted from Government land (including Forest Reserves) immediately adjacent to private estates that are being logged.

[18]Acting Conservator of Forests.

Empirical observations suggest that much timber is still harvested illegally from Northern Range forests despite provisions requiring licences for such movements of timber under the Sawmills Act No. 24 of 1999. It is suspected that high sales of portable sawmills over the past decade have exacerbated the problem as sawn lumber can often be seen on small and medium-sized trucks leaving forested areas particularly on weekends and on public holidays. Despite the Forestry Division's recent policy of not issuing licences for timber harvesting from the Northern Range (S. Faizool, pers. commun., 2003), trucks with logs are often seen traversing areas of the East-West Corridor, and assumptions are made by public officials that such activity might be originating from private lands in the Northern Range.

5.2.3.1.4 Quarrying

The increase in the wealth of the country has spawned a growing demand for construction material from quarries, and the Northern Range is the main source in the country of deposits of blue limestone and other non-hydrocarbon construction materials (Faizool 2002). Table 3 indicates the location and size of quarries in the Northern Range.

It is reported that 2,800 ha in the Valencia Forest Reserve and Wallerfield area was mined as at 1996 (Comeau 1996). This is estimated to be about 1% of forested area in Trinidad and Tobago.

In 1993, WS Atkins Limited and A De B Consultants reported that the method of operations of quarries in the Santa Cruz Watershed was dictated by business economics, to the exclusion of any environmental considerations, and that this was aggravated by the poor level of control in the industry. Studies have indicated that quarrying has impacted negatively on the water quality of the Santa Cruz/San Juan, Arima, and North Oropouche rivers (EMA 1999). Generally there is inadequate mitigation of the effects of quarry-floor runoff and effluent discharge that could lead to changes in sediment dynamics and river ecosystems (Alkins-Koo et al. 2004).

Table 3: Northern Range Quarries

No.	Quarry	Location	Acreage	Ownership
1	Home Construction Limited	Morne Coco Road, Petit Valley	72 Acres , 0 rods , 15 perches	Privately owned
2	Seereeram Brothers Limited	Cangreal Road, Santa Cruz	10 Acres	Leased from Stollmeyer
3	Caribbean Asphalt Pavers	Akal Trace , Santa Cruz	5 Acres	Privately owned
4	Nabbie Quarry	Cutucuphano Road, Santa Cruz	5 Acres	Privately owned
5	Fujiko Caribbean Limited	La Sagesse Road, Santa Cruz	10 Acres	Leased from Stollmeyer
6	San Antonio Quarry	La Sagesse Road, Santa Cruz	12 Acres, 2 rods , 20 perches	State
7	Bartholomew's Quarry	Cutucuphano Road, Santa Cruz	4 Acres , 2 rods, 20 perches	State

No.	Quarry	Location	Acreage	Ownership
8	P.T.F. Mining Limited	Verdant Vale, Arima	100 Acres	Privately owned
9	Dipcon Engineering Services Limited	Verdant Vale, Arima	36 Acres	State
10	National Quarries Company Limited	Verdant Vale, Arima	114 Acres	State
11	Coosal's Construction Company Limited	Eligon Road, Maracas, St. Joseph	300 Acres	Privately owned
12	Hermitage Limestone Limited	Heights of Guanapo Road	70 Acres	Privately owned part of a 114 - acre estate
13	Spring Bank Quarry	Heights of Guanapo Road	80 Acres	Privately owned part of a 114 - acre estate
14	Alescon Readymix Limited	Green Gate Road, Valencia	—	—
15	Alescon Readymix Limited	Toco Road, Valencia	—	—
16	Readymix West Indies Limited	Valencia Road, Valencia	—	—
17	Readymix West Indies Limited	Tapana Road, Valencia	—	—
18	PIUS Holdings Limited	Valencia/ Toco Road, Valencia	—	—
19	Aggregate Industries Limited	Orosco Road, Matura	—	—
20	Nasaja Contractors Company Limited	Oropouche Road, Valencia	—	—
21	Maharaj's Wash Plant	Andrew Trace, Matura	—	—
22	Anthony Castillo	Oropouche Road, Valencia	—	—
23	Carib Glassworks Limited	Matura	—	—
24	Ramdeo Harry	Tapana Road, Valencia	—	—
25	Castillo and Hughes Quarry Works Limited	Tapana Road, Valencia	—	—

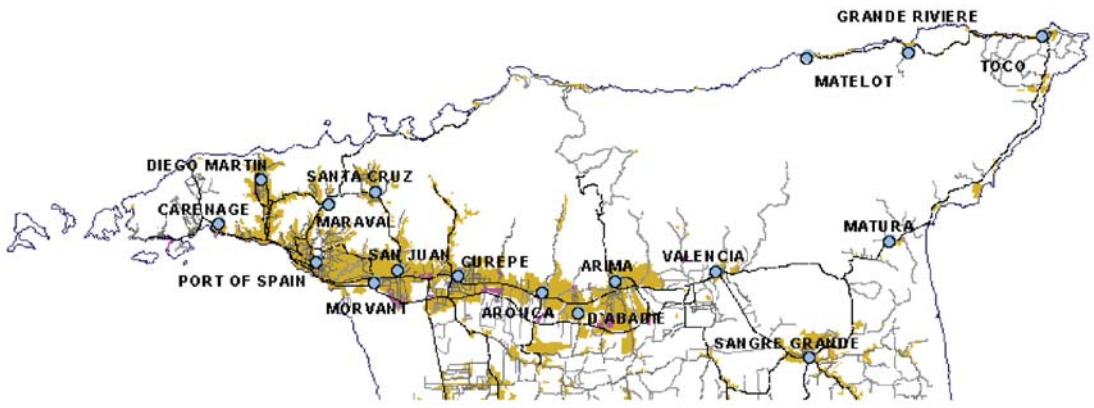
No.	Quarry	Location	Acreage	Ownership
26	Coosal's Construction Service s Limited	Block 1 , Tapana Road , Valencia	—	—
27	Coosal's Construction Services	Tapana Road , Valencia	—	—
28	Dipcon Engineering Services Limited	Block 2 , Tapana Road , Valencia	—	—
29	The Ministry of Agriculture , Land and Marine Resources	Tapana Bra nch Road , Valencia	—	—
30	Tapana Q uarry	Tapana Q uarry Road , Valencia	—	—
31	Margaret Yeates	William Lane, Valencia	—	—
32	Dar-ul-Islam	Tattoo Trace, Valencia	—	—
33	Caribbean Minerals Agency	Toco Main Road	—	—

Source: Ministry of Energy and Energy Industries (pers. commun., 2005)

5.2.3.1.5 Commercial/Industrial development

Industrial development, including smaller commercial and administrative activities, occurs only on the southern flanks of the Northern Range (Fig. 12), stretching from Chaguaramas to Arima. Some examples of industrial activities include boat building and repairs (Chaguaramas), paint manufacture (Laventille, Beetham, Wrightson Road), dairy, bakery, soft drinks, and sweets (El Soccorro, Champ Fleurs), and toiletries (Champ Fleurs; WRMU I, 2001). Industrial activity along the Eastern Main Road was identified as a potential source of freshwater pollution (EMA 1998b).

Fig. 12: Northern Range Residential, Commercial, and Municipal (brown); and Industrial (pink) Cover



Source: B. Ramlal and S. Surujdeo-Maharaj (unpublished; pers. commun., 2004)

Agro-processing has impacted negatively on the Santa Cruz/San Juan, Arima, and the Tacarigua rivers (EMA 1998b) in addition to the Maracas/St. Joseph River (Lucas 2003; Lucas and Alkins-Koo 2004). Runoff and leaking of underground fuel-storage tanks from service stations have adversely affected the Santa Cruz/San Juan, Arima, and the North Oropouche rivers. Contamination of the Caroni River and some of its tributaries with industrial effluents (notably synthetic organic chemicals) is documented (Moore and Karasek 1984). Industrial and other sources of heavy metals also contaminate water and sediments of these rivers at levels above the United States and Canadian standards (Mahabir 2003; Surujdeo-Maharaj et al. 2004).

5.2.3.2 Harvesting of Wildlife and Fish

Studies have shown that over-hunting has affected species such as the Pawi, howler monkey, ocelot, and wild hog (ENRP 1991). These will be discussed in more detail in Section 6.1.2.5, in Box 6 (the Pawi), and in Annex 3. Over-exploitation of fisheries, birds, and crustaceans on the North Coast are of concern for the sustainability of the harvesting activities as well as the health of the ecosystems. An assessment conducted by the Fisheries Division of the Ministry of Agriculture, Land and Marine Resources (MALMR) indicated that over-exploited species include carite, croaker, red and vermillion snappers, and yellow mouth grouper (WRA 2001). The national increase in fish catch between 1986 and 1995 has been a result of developments in technology, such as the use of multi-purpose vessels and chilled storage, and has been compounded by the fact that fish stocks are open-access resources and are therefore available for the public to use at will (WRA 2001). Indiscriminate harvesting of oyster species regardless of size and sex has led to a collapse of the oyster industry; this trend may also be seen with mussels in the near future (WRA 2001).

Factors involved in over-exploitation include:

- Oversized fleet
- Greater range of fishing vessels
- Inappropriate gear
- Open-access resource
- Three types of fisheries within the same fishing grounds
- Outdated legislation (Fisheries Act is 1916 with several amendments)
- Little information on biology of most fish species
- Focus on fisheries development rather than management
- Increased near-shore pollution from land-based sources: industrial, domestic, agricultural, and solid waste.

The consequences for fisher folk have been increasing fishing effort, falling yields, and declining financial returns. In addition, the coastal and marine environments are being degraded as a result of the destruction of wetlands.

5.2.3.3 External Inputs

5.2.3.3.1 Land-based sources of pollution

Land-based sources of pollution pose a major threat to the Northern Range freshwater resources and thus to coastal environments, as the coastal zone receives water from rivers and drains and is therefore the ultimate sink for effluents generated from land-use activities. A 1998 study by WASA and IMA showed that the lower reaches of some rivers are contaminated by domestic, industrial, and agricultural wastes (WRA 2001). Other studies showed that some of the rivers popular for recreational activities contain very high levels of faecal bacteria (Lawrence 2004). Pollution levels

generally increase during the rainy season with increased surface runoff. A study conducted in 2000 in the Chaguaramas area showed a higher level of pollutants (lead and chromium) in the rainy season (Mohammed et al. 2000).

Pollution has impacted severely on the species composition and abundance in coastal areas (WRA 2001). Pollutants affecting the coastal waters are derived from sewage resulting in eutrophication and consequent dinoflagellate and algal blooms which produce toxins and deplete the oxygen concentration of the water, respectively, causing fish kills; sediments from indiscriminate quarrying and agricultural activities which inhibit coral growth and smother seagrass beds; and solid waste which affects benthic and rocky-shore communities (Boodoosingh 1992). Toxic pollutants from domestic grey water, agricultural products, and industrial effluents, including the boat repair and maintenance industry concentrated within the Chaguaramas Bay area, are also found within the coastal zone.

Organic pollution in the form of sewage, livestock wastes, and fertilizers deteriorates the water quality in popular recreational beaches. There has been a decrease in water quality in Maracas Bay from 1995 to 2001 as the western end of the beach (near to the mouth of the Maracas Bay River) is no longer suitable for swimming according to international standards, even in the dry season (Bullock and Moonesar 2001). The eastern section remains safe but only because the currents are flowing in a westerly direction (Bullock and Moonesar 2001).

The numerous bush fires which ravage terrestrial vegetation during the dry season continue to take their toll on coastal vegetation during the rainy season, as exposed soil runs off into the sea, smothering coastal systems like the seagrass beds. Deforestation on the Northern Range slopes has also led to increased sedimentation in rivers, especially during the rainy season and therefore in the coastal waters (WRA 2001). The coastal waters polluted with solid waste become unappealing and murky in appearance. The unseen pathogens in the waters pose potential health hazards to bathers, especially to the more vulnerable young and elderly groups.

5.2.3.3.2 Wastewater treatment

Many wastewater treatment plants in Trinidad are not meeting national effluent standards and are therefore a major source of pollution (The Trinidad Guardian, 25/08/2003, p. 8). The wastewater sector is ultimately managed by WASA but the inadequate system is in part due to the avoidance of responsibility by private housing/land developers. Thirteen of the 16 operating treatment plants in the Northern Range are privately managed (Rodriguez-Atwell 2000) and an increase in private-sector stewardship can improve the system, but the returns on the financial investments are not viable.

Chronic or incidental pollution with untreated sewage wastewater or domestic grey water increases BOD and decreases dissolved oxygen, leading to eutrophication. While this may generate algal biodiversity, the trade-off is that it may also lead to fish kills or ecosystem degradation and loss of aesthetics.

It is expected that the Beetham waste-water treatment plant which has recently been operationalized will alleviate the problem of waste-water contamination in the Port-of-Spain area. Preliminary testing of the water exiting this plant indicates that the water may be of a good enough quality to be used for the irrigation of agricultural lands, and this may help to meet Trinidad's water demand more adequately in the future.

5.2.3.3.3 Solid-waste disposal

Large appliances and vehicles are commonly found in both forested areas and in ravines and rivers. In addition small operators of commercial enterprises (e.g., vendors) use these as alternatives to authorized dump sites. There have also been incidents of dumping of heavy metal waste on river banks thus leading to potential contamination of surface and ground waters via leaching of soluble components.

From the discussion in Section 5, it is evident that a range of factors (economic, demographic, institutional, natural, behavioural, technological) operates and interplays to explain how the Northern Range and its assets are being affected. The nature of the impacts has also been identified. The consequences of these impacts for the ecosystem and the services it provides, as well as their relationship with our well-being, are explored in the following section.

6.0 Assessment of Northern Range Ecosystem Services

6.1 Biodiversity

6.1.1 Links between Biological Diversity and Human Well-being

The Convention on Biological Diversity (CBD) defines biological diversity (or biodiversity) as 'the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems' (CBD 2001).

Humans benefit in many ways from the biodiversity of ecosystems-directly through the provisioning of biological products (such as food and timber), and from the cultural services provided by the aesthetic value of the ecosystem; and more indirectly and discreetly, from the supporting services provided by the diversity of an ecosystem. An example of the supporting service of biodiversity is where, in a terrestrial system, both the floral and faunal diversity help in the process of soil formation and in the cycling of nutrients in the ecosystem. We might also consider a river ecosystem in which the plant and animal species, and the interactions among them, help to maintain the water quality; the removal of certain species could have marked effects on the quality of the water in that freshwater ecosystem. Some species also serve as indicators of pollution and their presence could be important to the monitoring and management for water quality (e.g., Cladophora). Humans may not directly utilize all the products of the river, but without the diversity of these biological resources the quality of the water in the river may not be suitable as potable water for human use. In this way therefore, the elements of biodiversity underpin the ability of ecosystems to provide their ecological services, which support life on earth (MA 2003).[19]

6.1.2 Links between Northern Range Biodiversity and Human Well-being

Generally, the biodiversity of the Northern Range is a cross-cutting factor which contributes to human well-being in four ways: through its provisioning, cultural, supporting, and regulating services. The benefits gained from the provisioning aspects of biodiversity are quantifiable and can be economically valued; thus these links are fairly straightforward. The cultural services include the benefits gained from the amenity value (recreation and eco-tourism) as well as the educational

[19]Several published documents have already addressed the links between ecosystem services and biodiversity (e.g., Myers 1996) and have concluded that biodiversity is essential for sustaining ecological function. The current document does not seek to review this literature but rather focuses specifically on the Northern Range.

value of biodiversity. To some extent, it is possible to put an economic value to cultural services, but the way in which the amenity value is enjoyed remains largely subjective and thus difficult to quantify. The supporting and regulating services provided by the biodiversity of the Northern Range are understood in broad ecological terms, but the scientific evidence which would seal the links that are understood in principle simply does not exist.

6.1.2.1 Provisioning Services

Broadly, the provisioning services of Northern Range biodiversity include food and income from wild meat and several aquatic organisms; the production of honey, handicraft materials, economic gains, and building materials from timber; and potential genetic, chemical, and medical resources from species. The importance of timber and wild-meat harvesting in the Northern Range (discussed in the section on forests) has long been established (EMA 1997; ENRP 1991). Honey production and the provision of handicraft materials are dealt with in Section 6.2.2.1.2.

Special mention must be made of the red howler monkey, which is an important faunal species for Yellow Fever research. This species is a carrier for the Yellow Fever virus (EMA 1998c). Though in principle the potential for harvesting of other biological, medical, chemical, and genetic resources has also been recognized (Seaforth 1981; Seaforth et al. 1985), there is very little evidence in the literature to indicate the potential value of these products; thus, much more research is needed in this area.

6.1.2.2 Supporting and Regulating Services

Faizool (2002) notes that 'the Northern Range comprises a very definite and delicate ecosystem in which undue interference with its natural balance can significantly alter its function as a habitat for important species of plant and animal life and as a water source.' From basic principles of ecology, it is well established that biodiversity plays an integral role in maintaining the integrity of ecosystems through services such as soil formation, nutrient cycling, and water purification, and, in the case of the Northern Range, various authors and scientists have made mention of the causal links between biodiversity, ecosystem functioning, and human well-being (Kenny et al. 1997; ENRP 1991; Shrivastava 2003; Town and Country Planning Division[20] 1988).

The flora of the Northern Range can be considered important in three ways-as a habitat and food source for wildlife, for the soil-binding capacity of plants, and as heavy contributors to the humic content of soil which relates to soil fertility and structure. There is some specific information on the importance of floral species for providing food for birds, for example, several fruits (such as berries) of various plants such as *Miconia* sp. of the family Melastomaceae (ffrench 1991). The Pawi *(Pipile pipile)* found in the Northern Range feeds on fruits and berries of a variety of forest trees, including *Ocotea* sp., *Ponteria* sp., *Bursera* sp., *Didymopanax* sp., and *Erythroxylum* sp.

As is evident from Table 4 (and Annex 3), there is very little scientific information that establishes the value of faunal species to the ecological habitats of the Northern Range. This can be explained, however, because the application of scientific concepts such as 'keystone species' and 'ecological thresholds' requires both an extensive and intensive examination of the ecology of specific species and the interactions amongst them; for the Northern Range this type of rigorous research simply does not exist for most floral or faunal species in all of the habitat types.

[20]Northern Range Hillside Development Policy (1988).

There are some examples in the literature of the role of specific species in ecological systems. One such example is the oilbird, which has been given considerable attention both by the scientific community and tourists. The importance of this species, noted in Table 4, is borne out by its role in pollinating forest trees, dispersing seeds, controlling insect populations, and recycling nutrients in the food chains of caves. Another species whose importance is linked to the presence of the agouti *(Dasyprocta agouti)* is crappo tree species *(Carapa guinensis)*. According to Bacon (1978), the honey creepers and hummingbirds of Trinidad pollinate flowers of forest trees such as the immortelle *(Erythrina poeppigiana)*, and mountain rose *(Brownea coccinea)* while feeding on these trees.

6.1.2.3 Cultural Services

In the Northern Range, recreational, educational, and eco-tourism activities are increasing and are all predicated on the amenity value of the ecosystem. Many species are important as tourist attractions; some of these are the marine turtles, the oilbirds, and the Pawi. The Asa Wright Nature Centre (AWNC) in the Arima Valley, for example, attracts a growing number of tourists every year, generating appreciable annual revenues which allow the AWNC to make further conservation efforts in the Arima Valley. In the 1990s, it was reported that there were more than 8,000 day visitors annually, many of whom were school children. During the period 1990-1996, the maximum number of guest nights recorded was 16,836. Most visitors were recorded from the United States (between 50% and 60%), followed by 19.2% local visitors, and the remainder from the United Kingdom and Germany (Nelson et al. 1999). At the AWNC, the oilbird is one of the main attractions (AWNC 1999). The Pawi has given rise to species-specific tourism in Grande Riviere and so contributes to income of that community. The turtles which nest on the north-east coast also provide a source of income for some of the local communities in the area. Local and rare species (like marine turtles and oilbirds) are very valuable for scientific research and educational activities.

Plant products from bamboo *(Bambusa vulgaris)* are used in the Hindu festival of Divali for decoration while the heart of palm from the Royal palm *(Roystonia oleracea)* is used for food (L. Doodnath, pers. commun., 2005). Another important species, *Ryania speciosa*, is discussed in more detail in Section 6.2.2.1.2.

Though not currently fully exploited there is potential for communities in the Northern Range to benefit from the rich diversity of faunal species present. For example, given the richness of butterfly species on the island (Barcant 1970), butterfly farming can be combined with agro-forestry activities to provide a source of income for local communities through recreational and eco-tourism activities.

6.1.2.4 Northern Range Flora

The Northern Range is an extension of the Coastal Cordillera of Venezuela which has been declared to be of great plant conservation importance by the World Wildlife Fund (Huber 1997). Phytogeographically the flora of the Coastal Cordillera and the Northern Range shows a stronger relationship with the Mesoamerican and Caribbean floristic regions than with the northern Andean flora (Huber 1997) and the Guyanian flora (Steyermark 1979). The Coastal Cordillera Montane forests are rich in species and are considered the most important endemic zones for flora and fauna in Venezuela, and probably also for Trinidad. It would appear that the primary factor for determining this degree of endemism in these areas is related to the establishment of barriers that separate the Coastal Cordillera and the Northern Range from other mountain systems (Steyermark 1979).

6.1.2.5 Northern Range Fauna

Table 4 includes, among other information, qualitative information on how certain key Northern Range species contribute to our well-being.

Table 4: Summary of Key Faunal Species of the Eastern Northern Range[21]

Species Common name (*Scientific name*) Family name	Habitat type	Links to human well-being	Condition	Trend	Main threats	Reference
Pawi (*Pipile pipile*) Cracidae	Forest	Recreation Scientific research (probably an island - endemic species)	Rare Only 200 individuals left in the wild as at 2003	Decreasing population size and distribution as at 2003	Habitat destruction and hunting	ENRP 1991; EMA 1998c; Bird Life International 2003; Alexander 2002; IUCN 2004
Howler monkey (*Alouatta seniculus insularis*) Cebidae	Forest	Medical research (Yellow Fever) Recreation	Scattered populations	Decreasing population size and distribution as at 1997	Habitat destruction and hunting	James (pers. commun. with villagers, wood workers, hunters 1983), in ENRP 1991; Kenny et al. 1997; Alkins -Koo and So omai 1993
Agouti (*Dasyprocta agouti*) Agoutidae	Forest	Economic (extraction of thyroid and other hormones to facilitate breeding on large scale); food; pets	Common	—[22]	Hunting	Alkins -Koo and So omai 1993
Brocket deer (*Mazama americana trinitatis*) Cervidae	Forest	Economic (extraction of thyroid and other hormones to facilitate breeding on large scale); hunting; food	Vulnerable		Hunting	Alkins -Koo and So omai 1993
Ocelot (*Felis pardalis*) Felidae	Forest	Recreation Scientific research	Rare and threatened	Decreasing population size noted in 1991	Habitat destruction and hunting	ENRP 1991
Wild hog (quenk) (*Tayassu tajacu*) Tayassuidae	Forest	Recreation Economic (food and other uses through captive breeding)	—	Decreasing population size noted in 1991	Habitat destruction and hunting	ENRP 1991; Alkins -Koo and Soomai 1993

[21]See Annex 3 for a comprehensive account of the information from the ENRP (1991). The species included in this table are considered key species and are the species for which information is available, but the list is by no means exhaustive of the faunal species of the Northern Range.
[22]A dash indicates that no data is available.

Species Common name (*Scientific name*) Family name	Habitat type	Links to human well-being	Condition	Trend	Main threats	Reference
Otter *(Lutra longicaudis)* Mustelidae	Rivers	—	Rare as at 1998	—	—	EMA 1998c
Oilbird (*Steatornis caripensis*) Steatornithidae	Caves	Tourism Aesthetics Scientific research Pollinate forest trees; disperse seeds; control insect population; recycle nutrients in cave food chain	Stable population as at 1999	—	Habitat destruction and human disturbance	ENRP 1991 AWNC 1999[23]
Golden tree frog *(Phyllodytes auratus)* Hylidae		Tourism Scientific research	Stable population as at 2005	Stable	—	Kenny et al. 1997; Kenny 2000; J. Kenny pers. commun., 2005
Marine turtles: Leatherback (*Dermochelys coriacea*) Dermochylidae Green turtle (*Chelonia mydas*) Cheloniidae Hawksbill (*Eretmochelys imbricata*) Cheloniidae Olive Ridley (*Lepidochelys olivacea*) Cheloniidae	Beaches and coral reefs	Tourism development (economic) Scientific research Educational Meat, eggs, oil (medicinal) Food—meat, eggs, and calipee (soup); Handicraft—shell; oil (cosmetic); skin Handicraft—shell; meat; eggs Skin; meat; eggs	—	—	—	ENRP 1991 Kenny and Bacon 1981

[23]See: www.asawright.org/nature/oilbirds.html .

Species Common name (*Scientific name*) Family name	Habitat type	Links to human well-being	Condition	Trend	Main threats	Reference
Freshwater species:	Rivers and streams	Recreation Educational Scientific Economic	Good population sizes throughout the ENR as at 1991	—	—	ENRP 1991
Lappe (*Agouti paca*) Agoutidae		Economic (wild meat) and recreation (hunting)	Common in 1991; vulnerable in 1993	Decreasing		ENRP 1991; Alkins-Koo and Soomai 1993)
Tatoo (*Dasypus novemcinctus novemcinctus*) Dasypodidae						
Sea moss *Gracilaria* sp.	Submerged rocks and coral reefs	Food (beverages); handicraft	Population depleted as at 2005	—	Habitat destruction; unsustainable rates of harvesting	Duncan (pers. commun., 2005)

6.1.3 Description of the Condition and Trends in Northern Range Biodiversity

The islands of Trinidad and Tobago boast a very rich biota relative to their size, which is largely attributable to the history and location of the islands in relation to the South American continent (EMA 1997; Kenny et al. 1997; Barcant 1970). Having been connected to South America until probably as recently as 1,500 years ago, Trinidad's terrestrial biota is largely relict continental biota (Kenny 2000), but some species, such as birds and fish, are also of Antillean origin (Kenny 2000).

Table 5 shows estimated figures for national biodiversity, along with some estimates for species diversity in the Northern Range, and on the islands off the north-west coast of Trinidad. The eastern section of the Northern Range is the largest block of undisturbed forest remaining, and it can be expected to contain a high level of biodiversity.

Table 5: Species Diversity in Trinidad and Tobago and in the Northern Range

Major groups	Number of recorded species in Trinidad and Tobago (EMA 2001a) [24]	Northern Range		North-west Islands	
		No. of species recorded [25]	Data source(s)	No. of species recorded	Data source(s)
Mammals	95	29 bats [26]	AWNC 1999	4	Lall and Hayes 2000
Reptiles	140	57	Murphy 1997	14	Lall and Hayes 2000; Boos 1983; Boos and Quesnel 1993; Lall and Hayes 2000
Snakes	55	35	Murphy 1997	3	
Amphibians	30	18	Murphy 1997	—	—
Birds	450	159 99	AWNC 1999; ffrench and ffrench 2000	135 14	Hayes and Samad 1998, 2002; ffrench 1967, 1969
Freshwater fishes	45	23	Kenny 1995; Phillip 1999	—	—
Marine fishes	354	—	—	—	—
Butterflies	600 [27]	42 12 Families 35	AWNC 1999 Barcant 1970 Garcia 1999	—	—
Nematodes	200–300	—	—	—	—
Vascular plants	2,160	—	—	—	—
Ferns	13	12	Baksh-Comeau 2000	—	—
Marine algae	198	59	Duncan and Lee Lum 2004	5	Duncan and Lee Lum 2004

Combining the information in tables 4 and 5, and Annex 3, it is possible to speak generally about the current condition of Northern Range biodiversity, and about trends in the population size and distribution of certain taxonomic groups:

Mammals: Though there are little quantifiable data for mammalian species in the Northern Range, the presence of certain species has been well documented in the literature. Some of the better-known species include deer, bats, squirrels, wild pigs, agouti, armadillos, monkeys, and ocelots (ffrench 1991; Kenny 2000). The larger species are the most sought after for hunting (EMA 1997). The 1999 Tourism and Industrial Development Company of Trinidad and Tobago (TIDCO) carrying-capacity study indicated that in the Northern Range hunting pressure is already at, or close to, carrying capacity. Furthermore, it was felt that in many areas the carrying capacity for hunting has already been exceeded and game populations are over-exploited with a threat to population stability (TIDCO 1999). Based on the evidence in Table 4 and Annex 3, both the numbers and distribution of species like the wild pigs, monkeys, and ocelot are decreasing.

[24]It is not clear what proportion of the species noted are introduced (vis-à-vis native). Agard and Gowrie (2003) note that as much as 24.1% of the flora of Trinidad and Tobago is introduced, yet there are little data on faunal species relating to introduction.
[25]The numbers recorded by AWNC (1999) and Murphy (1997), especially for birds and butterflies, probably do not represent the full diversity of species in the Northern Range, since surveys were done mainly in the Arima Valley in the Eastern Northern Range.
[26]Bats are the only mammals for which quantitative data are available.
[27]Barcant (1970) makes mention of 617 species. Figures relating to the diversity of skipper butterflies based on the work of Matthew Cock are not included.

It is known also that the Bocas Islands off the north-west peninsula, Gasparee, the Five Islands, and Saut d'eau Island do not boast a very rich mammalian diversity (Alkins 1979). Based on the survey conducted by Lall and Hayes (2000), only four mammalian species were recorded including a squirrel, rat, and bats. But it has been noted that the bats are very abundant on these islands (J. Kenny, pers. commun., 2005). Though no monkeys were recorded by these researchers, historical accounts indicate that they were present on the island when Christopher Columbus arrived in 1498 (McDonald 2000).

Reptiles and Amphibians: Based on work done by Murphy (1997), we know that 'the Arima Valley contains 75 species of amphibians and reptiles, 64% of the herpetofauna known from the island. These include 16 frog species, 1 crocodilian species, 4 species of turtles, 2 species of amphisbaenids, 17 species of lizards and 35 species of snakes.'

There are no accounts of amphibians on the islands off the north-west coast, but Lall and Hayes (2000) reported 17 reptilian species including snakes. In 2002, Hayes and Eithiear reported sighting the spectacled caiman *(Caiman crocodylus)* for the first time on Chacachacare. These numbers are notably lower than those in the Arima Valley. Certain 'vagrant' species such as the American crocodile *(Crocodylus acutus)* and the Orinoco crocodile *(Crocodylus intermedius)* may have, at one point in the past, been present in certain areas of the Northern Range such as Chacachacare Island and Balandra Bay (Murphy 1997). But it is doubtful, based on archaeological evidence, that there ever were stable populations present.

Birds: Though there are several studies of birds done in the Northern Range, it is difficult to extract quantitative data to document the condition and trends in avian diversity. From AWNC (1999), we know that there are at least 159 bird species in the Arima Valley. There are likely more species in the Northern Range as a whole.

Freshwater Fish: The Northern Range is a very important biogeographical barrier to freshwater fish species. South of the Northern Range are fish that are typically South American, and the biota is dominated by primary fish like the characiniform fishes. The fish biota of the rivers and streams of the northern flanks of the Northern Range is described as secondary or peripheral and is dominated by gobies and mountain mullet (Kenny et al. 1997). South American fish include several species of sardines, catfish, and cichlids. Some relict species populations are decreasing in distribution range like the Stout sardine, which is confined to a small area in the Northern Range. In the lower reaches of the river the diversity of fish is greater and many species of sardines, guabine *(Hoplias malabaricus)*, pui pui *(Corydoras aeneus)*, teta *(Hypostomus robinii)*, and coscorob *(Aequidens pulcher)* can be found (Gilliam et al. 1993; Kenny 1995). The guppy *(Poecilia reticulata)* is widespread and found in a variety of habitats.

Based on studies conducted by Kenny (1995) and Phillip (1999), it is evident that approximately 50% of the freshwater fish species known to Trinidad can be found in the Northern Range, and this may be because of the number of rivers that originate in the Northern Range.

Butterflies: Based on available data, there are at least 42 recorded butterfly species in 12 families found in the Northern Range. The number of species is more than likely higher than this, however, because the skipper butterflies, a very large group, are not included in this count.

Ferns: Ferns have been very well studied in the country, especially in the Northern Range, and there is much documentation available. They are also the largest and most well-known group of plants in Trinidad and Tobago and are highly vulnerable to habitat change. According to Baksh-

Comeau (1999),[28] it was found that 94 species of ferns (31% of the fern species found in Trinidad and Tobago) are now regarded as rare, threatened, or endangered, with the largest number occurring in the Northern Range. The study by Baksh-Comeau (1999) also indicates that while the Northern Range has a few sites that display poor fern species richness, it contains all of the good to very good sites in the country, with up to 25 species of ferns in the richest plots. This indicates that the Northern Range is the richest site for fern species in Trinidad, and this is largely explained by the fact that fern abundance and diversity depend on altitude and rainfall, with higher altitudes and rainfall levels favouring the presence of fern species.

Tree ferns: Most tree ferns (Baksh-Comeau 2000) belong to the family Cyatheaceae with the exception of one individual in the family Lophosoriaceae (Table 6). Twelve of the 13 species found in Trinidad are found in the Northern Range (Table 6), and the tallest tree fern in the Northern Range is *Cyathea tenera*, which attains a height of up to 8 m. Tree ferns are commonly harvested from the Northern Range on a small scale to be used as a base for orchids and other plants (Y. Baksh-Comeau, pers. commun., 2005). Three species–*Cyathea hombersleyi, Cyathea sagittifolia*, and *Cyathea trinitensis*–are endemic to Trinidad; the first two are described from the Northern Range.

Table 6: Trinidad's Tree Ferns

Scientific name	Family	Habitat	Location in Northern Range
Lophosoria quadripinnata	Lophosoriaceae	Rare; terrestrial in montane forests and thickets	El Tucuche; Morne Bleu
Alsophila imrayana	Cyatheaceae	Local; terrestrial in mossy forest and cloud forest	El Tucuche; El Tucuche to Naranjo; Morne Bleu; Arima–Blanchisseuse Road; Aripo Heights; Cerro del Aripo
Cnemidaria consimilis	Cyatheaceae	Rare; terrestrial in clearing with some low bushes, in submontane forest on mountain tops	El Tucuche; Blanchisseuse Ridge
Cnemidaria grandifolia	Cyatheaceae	Rare; terrestrial on shaded banks and gullies, on stream banks and forested mountainsides	La Seiva Valley
Cnemidaria spectabilis	Cyatheaceae	Common; terrestrial at track sides and streams in forest	Morne Catherine; Blue Basin; Cano Venturo Valley; Cascade; El Tucuche
Cyathea cyatheoides	Cyatheaceae	Rare and local; terrestrial in forests	Hollis Resevoir; Oropouche

[28]Combines information from the National Herbarium of Trinidad and Tobago, and field and literature surveys.

Scientific name	Family	Habitat	Location in Northern Range
Cyathea hombersleyi (endemic to Trinidad)	Cyatheaceae	Rare; terrestrial on trailside banks	Arima–Blanchisseuse Road; Las Lapas Road; Aripo Road
Cyathea microdonta	Cyatheaceae	Common; terrestrial on banks and streams	Morne Catherine; Chaguaramas; Maraval; Maracas Bay; Las Cuevas
Cyathea pungens	Cyatheaceae	Locally abundant; terrestrial in forests	Maraval; El Tucuche; Maracas Falls; Tunapuna Ravine; Arima–Blanchisseuse Road – Morne Bleu
Cyathea sagittifolia (endemic to Trindad)	Cyatheaceae	Locally abundant; terrestrial in upper montane forest, common near mountain summits	El Tucuche; Maracas; Arima–Blanchisseuse Road–Morne Bleu; Aripo Heights
Cyathea surinamensis	Cyatheaceae	Occasional; terrestrial in forests	Maracas Mountains; Arima–Blanchisseuse Road; Aripo Road; Quare Dam; Cumaca Road
Cyathea tenera	Cyatheaceae	Occasional; terrestrial in forests	Acono–Caura trail; Morne Bleu; Arima–Blanchisseuse Road; Aripo Heights
Cyathea trinitensis (endemic to Trinidad)	Cyatheaceae	Unknown	Trinidad (no location is recorded for this species in the Herbarium)

Source: (Baksh-Comeau 2000)

6.1.3.1 Species Endemism

It is noted (Kenny 2000) that in Trinidad there are accounts of both floral and faunal endemism, most of which may be grossly exaggerated. A low degree of endemism can be expected because of the relatively short period of separation of Trinidad from the South American mainland and because of the close proximity of the island to both the mainland and other Caribbean islands (Kenny 2000). The inaccuracies in accounts of species endemism can be explained by the relatively poor understanding surrounding the distribution of certain species, both in Trinidad and on the South American mainland (Kenny 2000). However, it is suggested (Kenny 2000) that the endemic species in Trinidad most probably exist in the oldest part of the island, the Northern Range, and at elevations where there are significant differences in climate. Depending on the degree of endemism, species are classified as follows-island-endemic species, island-endemic subspecies, and island-endemic morphs.

Flora: Adams and Baksh (1982) reported that 37.8% of the overall flora of Trinidad was endemic. Since that time, however, the estimate for the number of endemic floral species has been changing because of new research findings on the South American continent, and the discovery of many species once thought to be endemic to Trinidad. It is possible therefore that the level of endemism of the floral species of Trinidad can be as low as a single-digit percentage (Y. Baksh-Comeau, pers. commun., 2005). In fact, current estimates, according to Adams and Comeau (in Agard and Gowrie 2003), put the endemic floral species for Trinidad at 91, with 17 of those occurring in both Trinidad and Tobago jointly. The overall degree of endemism in the flora for Trinidad and Tobago is therefore about 5.5%, which means there is no significant floral endemism. This is not exceptional for an island, and is expected to be the case for the island of Trinidad, given its origins (see Section 6.1.3).

Some possible Trinidad and Tobago endemics in the Northern Range[29] are:

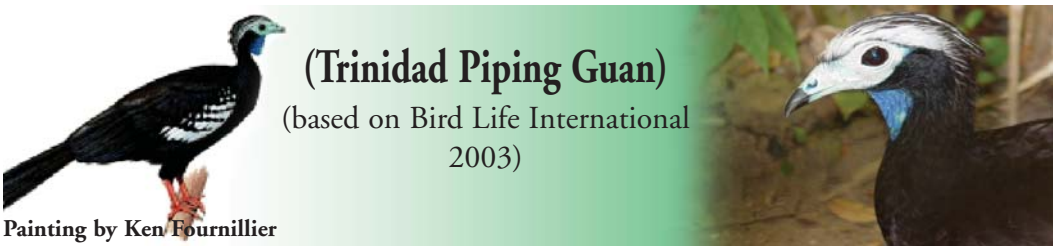
- Toco bromeliad *(Aechmea diclamydea trinitensis)*
- *Beilschmiedia sulcata* (Ruiz. & Pav.) Mez (Lauraceae) Mt. Aripo 1959; Aripo, above first cave 1959
- *Chimarrhis microcarpa* Standley (Rubiaceae) Maraval and growing in forest (1 ecological niche)
- *Clusia aripoensis* Britton Lalaja Rd 1990; Lalaja/Paria Tr. 1990; Las Lapas Tr. 1962, 1976; western slope of El Tucuche 1989; Morne Bleu 1981; Heights of Aripo 1922
- *Clusia intertexta* Britton Cerro del Aripo 1990, 1991; Hts. of Aripo 1922
- *Dacryodes trinitensis* Sandwith (Burseraceae) Arima Valley 1960; A-B Rd. 9 mp 1960, 1963
- *Maytenus monticola* Sandwith (Celestraceae) Hillsborough Watershed 2000; Morne Bleu trail 1998; Roxborough - Bloody Bay Rd 1979; Aripo Hts. 1922; Chaguanas 1905; mp 2 Aripo Rd 1926
- *Ocotea tomentella* Sandwith (Lauraceae) Blanchisseuse Rd 9.25 mp 1960
- *Philodendron fendleri* Krause (Araceae) Mathura Forest, San Souci, St. Ann's, Valencia (4 localities). Climber on cliffs and trees (2 ecological niches)
- *Securidaca lophosoma* (Blake) Cheesman (Polygalaceae). Road to Maracas, climber
- *Swartzia trinitensis* Urb (Leguminosae) El Tucuche 1868; Morne Bleu 1997; A-B Rd 1963, 1949, 1933, 1963; Maracas 1861
- Two species of tree ferns are known to be endemic to the Northern Range: *Cyathea hombersleyi* and *Cyathea sagittifolia.*

The importance of these endemic floral species to humans, and their rarity, are not well known. It is known that *Clusia intertexta* occurs at high enough density in a critical point in the landscape to serve as a soil protector. Otherwise the endemic floral species could be of considerable scientific importance particularly in taxonomic and phytogeographic studies, and they could be of horticultural value to collectors of specific taxonomic groups.

Fauna: It is evident from the literature that there may be three island-endemic faunal species in the Northern Range. The first two are confirmed as the golden tree frog *(Phyllodytes auratus)* found in the bases of tank bromeliads near the peaks of El Tucuche, Naranjo, Piedra Blanca, Morne Bleu, and Cerro del Aripo (Kenny 2000); and the luminous lizard *(Proctoporus shrevei)* which has a similar range to the golden tree frog (Murphy 1997). The third may be the Pawi or Trinidad piping guan (*Pipile pipile;* Box 6; Footnote 9).

[29]Subject to revision of the vascular flora of Trinidad and Tobago (not yet published).

Box 6: The Pawi



Painting by Ken Fournillier

The Pawi (*Pipile pipile*; known locally as the Trinidad piping guan) is a species widely regarded as locally endemic to the island of Trinidad. Though it was once abundant throughout the island (in the Northern Range, the Trinity Hills, the Nariva Swamp, and the Aripo Savannahs), it is currently found in only two locations of the Northern Range-Grande Riviere and Aripo. Estimates for population size range between 70 and 200 individuals and it is currently listed as Endangered on the IUCN Red List (2004). The most immediate threats to this bird are illegal hunting, habitat degradation through logging, and conversion of forested land to agricultural holdings. The species has been protected since 1963 and is now considered an environmentally sensitive species under the Environmentally Sensitive Species Rules (2001) of the Environmental Management Authority (EMA). Though most of its current range exists within forest reserves and State lands, the number of individuals continues to be on the decline, and this may be most explained by the lack of knowledge about the ecology of the species, and the lack of enforcement of existing legislation which would serve to protect the animals.

Though there is no evidence to suggest that the extinction of the Pawi will cause dramatic changes to the functioning of the ecosystem, we can certainly speak to the potential effects on human well-being. Being such a rare species, the Pawi is of scientific and educational value, and it provides a source of income to local communities in Grande Riviere through species-specific tourism. There has been an increasing effort to understand the Pawi through scientific research, and through educational campaigns that aim to heighten awareness about the potential fate of this bird if its destruction continues to go unchecked.

An example of an island-endemic subspecies is the howler monkey *(Alouatta seniculus insularis)*, and an example of an island-endemic morph in the Northern Range is the blind cave fish *(Rhamdia quelen)* found in the Cumaca cave. This latter species has departed morphologically (eyelessness and pigmentation) from the silver catfish common throughout Trinidad, to be better suited to its cave habitat. However, because these species are still poorly understood, it is difficult to gauge their importance to the Northern Range ecosystem, and hence the effects of decline in their populations.

6.1.3.2 Species Extinctions

There are no known records of species becoming extinct within Trinidad (and by extension the Northern Range), though it is clear that some species populations, such as the Pawi, have become very depleted (Kenny et al. 1997). From perceptible trends in habitat destruction and the current rate of exploitation of certain species, Kenny et al. (1997) postulated that the terrestrial species in the Northern Range likely to become extinct include the larger mammals such as the deer, otter, ocelot, lappe, and peccary, and that birds like the Pawi and some finches, and snakes like the bushmaster, might also disappear.[30]

[30]An account of extinction-prone bird species in Trinidad and Tobago is given by Temple (2002).

6.1.4 Summary of Assessment of Northern Range Biodiversity

- ***Given the origins of the island of Trinidad, the Northern Range represents a dividing line (an ecotone) between Antillean and Continental species, and it therefore contains elevated species diversity.***

- ***Many of the species recorded for the islands of Trinidad and Tobago are found in the Northern Range*** (Table 5).

- ***A deep understanding of the species diversity of the Northern Range - its links with human well-being; detailed knowledge about the condition and trends in the abundance, diversity, and distribution of species; and how these are affected by driving forces-is constrained by data and information paucity. Several species have not been reflected in the current assessment for this reason. Lack of scientific information results in not knowing how critical is the role of any species within the ecosystem and therefore the precise ways in which they contribute to ecosystem services. We can only speculate, based on general scientific principles, about the ecological value of species found in the Northern Range.***

- ***A few species are endemic to the Northern Range because of the special climatic and edaphic conditions, which exist especially at higher altitude, e.g., the golden tree frog*** *(Phyllodytes auratus)* ***and the luminous lizard*** *(Proctoporus shrevei)****. Several plant species currently considered to be endemic are noted.***

- ***Species diversity is linked to genetic diversity, but very little information exists about the genetic diversity of Northern Range species, except for cocoa, which has been cultivated in the Northern Range and elsewhere in Trinidad as a commercial crop.***

- ***Several faunal species have demonstrated economic value (Table 4). For example, the*** lappe, agouti, and deer are prized hunting game species. Species like the Pawi and marine turtles draw revenue through eco-tourism activities. The amenity value of species diversity, especially birds, is high but the economic potential of this is not significantly realized. Some species, like the howler monkey *(Alouatta seniculus)*, which is known to be a carrier of the Yellow Fever virus, have also been identified as a potential species for medical research (ENRP 1991).

- ***Some floral species have potential economic and scientific importance. For example,*** several plants, like orchids and ferns, can be cultivated and marketed commercially. *Ryania speciosa*, which is used in the manufacture of an organic pesticide, can potentially be of significant economic value. Several tree fern species have been noted as being endemic and so are of scientific importance.

- ***Species which are not known to be or are not currently of economic value, and for which information does not currently exist, may be potentially important for medical research and for maintaining integrity of the ecosystem, as well as for their use for recreational and educational purposes.***

- ***Serious threats to the biodiversity of the Northern Range exist, due to changes in land cover and land use (habitat loss and alteration caused by housing, agricultural activities, and logging), water-quality degradation, and forest fires.***

Information about the pattern and frequency of such threats indicates negative consequences for distribution and abundance of species in the Northern Range, especially for specialist species like the Pawi, oilbirds, golden tree frog, river otter, and other forest interior species like the ocelot and lappe. Over-exploitation of wildlife species also poses a serious threat to the biodiversity of the Northern Range.

- The species most under threat are the Pawi [which is an endangered species according to the IUCN Red List 2004 (IUCN 2004)] and has been recommended to be formally designated as an Environmentally Sensitive Species (EMA 2001d), as well as other forest-dependent species such as the ocelot and the river otter.

- ***Ineffective, or lack of, enforcement of existing regulations allows unmanaged harvesting of wildlife species to occur. Decline in population numbers and distribution range for some species have been observed.***[31]

6.2 Forest Ecosystems

6.2.1 Introduction to the Forests and Soils of the Northern Range

6.2.1.1 Forests

A detailed classification of the forests of the Northern Range is provided in Annex 4.[32] The most recognized classification of the forest types of Trinidad and Tobago is that proposed by Beard in 1946 (Annex 4), which adopted a physiognomic approach to classifying natural forest communities in Trinidad, and recognized two major controlling factors that influenced distribution patterns, climatic and edaphic. The climatic factors considered were moisture, temperature determined in part by elevation (warm to cool), and wind. Edaphic factors were soil type and the nature and proximity of the water table. This was the classification that was adopted for the National Forest Inventory conducted in 1980; the comparative terminology used by these two sources is noted in Annex 4. Another classification of forest types is proposed by Huber (1997). According to Huber (1997), the mountains include three forest types: evergreen transition forests, evergreen montane cloud forests, and upper montane elfin forests. The general pattern in the distribution of vegetation is due to elevation and is common in most of the mountains of the Cordillera de la Costa and the Northern Range. In some regions such as the mountains of the Peninsula of Paria and Trinidad, exposure to the prevailing winds makes strong modifications in the local conditions allowing lower montane evergreen forests to start much lower above sea level (Moore and Beament 1989; Stattersfield et al. 1998).

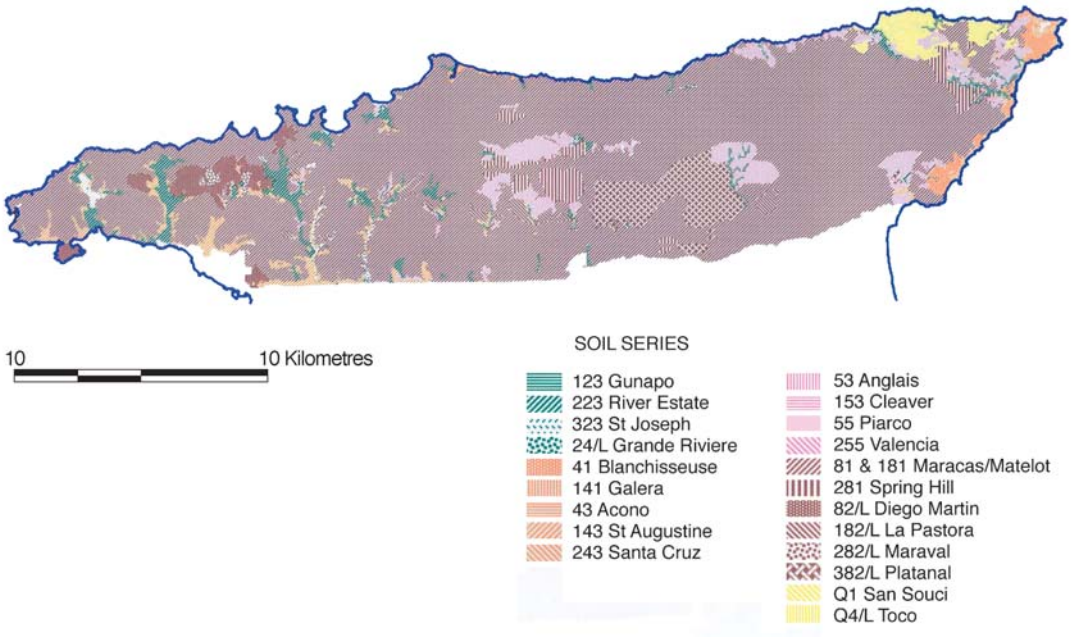
6.2.1.2 Soils

The soils of the Northern Range of Trinidad are closely associated with the geology and topography of the region. There is a range of soils that is associated with the rocks of the Northern Range; these soils are listed in Annex 1 and their distribution is shown in Figure 13.

[31]Some specific studies done in various watersheds in the Northern Range help to illuminate how driving forces have been impacting on Northern Range biodiversity. For example, Kairi (1998) noted that the removal of forest vegetation and forest fires in St. Ann's Watershed resulted in loss of wildlife. Faizool (2002) notes that 'the biodiversity in areas between the Arima Southern Slopes and Chaguaramas have been threatened for years mainly by urban and industrial development, fires, quarrying, squatting, indiscriminate logging, use of pesticides and ill-suited agricultural techniques. This has resulted in a decline and loss in species and communities and impairment of the processes that sustain them. All remaining forest and wildlife now have a much more restricted distribution than before.'

[32]A comprehensive reclassification of the forests of Trinidad and Tobago is about to be undertaken by UWI with assistance from Oxford University.

Fig. 13: Northern Range Soils



Courtesy: Soil Section of the Ministry of Agriculture, Central Experiment Station, Centeno, Trinidad

A classification of the soils based on their parent materials and topographic associations is given in Table 20 (in Annex 1) while their main features are summarized in Table 21 (in Annex 1).

Two main soils are associated with the noncalcareous schists and phyllites, i.e., Maracas and Matelot (Ahmad et al. 1967). These highly erodible soils are marginal soils for agriculture; forestry, conservation, and tree crops are thus recommended. There are several minor soils formed on the limestones and calcareous schists and phyllites and, by comparison, are less erodible and better for agriculture. In many locations they support staple food and vegetable crop production. The soils on terraces are either well drained or poorly drained. The former group are soils of good agricultural potential but their main limitations are low fertility and droughtiness. The latter group are soils of low to very low potential for agriculture since they suffer from very unfavourable physical and chemical fertility. A number of minor soils occur as alluvial soils on the current flood plains of the rivers flowing through the Range. On the whole these soils have high potential for agriculture, but there are limitations as well.

The geological substrates and main mineral resources of the Northern Range are limestone (blue, yellow for production of aggregate, lime) and silica sand (glass). A blue limestone vein runs from the north-east of the Range through the main ridge (e.g., Guanapo, Arima, Santa Cruz valleys), yellow limestone south of the Chaguaramas peninsula to the Laventille Hills, and silica sand in the east (Matura).

6.2.2 Links between Forest Ecosystems and Human Well-Being

Generally, forests contribute directly to a variety of functions: maintaining the integrity of an ecosystem, providing wildlife habitats, protecting watersheds, mitigating impacts of extreme weather, sequestering carbon, and generating goods and services for direct use by people for consumption, other economic uses, and recreation. The forests of the Northern Range do no less: as Section 6.2.2.1 indicates, they provide provisioning, regulating and supporting, and cultural services which contribute directly and indirectly to our well-being.

6.2.2.1 Importance of Northern Range Timber and Non-timber Forest Products

6.2.2.1.1 Timber

In Trinidad and Tobago timber species are classified into four classes depending on their potential commercial use and durability. These classes determine the stumpage (prices paid to the Government where the tree is felled not including costs for extraction from the forest) or royalty rates (income earned for quantity sold). Class I species are used for furniture and cabinet work, and there are nine local species (Clubbe and Jhilmit 1992) in this class. This classification system differs slightly from the one used in the Forestry Handbook (Forestry Division 1996a). Class II contains 11 species and Class III contains 15 species; species of classes II and III can be used for cabinet work but are also valuable for construction and load-bearing work. They are generally less valuable than Class I species. Class IV species are even less valuable commercially and are useful for form work or dunnage (loose material used to support or protect, or may be smaller parts of the tree apart from the commercially used portions). There are six species in this class. Only about fifty native species (EMA 1998b) are exploited for timber, with about a fifth of these being Class I species as declared in the schedule to the Act (Forests Act, Chapter 66:01). Three exotic species: teak *(Tectona grandis)*, mahogany *(Swietenia sp.)*, and Caribbean pine *(Pinus caribea)* are important in the local timber industry and these are Class I species.

Table 7 shows the classification of some Class 1 and 2 timber types in Trinidad, indicating those found in the Northern Range. The presence of these species does not, however, indicate if the quantity is sufficient for commercial harvest of timber.

Table 7: Classification of Some of the Class 1 and 2 Timber Species Marketed in Trinidad (Clubbe and Jhilmit 1992)

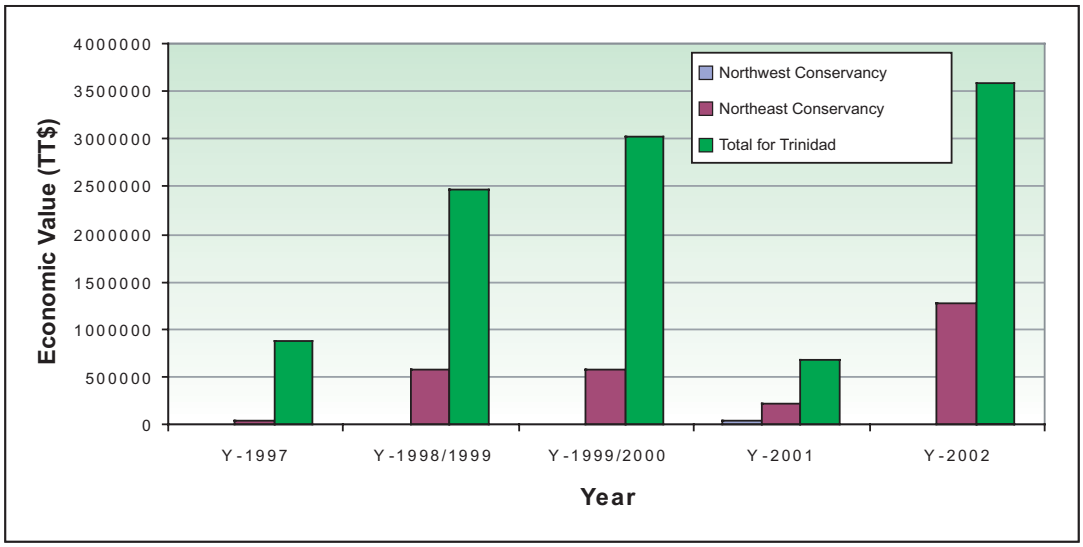
Common name	Scientific name	Family	Class	Girth limit (cm)	Diameter at breast height (cm)	Presence in Northern Range
Acoma	*Sideroxylon foetidissimum*	Sapotaceae	1	183	58	Present
Balata	*Manilkara bidentata*	Sapotaceae	1	183	58	Present
Balsam	*Copaifera officinalis*	Leguminosae	1	183	58	Unknown
Cedar	*Cedrela odorata*	Meliaceae	1	244	78	Present
Cypre	*Cordia alliodora*	Boraginaceae	1	183	58	Present
Locust	*Hymenaea courbaril*	Leguminosae	1	183	58	Present
Mahogany	*Swietenia* sp.*	Meliaceae	1	183	58	Present
Apamat (pink poui)	*Tabebuia rosea***	Bignoneaceae	1	183	58	Present
Roble	*Platymiscium trinitatis*	Leguminosae	1	183	58	Present
Angelin	*Andira inermis*	Leguminosae	2	183	58	Present
Crappo	*Carapa guinensis*	Meliaceae	2	153	49	Present

Common name	Scientific name	Family	Class	Girth limit (cm)	Diameter at breast height (cm)	Presence in Northern Range
Fiddlewood (black)	*Vitex divaricata*	Verbenaceae	2	183	58	Unknown
Fiddlewood (white)	*Vitex capitata*	Verbenaceae	2	183	58	Present
Fustic	*Maclura tinctoria*	Moraceae	2	153	49	Unknown but most probably found in the NR
Galba	*Callophyllum lucidum*	Guttiferae	2	183	58	Present
Guatecare	*Eschweilera subglandulosa*	Lecythidaceae	2	153	49	Present
Laurier	*Aniba panurensis*	Lauraceae	2	153	49	Present
Mora	*Mora excelsa*	Leguminosae	2	183	58	Present
Olivier	*Terminalia amazonia*	Combretaceae	2	153	49	Present
Serrette	*Byrsonima spicata*	Malpighiaceae	2	153	49	Present

Notes: The presence of these timber species in the Northern Range was determined by cross-checking Marshall (1934, 1939) and Quesnel and Farrell (2000) with Mr. W. Johnston (pers. commun., 2005) from the National Herbarium.
Figures are rounded to the nearest whole number.
*Introduced.
**Introduced and now naturalized.

According to the Forestry Division (2003), the economic value of timber from State lands in the Northeast Conservancy (TT $1,280,450 in 2002) far exceeds that for the Northwest Conservancy (TT $8,540). Overall for Trinidad, the Northwest and Northeast conservancies (i.e., the Northern Range) contribute about one third of the economic value of sawn log from State lands (Fig. 14).

Fig. 14: Economic Value of the Sawn-log Outturn from State Lands in Trinidad



Source: Forestry Division (1998, 1999, 2002a, 2002b, 2002c, 2003)

Forestry accounted for 2.5% annually of the GDP between 1980 and 1988 (Forestry Division 2003). This is an underestimate of the value of forests as it did not take into account the jobs created in the processing industry, or a value for environmental services such as its role in water cycling and replenishment, soil preservation, carbon sequestration, and flood control. However, the forest may be more valuable for these environmental services than for its contribution to employment and income. Recognition of this is an important consideration in policy choices about use and conservation.

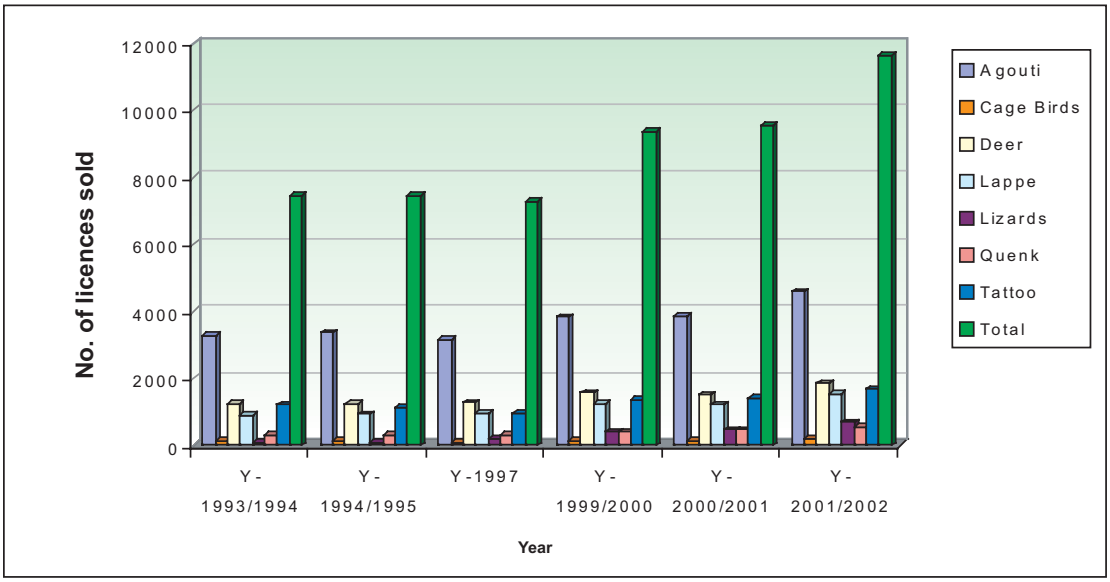
An important product of timber that often goes unmentioned is charcoal. For many decades, even into the twentieth century, charcoal was an important domestic cooking fuel. Much of the charcoal produced came from the foothills of the southern flanks of the eastern section of the Northern Range, especially where mora was being harvested. Charcoal is still produced today in the north-east but on a smaller scale, and it is retailed in small bags in urban areas primarily for use in barbeque cooking. No reliable figures on production are available, however.

6.2.2.1.2 Non-timber forest products

Local non-timber forest products include wildlife, handicraft raw materials, tannins and dyes, and extractives for local medicines and insecticides.

Wildlife contributes to human well-being in several ways—through harvesting of certain species for food, through amenity value that contributes to the eco-tourism industry, and to scientific research and education. Wild meat hunting activities rely heavily on species such as the wild hog, lappe, tattoo, agouti, iguana, and deer (Fig. 15) and are a source of income (EMA 1997). The figures which are for Trinidad and Tobago indicate the popularity and value of hunting wild species in the country. The amendment of the Conservation of Wildlife Act lifted the ban on hunting in the Western Northern Range as at the start of the 2002/2003 season. This no doubt increased the removal of species in the Western Northern Range.

Fig. 15: Sale of State Game Licences in Trinidad for the Period 1993–2002[33]



Source: Forestry Division (1995, 1996b, 1998, 1999, 2002a, 2002b, 2002c, 2003)

[33]Figures for the year 1996 are not available.

Table 8 shows the national annual estimated revenue from game harvests and hunting permits for the period 1990–1995 (EMA 1997). Though these figures are slightly different from those shown above, they also indicate the importance of the game harvest industry. It should be noted that the revenue to the State from the sale of game harvests is small in relation to the value of what is harvested. As Figure 15 indicates, there is an increasing trend in the demand for game licences (which does not fully reflect the extent of game hunting as licences may not be obtained in some instances). There is scope here for increasing the revenue derived, which could be invested in management and monitoring capacity to ensure that harvesting is sustainable and that regulations are enforced.

Table 8: Annual Estimated Revenue from Game Harvests and Hunting Permits

SEASON	90–91	91–92	92–93	93–94	94–95
Revenue generated from the sale of hunting permits (TT $)	144,120	147,700	136,700	154,520	146,260
Estimated revenue from game harvest (TT $)	5,507,706	5,588,375	3,774,612	5,592,309	4,680,221

Source: EMA (1997, 28)

There is a wide variety of plants which provides the forage requirements for bees *(Apis mellifera* or *Apis mellifera sculettatta)* of the Northern Range. Many of these species provide an abundant supply of bee forage during the dry season (honey flow season), January–June, while others provide a maintenance supply all year through.

Several plant species and other natural resources which provide the necessary raw material for crafts (Green and Maundy 1968) are still being used in the present handicraft industry. However, the availability of these species has become limited due to habitat destruction and over-exploitation (FAO 2000). Raw materials for the manufacture of handicraft products are obtained primarily from State natural forests, and to a small extent on lands outside of forested areas. Some of the plant species include: bamboo (*Bambusa vulgaris*), banana (*Musa* sp.), calabash (*Crescentia cujete*), camwall (*Desmoncus* sp.), khus khus grass (*Vetivera zizanioides*), mamoo grass (*Calamus* sp., *Daemonorops* sp., *Asplundia* sp.), screw pine (*Pandanus utilities*), sisal, and tirite (*Ischnosiphon aronma*). At present it seems that the handicraft industry is declining. One of the constraints to production includes inadequate and irregular supply of local material. Other forest resources have potential value for the commercial cut-flower and potted-plant industry (e.g., orchids and bromeliads); landscaping; industrial chemicals; and cosmetic, medicinal, and related applications.

Some species are of value for medical research, and hence a potential source of genetic and biochemical resources. Locally it is reported that as many as 300 floral species are currently being used to treat a variety of common ailments (FAO 2000). Some of the floral species which are used in Trinidad and Tobago (FAO 1999) and may occur in Northern Range natural forest areas are aloes (*Aloe vera*), caraille (*Momordica charantia*), fever grass (*Cymbopogon citratus*), kayakeet (*Lantana camara*), lickrish (*Abrus precatorius*), shining bush (*Peperomia pellucida*), vervain (*Stachytarpheta jamaicensis*), and wild senna (*Cassia alata*). There are numerous plants which have been tested scientifically to elucidate their active components, some of which have been proven to have medicinal use. Some of these from the Northern Range are listed in Table 9.

Table 9: Some Northern Range Floral Species That Have Some Proven Medicinal Use (Seaforth et al. 1985)

Common name	Scientific name	Family	Uses
Jumbie bead	*Abrus precatorius*	Leguminosae	Coughs, colds, fevers
Bamboo	*Bambusa vulgaris*	Graminae	Malaria
Railway daisy	*Bidens pilosa*	Compositae	As a tonic, diabetes
Roukou	*Bixa orellana*	Bixaceae	Diabetes, sprains
Olive bush	*Bontia daphnoides*	Myoporaceae	Bladder weakness, womb cleaning, menstrual pains
Wonder-of-the-world	*Bryophyllum pinnatum*	Crassulaceae	Earache , sprains, bruises
Bird pepper	*Capsicum frutescens*	Solanaceae	Palpitations
Paw-paw	*Carica papaya*	Caricaceae	Ringworm, to produce sterility in women, high blood pressure
Wild senna	*Cassia alata*	Leguminosae	Skin fungus, for 'cooling,' as a blood purifier
Bois canois	*Cecropia peltata*	Moraceae	Colds, coughs, hypertension
Black sage	*Cordia curassavica*	Boraginaceae	Colds, fevers
Cancanapiray	*Croton conduplicatus**	Euphorbiaceae	Earache
Love vine	*Cuscuta americana*	Convolvulaceae	For 'cooling,' jaundice
Fever grass	*Cymbopogan citratus*	Graminae	Fevers, colds
Mayoc chapelle	*Entada polystachya*	Leguminosae	'Heat,' veneral disease
Urine bush	*Euphorbia oerstediana*	Euphorbiaceae	Oliguria
Cotton	*Gossypium* sp.	Malvaceae	Constipation, earache
Spiderlily	*Hymenocallis tubiflora*	Amaryllidaceae	Asthma
Santa maria	*Lippia alba*	Verbenaceae	Asthma
Mango	*Mangifera indica*	Anarcardiaceae	Ringworm
Pain bush	*Morinda citrifolia*	Rubiaceae	To reduce pain in body
Nutmeg	*Myristica fragrans*	Myristicaceae	Stroke
Cocoa mint	*Peperomia rotundifolia*	Piperaceae	Lip sores, botfly larvae parasitizing on skin
Candle bush	*Piper tuberculatum*	Piperaceae	Colds, fevers

Common name	Scientific name	Family	Uses
Castor oil	*Ricinus communis*	Euphorbiaceae	As a purgative, headaches
Bois bande	*Roupala montana*	Proteaceae	As an aphrodisiac
Hog plum	*Spondias mombin*	Anacardiaceae	Sore throat

*The Bocas Islands

Specific mention must be made of *Ryania speciosa*, the stems of which are exported and processed abroad for manufacture of an organic pesticide (FAO 2000). This is an evergreen understorey species, which is sporadically distributed primarily in natural forests throughout Trinidad on both clays and sands.[34] The tree attains a height of 8 m and a diameter of 10 cm at maturity. Research and inventory data (Faizool and Mahabir 1997) show that approximately twelve thousand metric tonnes (12,000 mt) were available for harvesting in Trinidad. However, there are indications that the species has been over-exploited. Sale of the trees is controlled by a girth system not less than 13 cm at 10 cm from ground level. In 1999 a total of 144 cords were sold giving a royalty total of TT $2,980.80. The financial return to Trinidad and Tobago is thus low. Attempts could be made to increase these returns, to ensure that harvesting is sustainable, to cultivate this species for the commercial market, and to explore the possibility of manufacturing the insecticide locally. Similar cultivation may be considered for tirite (*Ischnosiphon aronma*) and screw pine (*Pandanus utilities*) for which the Caribbean Industrial Research Institute has done research for cultivation.

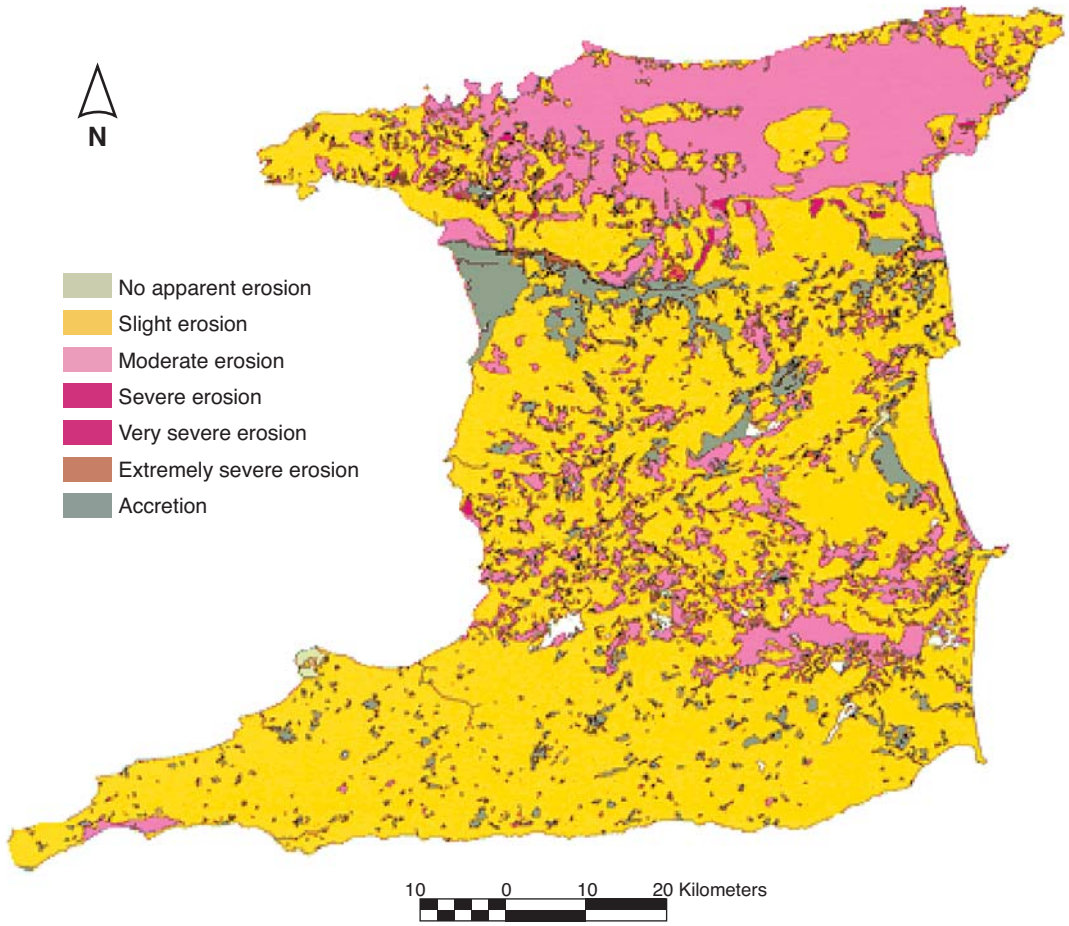
Apart from the various mangrove species, juniper (*Genipa americana*) can be used as a source of tannins and dyes. It is widespread in many kinds of forests and is particularly noticeable in second growth along the road from Toco to Sangre Grande (Quesnel and Farrell 2000).

6.2.2.2 Soil Conservation, Regulation of Water Runoff, and Retention

The prevention of soil erosion by maintenance of forest cover has many impacts on human well-being, including the agricultural and therefore economic value of soil fertility, support of forest communities, and the maintenance of low turbidity waters necessary for potable water supplies. The soil-erosion categories for the Northern Range, based on sensitivity and potential for erosion, are shown in Figure 16. It is evident that soil and slope characteristics render the eastern section of the Range and the North Coast prone to moderate erosion, and this underlines the need to maintain forest cover in these areas as a way of mitigating soil erosion.

[34] Morne Catherine 1959, 1980; Las Lapas Forest 1962, 1976; A–B Rd 1978, 9mp 1962, 10mp 1947, 1962, 11-14mp 1922; Guanapo Hts Rd 1973; Guanapo Rd 2.5 mi 1973; Matura Forest Rsv 1973; Arima Valley 1959; Morne Bleu 1921; St. Pat's Estate, Arima Valley 1954; St Ann's 1846; Mora Forest Sangre Grande 1927; Valencia Forest 1929; Maracas Bay Tr. 1951; Matura, Quebrada Rd 1968.

Fig. 16: Trinidad's Soil Erosion Categories



Generated by J. Opadeyi, Centre for Geospatial Studies, UWI, St. Augustine; from the Land Capability Survey of Trinidad and Tobago, No. 6. Trinidad - Land Capability. F. Hardy 1974

Studies conducted on soil loss in the Maracas Valley between 1984 and 1989 show that areas under cultivation lost 279 times more soil than areas under forest cover (Table 10). Additionally, land under burnt forest plantation was found to be nineteen times more susceptible to soil erosion than land under unburnt forest plantation (Faizool 2002).

Table 10: Soil Loss for an Annual Average Rainfall of 161.7 cm under Varying Vegetative Cover between 1984 and 1989

Land use	Average annual (t/ha–1/year–1)	Loss factor
Natural forest	**0.046**	**1**
Degraded forest	**0.516**	**12**
Grassland	**2.673**	**63**
Cultivation	**11.878**	**279**

Source: Faizool 2002 (based on Forestry Division, Watershed Management Unit)

The original Forest Reserves in the country were largely established for management of timber harvesting as well as to protect the watersheds (including the provision of freshwater). Watershed protection remains an important objective of the management of the Northern Range forests. One study has shown that rivers flowing from primary forest release twice as much water halfway through the dry season, and between three and five times as much at the end of the dry season, as do rivers flowing through coffee plantations (Myers 1988).

There are some scientific data to support the finding of negative impacts of human activity on river quality. The upper reaches of rivers dominated by forests were found to maintain good water quality in both the rainy and dry seasons (Lucas 2003; Lucas and Alkins-Koo 2004). However, in areas of greater land conversion, moderate effects of pollution were found in the dry season.

Observations of the consequences of forest clearing and shifting agriculture for soil erosion and severe flooding were documented from the early 1900s in the Maracas Valley and on the Caroni Plains (Jacks and Whyte 1941). Erosion is most readily visible in the north-west–region and on the southern slopes of the Northern Range, which coincide with the location of major housing settlements. Flooding is reputed to be more frequent in some locations as a result of forest destruction and is now occurring in areas not previously prone to flooding, such as the suburbs of Woodbrook and within the Diego Martin Valley.

6.2.2.3 Amenity Value

The forests of the Northern Range offer many opportunities for recreation and leisure activities. Though there is little systematic documentation of the flow of visitors and monetary value of these activities to the national economy, the importance of eco-tourism is growing, as evidenced by the growing number of tourists visiting the AWNC annually. The increase in national income might explain increasing appreciation of the amenity value of the Northern Range. Bird-watching is a major motivation for tourists visiting the islands. Although the number of local visitors cannot be distilled from total visitors to some of the National Parks (Table 11), the figures indicate the interest and therefore value of the cultural services provided by the Northern Range. It remains difficult, however, to compare the economic returns from such use with those from other competitive uses such as the sale of timber.

Table 11: Summary of Visitor Numbers to Northern Range Sites for 1997–2002[35]

Site	1997	1998	1999	2000	2001	2002
Cleaver Woods Recreation Park	14,730	12,000	12,000	4,009	7,596	30,000
Matura National Park	12,000	10,800	13,705	14,600	14,100	17,000
River Estate Museum and Water Wheel	30,000	45,000	36,737	29,014	19,524	20,000
Lopinot Historical Complex	60,000	85,000	77,670	138,258	126,000	130,000
Fort George	43,000	40,000	51,000	41,649	61,752	50,000
Fort Picton	9,300	10,000	5,078	8,558	3,600	4,200

Source: Forestry Division (1998, 2003)

Floral species from the Northern Range are also used for natural landscape improvement throughout the country. The species used are selected on the basis of their inherent silvicultural characteristics and their landscape and ornamental values. Some of these species include: bois sang (*Croton gossipifolios*), double chaconia (*Warszewiczia coccinea* cv David Auyong) wild island endemic morph, cypre (*Cordia alliodora*), flamboyant (*Poinciana regia*) introduced, pink poui (*Tabebuia rosea*) introduced, samaan (*Samanea samaan*) introduced, savonette (*Lonchacarpus*

[35]These figures include schools, communities, families, foreigners, researchers, and varied groups, and thus can potentially represent the recreational value and the educational/research value of Northern Range sites.

sericeus), yellow cassia (*Cassia siamea*), yellow poui (*Tabebuia serratifolia*), and blue petrea (*Petrea arborea*).

6.2.2.4 Scientific Research/Education

The forests of the Northern Range and their biota have supported significant international research in a variety of fields for almost 100 years. Very early research was based on activities centred at the Imperial College of Tropical Agriculture from 1922, which later became the University College of the West Indies and then The University of the West Indies. The areas of research included crop science, soil science, and entomology. The staff of the Trinidad Regional Virus Laboratory (now the Caribbean Epidemiology Centre) conducted early research from 1952 with Rockefeller Foundation funding on arboviruses, their vectors, and their habitats in addition to extensive natural-history studies (Tikasingh 2000). In 1949 Dr William Beebe established the Tropical Research Station of the New York Zoological Society at Simla in the Arima Valley, a facility that still exists as part of the Asa Wright Nature Centre. A variety of ecological and biological studies were conducted on a range of organisms producing, up to the present time, more than 300 internationally published scientific papers including books by significant researchers such as William Beebe, Jocelyn Crane, David Snow, Michael Emsley, and Donald Griffin. Seminars on painting from nature, led by famous nature artists such as the late Don Eckelbury, helped to launch the careers of many painters (J. Duncan, pers. commun., 2005).

The forests and associated habitats of the Northern Range also serve as a valuable facility for environmental and science teaching. For many years the AWNC conducted tropical ecology workshops and seminars on the Northern Range, but these ended in the late 1970s (J. Duncan, pers. commun., 2005). Currently, the demand for school tours of all ages to the AWNC is evidence of the value of the Northern Range for education.

The Northern Range is also home to the last decendents in Trinidad of Amerindian peoples who occupied the northern part of the island before colonization. Their location in Arima now serves as a gathering point for Amerindians from the Caribbean region, and their artifacts are on display at the Cleaver Woods Recreational Site. This is another aspect of our national heritage that is associated with the Northern Range.

6.2.3 Condition and Trends in Northern Range Forests Resources

Estimates for forest cover in Trinidad and Tobago vary widely as shown in Table 12. The most objective of these is perhaps the estimate of 229,000 ha (or 46% of the total land area of Trinidad and Tobago) provided by the University of Maryland Global Land Cover Facility using MODIS satellite coverage which mapped forested areas with crown cover greater than 75% (Agard and Gowrie 2003).

The area of forest (including primary, secondary, and plantation forests) which exists on the Northern Range is not known with precision but is estimated at about 83,000 ha or about 67.5% of its area (Faizool 2002).[36] Though it is estimated that the Northern Range forested lands consist of 85% to 95% primary forests and the rest of secondary forests in lower more accessible foothills (Faizool 2002), it is possible that these figures may overestimate the area of primary forest in the Northern Range, given the (perceived) rate of deforestation (including fire damage) occurring especially in the Western Northern Range.

[36]This estimate is based on data for the Northeast and Northwest conservancies.

Table 12: Forest Cover of Trinidad and Tobago and the Northern Range

Forest Cover (area and forest type)		Extent (ha)	Year	Source(s)
Trinidad and Tobago	Total forest	172,140	1946	Beard[37] (1946; in Forestry Division 2003)
	Evergreen seasonal	98,180	1946	
	Deciduous seasonal	3,620	1946	
	Dry ever green	500	1946	
	Seasonal montane	930	1946	
	Montane	21,620	1946	
	Secondary	1,563	1946	
	Swamp	16,730	1946	
Trinidad and Tobago	Total forest	246,240	1996	GIS map based on 1996 aerial photography with limited ground truthing (in Agard and Gowrie 2003)
Trinidad and Tobago	Total forest	159,000	1999	UN World Statistics Pocket Book, Dept. for Economic and Social Information and Policy Analysis (UN; in Agard and Gowrie 2003)
Trinidad and Tobago	Total forest[38]	229,000	2000	EarthTrends (2003) based on a study done by the University of Maryland Global Land Cover Facility using MODIS satellite coverage (in Agard and Gowrie 2003)
Trinidad and Tobago	Total forest	259,065	2003	FAO State of the World's Forests (in Agard and Gowrie 2003)
Trinidad and Tobago	Secondary	16,630	1980	CIDA Forest Inventory (1980; in Kenny et al. 1997)
Trinidad and Tobago	State-owned commercial timber plantations	15,254	1992	Kenny et al. (1997)
		14,608 15,254 15,496 15,080 15,005 15,141	1997 1997 1998 1999/2000 2001 2002	Forestry Division (1998, 1999; 2002a, 2002b, 2002c, 2003)
Northern Range	Total forest: Primary, secondary, and plantation	83,000	1988	Faizool (2002)
St. David Reserve	Lower montane	9,150	1946	Beard (1946; in Kenny et al. 1997)

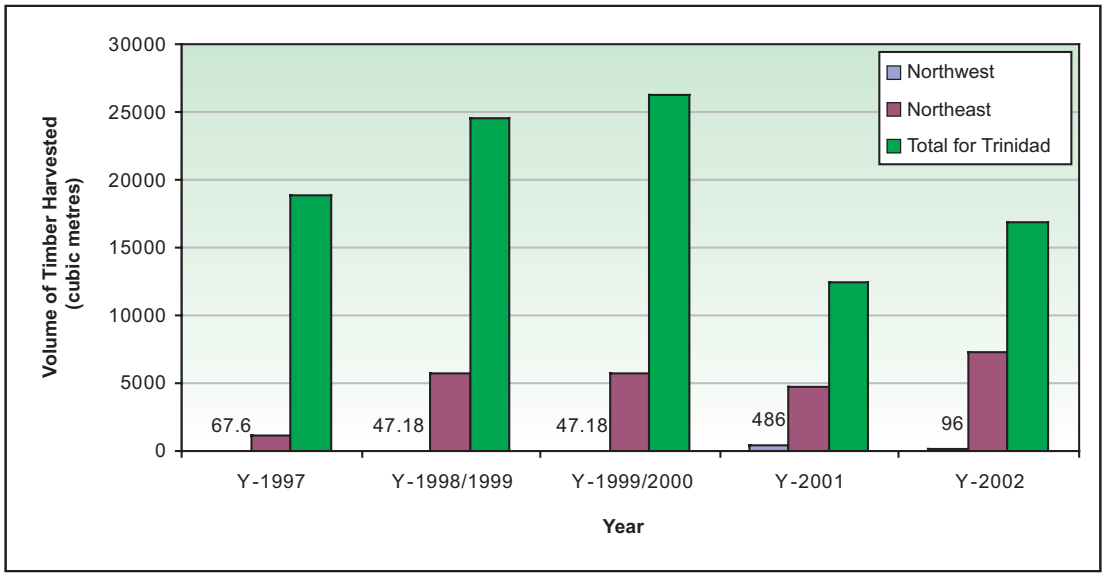
Comeau (1996) reported that fire, plantations, and quarries were the major threats to forest, and estimated that about 17.5% of the total forested area in Trinidad and Tobago, based on a 1987 estimate of 256,613 ha, was affected by these three activities.

Though actual figures for the rate of deforestation do not exist, we may deduce the extent of deforestation due to various activities from different information sources. For example, Figure 17 shows the volume of timber harvested on State lands, as reported by the Forestry Division, for the period 1997–2002. Presumably, these figures would not include illegal removals and would so tend to be an underestimate of the actual volume of timber removed from State lands. The amount of authorized timber removal peaked in the 1999/2000 period but then fell off. Additionally, the volume of timber removed from the Northeast Conservancy was significantly higher than that

[37]See Table 22 in Annex 4 for a comprehensive breakdown of area by forest type for Trinidad and Tobago based on Beard's 1946 inventory.
[38]Total forest area includes both natural forests and plantations and is defined as land with tree crown cover of more than 10% of the ground and area of more than 0.5 ha. Tree height at maturity should exceed 5 m (EarthTrends 2003).

removed from the Northwest Conservancy for all years. This may be taken as an indication of depletion in the Northwest and of harvesting moving eastward into previously intact areas, and underlines the need for policy and management for the eastern section of the Northern Range.

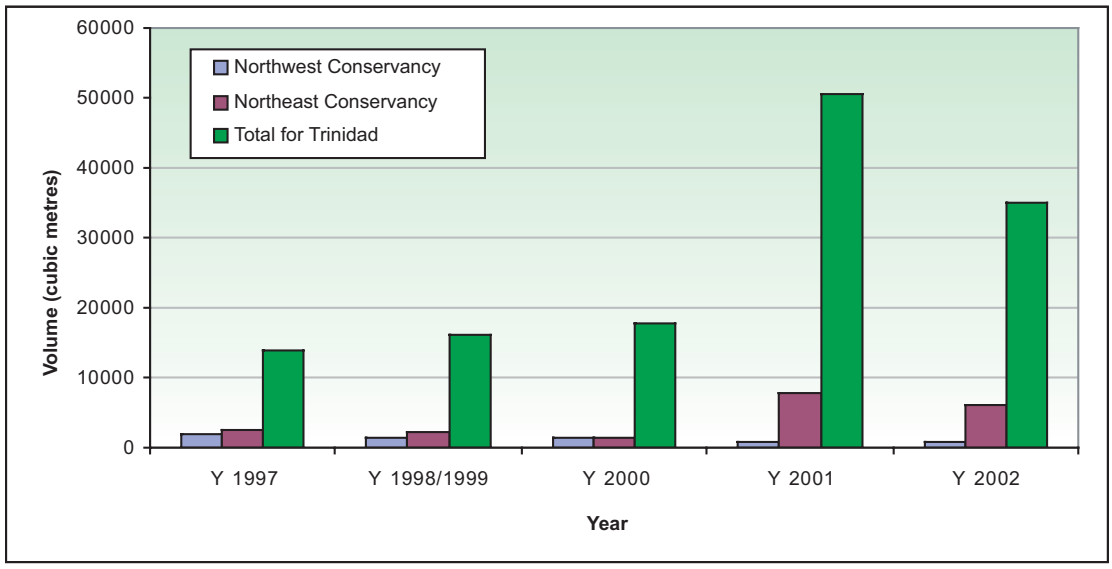
Fig. 17: Sawn-log Outturn from State Lands in Trinidad



Source: Forestry Division (1998, 1999, 2002a, 2002b, 2002c, 2003)

Figure 18 shows the scale of removal of timber from private lands. What is evident when figures 17 and 18 are compared is that within the Northwest Conservancy, there is greater removal of timber from private lands than there is from State lands. This may be because timber resources are already heavily depleted in the Western Conservancy and probably because of better enforcement in this section of the Northern Range.

Fig. 18: Summary of Timber Removal from Private Lands



Source: Forestry Division (1998, 1999, 2002a, 2002b, 2002c, 2003)

6.2.4 Summary of Assessment of Northern Range Forest Ecosystems

- ***There are very little up-to-date, organized, accessible data on the extent of forest cover in the Northern Range and it is not possible to give an accurate account of the current extent of Northern Range forest cover:***
  - A comprehensive inventory of the forest types of the Northern Range was undertaken in 1980, but this has not yet been aggregated in a form that can be used in this assessment. However, a comprehensive classification of the forests of Trinidad and Tobago is about to be undertaken by UWI with assistance from Oxford University.
  - There are also very little data and information on the rates of substitution and regeneration vis-à-vis rates of harvesting or removal by other means.
  - Information on land use and land cover, based on aerial photography and satellite imagery, has been collected since 1969. Some of this information has been used to construct land-use maps, most of which are not reliable. Though reliable land-use and land cover maps for the Northern Range can be used to provide snapshot information on the extent of different land-use activities and vegetation types in the Northern Range, the actual rates of deforestation, and precise changes in land cover, cannot be deduced from these maps.

- ***Yet it is known that the forests of the Northern Range have continued to be altered from forest clearance for various uses such as housing developments and supporting infrastructure, agriculture, quarrying, and timber harvesting. Forest fires are also a source of forest degradation.***
  - Three factors influence the number and extent of forest fires—slash-and-burn practice to clear land for cultivation, amount of rainfall, and responsiveness of the fire services. Over the last fifteen years or so, there has been no steady increase in the extent of land in Trinidad affected by fire (see Fig. 27), but the Forestry Division has noted the increasing threat to primary forests within the valleys of the Northern Range by fires due to inappropriate agricultural practices.

- ***The forests of the Western Conservancy have been more extensively converted. Though this is readily visible, it is not possible on existing data to quantify the physical extent of this change in terms of area and degree of forest fragmentation.***
  - Past and continuing land use for housing, including high-income housing, is the dominant cause of conversion of the southern slopes in the West. Although regulations prohibit building on gradients greater than 1 in 6 (see Section 9.1.1), these are not strictly enforced.
  - The highest proportion of forest fires occurs in the Northwest Conservancy in the areas that are most heavily settled (Annex 5).

- ***One of the major factors that contributes to the degradation of forest resources is the lack of capacity to monitor activities and enforce legislation even where it exists.***
  One response to this has been the establishment of a system of honorary game wardens by the Wildlife Section of the Forestry Division which enlists the help of volunteers to monitor illegal hunting of wildlife in Trinidad's forests. However, this system has not achieved its main objective mainly because of the threats to personal safety.

- ***The geology of the Northern Range makes it prone to land slippage, with consequent soil loss. This underscores the importance of the forest cover of the Northern Range, as natural forests seem to be most effective in helping to control downstream effects such as flooding and sedimentation*** (Table 10).

- ***The economic returns from timber harvesting from the Northern Range are relatively insignificant. The presumed value of the forest of the Northern Range for its ecological contributions and for its amenity value as well as for economic activities based on such amenity value could be considerably higher.***
    - The Northern Range is important as a recreational and tourist site (Table 11), and the number of visitors to some of its sites exceeds the total for all sites in other parts of Trinidad.

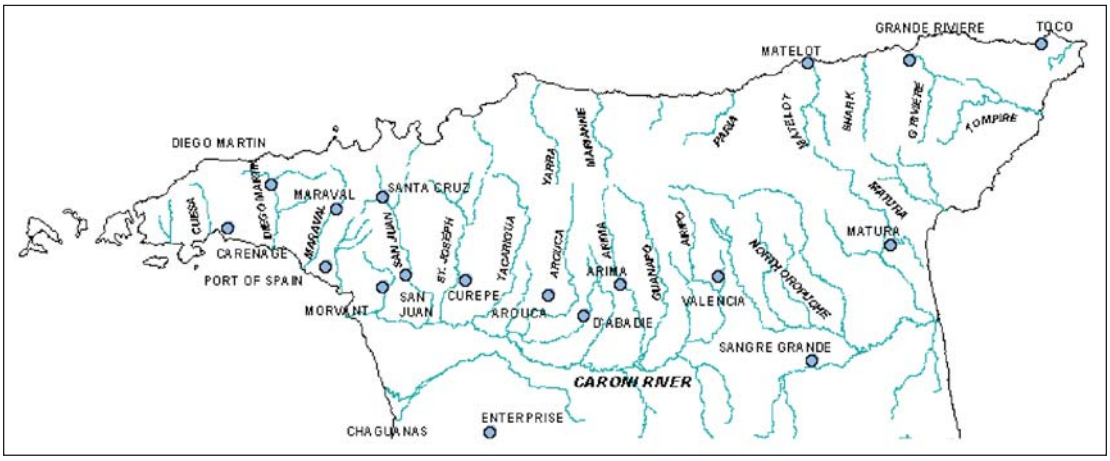
- ***It is evident that the pattern of housing and hillside agriculture, planned and unplanned, which has taken place in the western section of the Northern Range, is now moving eastwards. Appropriate planning will be required to ensure that the forests of the eastern section of the Northern Range, together with the biodiversity and water resources which it encompasses, remain intact so that all its services can be sustained. Zoning of the eastern section of the Northern Range for conservation purposes and appropriate but prescribed activities, and strict enforcement thereof, would be the single most effective intervention that can be made. This would provide the planning framework for numerous other responses that are required in relation to other ecosystem services.***

6.3 Freshwater Ecosystems

6.3.1 Introduction to the Freshwater Ecosystems of the Northern Range

The Northern Range is dissected by streams flowing on both its north and south slopes (Fig.19) and are generally clear water and fast flowing, with a range of boulder-to-gravel substrata in the upper and middle courses.

Fig. 19: Northern Range Major Water-catchment Areas



Courtesy: B. Ramlal and S. Surujdeo-Maharaj (pers. commun., 2004)

The northerly flowing streams drain directly into the north coastal areas and the Caribbean Sea, and Faizool and Thelen (1980) have reported that there are only five places on the North Coast where the rivers have appreciable alluvial flat—Grande Riviere, Blanchisseuse, La Fillette, Las Cuevas, and Maracas. On the southern side, the northern drainage area contains the larger Caroni and Oropouche basins, both characterized by mature systems with wide alluvial-infilled valleys and meandering in the lower courses. Many of the streams draining from the south-western slopes become tributaries for the westerly flowing Caroni River which culminates into a tidal swamp on

the north-east coast of the Gulf of Paria. Eastern tributaries join to form the North Oropouche River which drains eastwards into the Atlantic Ocean.

The Northern Range is subdivided into thirty-five watersheds (Annex 6) which are the areas of origin for most of the nation's rivers and are therefore of paramount importance in the water-supply system (Faizool 2002). There are twenty-one rivers within the Northern Range Assessment boundary, of which twelve flow along the southern slopes and traverse the more developed areas. The highest rainfall levels lie in the north-eastern part of the Range and decrease westwards and southwards thus dictating discharge and permanence of rivers in these regions.

There are also five major aquifer systems within the Northern Range: the Northwest Peninsula Gravels, Northern Gravels, Coastal Sands, Minor Valley Alluvials, and Limestone Aquifers (WRMU I, 2001). Aquifers are found along the southern foothills of the Range from Teteron Bay in the west to Valencia in the east and have been almost fully developed with some parts being over-exploited, resulting in the intrusion of salt water into the system, for example, the El Socorro Gravels (WRMU I, 2001). Off the west coast, minor ground-water systems can be found in Scotland Bay (WRMU I, 2001). The aquifers are supplied mainly from rainfall entering the soil and reaching the impervious bed by normal filtration and by the passage of water through fractures and solution channels. Stream flow and subsurface flow are also significant contributors in the continual process by which these large underground storage reservoirs are recharged. Stream-bed infiltration is a secondary source of recharge and occurs as rivers run through the gravel fans, especially in undeveloped areas such as Tucker Valley.

6.3.2 Links between Freshwater Ecosystems and Human Well-Being

6.3.2.1 Provision of Freshwater

Of the surface water sources exploited in Trinidad and Tobago by WASA, 80% originates within the Northern Range (WRA, 2002). On the south-facing slopes, several major tributaries contribute to the Caroni River above the intake of the Caroni–Arena Water Treatment Plant, which supplies 51% of the nation's potable water (WRMU I, 2001). Other major sources include the North Oropouche intake and the Hollis Reservoir although several smaller intakes occur on the Aripo, Guanapo, Caura, Acono, and Maraval rivers (WRMU I, 2001). Estimates of Safe Yield indicate that 72% of the total potential yield of surface-water sources and 58% of ground-water sources for the island of Trinidad occur in the Northern Range (H. Phelps, pers. commun., 2003).

Data collected for 1997 and 2000 show that the domestic sector is the biggest single user of water, seconded by minor and major industrial activities. Losses during transmission of water account for approximately 40% of the water demand (WRMU 2002). In some areas, for instance, Talparo, Mundo Nuevo, and Mamoral, there is no pipe-borne water, and the rivers are used for domestic purposes including bathing and washing (IMA 2001).

6.3.2.2 Provision of Fisheries

Although recreational fishing occurs along the length of Northern Range rivers, fish, including crayfish (*Atya scabra*, *Macrobrachium carcinus*, *M. crenulatum*, M. *jelskii*), the manicou crab (*Kingsleya garmani*; Kenny et al. 1997), molluscs, and the caiman (*Caiman cocodilus*) are mainly harvested in the lower reaches. The guabine (*Hoplias malabaricus*) and tilapia are fished fairly frequently in the lower reaches of the Caroni and Guayamare rivers and are considered a delicacy locally. Teta are also fished for the aquarium trade and can be considered a potential source of income on a very small scale (Kenny et al. 1997). However, since these fish have begun to be bred abroad artificially, Trinidad and Tobago's export market has declined (C. James, pers. commun., 2004).

6.3.2.3 Waste Disposal, Assimilation, and Treatment

Rivers and other natural waters are used for both solid and liquid waste disposal as communities are generally sited along rivers and watercourses. Solid wastes range from household garbage to vehicles and appliances while liquid wastes include sewage and household grey water and industrial effluents. Due to the lack of adequate regulations and alternatives for waste disposal, rivers are informally providing the role of a low-cost liquid-receiving and transportation system (Lucas and Alkins-Koo 2004). Examples of this are extremely high BODs and low dissolved oxygen found in the Lower Caroni, San Juan, and St. Joseph rivers resulting from the release of untreated industrial effluents into these rivers. Industries contributing to the high BOD loading of these rivers were brewing, food processing, and distilling (IMA 2001).

With respect to sewage treatment the IMA (2001), based on an earlier report conducted by the IMA in 1992, estimates that only 23% of the population is served by the central sewage-treatment systems that are located in Port-of-Spain, San Fernando, and Arima. In addition, it was found that small package sewage-treatment plants are used for large housing estates, hotels, and schools and other institutions outside the centrally sewered areas. Seventy-three sewer-treatment plants were identified on the Caroni River Basin.[39] Some of these located along the Santa Cruz/San Juan, Maracas/St. Joseph, and Tacarigua rivers were categorized as nonfunctional and were identified as contributing high BODs, faecal coliforms, and low dissolved oxygen values for these rivers.

With respect to solid waste, there are four landfill sites in Trinidad which are located at Beetham, Guanapo, Felicity, and Forres Park. According to the Solid Waste Company of Trinidad and Tobago, in 1991, an estimated 1,000 tonnes of waste was generated daily, for Trinidad and Tobago. However, the main sites receive only 800 tonnes of waste per day; as a result it was assumed that the remaining 200 tonnes was disposed of at smaller dumps or in watercourses. These aquatic systems have a natural capacity for assimilation and degradation of wastes largely through the action of algae, micro-organisms, and decomposer food webs. Wastes can be absorbed so long as their quantity does not exceed the assimilative capacity of a healthy aquatic ecosystem and that they are biodegradable, e.g., sewage and other organic matter. Many lower-course rivers of the Northern Range show symptoms of moderate nutrient enrichment as they absorb and incorporate non-point source runoff and domestic wastes into enhanced organism biomass and abundance (Turner 2003). Under certain conditions, however, wastes may overload this natural capacity for self-purification resulting in ecological degradation (e.g., lower Tacarigua River); or the type of waste may not be biodegradable (e.g., synthetic materials and heavy metals) and bioaccumulation of these substances in human food chains is possible (Surujdeo-Maharaj et al. 2004).

6.3.2.4 Amenity Value

Some of the rivers of the Northern Range are popular recreational sites for activities such as 'liming,' cooking, and bathing especially over holidays or weekends. Conflicting use such as bathing and meat preparation occur side by side. Due to large numbers of day visitors and campers, villagers (e.g., in Blanchisseuse) avoid using these rivers during and after these events as they claim to suffer from skin rashes[40] (Meredith, Sunday Express, 16/06/2002, p. 9). These outbreaks are a result of human excrement contaminating the rivers, as there is a lack of public toilet facilities in popular bathing areas along the coast and rivers.

Shark River, with its crystal clear waters and multiple deep pools, is an indication of past

[39]The Caroni River Basin is a part of the Northern Basin, which is located between the Northern Range and the Central Range. It covers an area of approximately 740 km^2 and includes the Caroni Swamp (WRMU I, 2001).
[40]Also see Box 9.
[41]Express, 30/12/2003.

conditions of Northern Range rivers (Kenny 2003).[41] Its forested steep-sided valley and isolation have so far prohibited even moderate human settlement, but it is a popular recreation area. Like many sites, there is a lack of waste-disposal facilities and the potential for degradation exists.

One longstanding river recreation site, Caura Recreation Park, was recorded to host more than 1,000 persons per day on weekends and more than 300 per day on weekdays (Meganck et al. 1983). Currently the use of this river and many others in the Northern Range has expanded to include almost every bank area accessible from the road.

The Northern Range also provides sites for religious pilgrimages, like the Hindu River Festival, *Ganga Dhaara*, at the Marianne River in Blanchisseuse, and the *Orisha Rain Festival* in Santa Cruz, which bring thousands of worshippers to the areas. No facilities for these activities are provided. The same watercourses are also used downstream domestically and recreationally by villagers of these areas. These multiple and sometimes conflicting uses of watercourses, as well as their consequences for water quality, need to be managed to avoid latent social tensions among the user groups.

Rivers are also used for baptism by various Christian groups and the banks of the Caroni and the Cunupia rivers are used for cremations (IMA 2001). These waterways are also of importance to the people of the Shango and Baptist faith as well as the Rastafarians.

6.3.2.5 Scientific Research/Education

Scientific research conducted on the Northern Range has always included some coverage of the rivers and other aquatic ecosystems (e.g., Beebe 1952). Hynes (1971) conducted a longitudinal survey of the Arima Valley, examining the changes in riverine macroinvertebrate community composition. Local studies of freshwater fish (summarized in Kenny 1995; Phillip 1999) have included characterization of the Northern Range fish fauna. However, early experimental studies on guppies in the mid-1960s by Caryl Haskins initiated a burgeoning research effort that continues to today. In particular these studies consider the effects of predation and other environmental drivers on life histories, growth, reproduction, and behaviour of guppies and jumping guabine. It is estimated that the number of scientific publications produced by this research effort totals about 260 over the period 1981–2002. The quantum of research funding is not known exactly but is estimated to be several hundreds of thousands of U.S. dollars to date with an unknown proportion of this spent locally on accommodation, transport, and materials. Major researchers have had research programmes involving generations of graduate students for 15–20 years. The output of this research has been cited extensively and provides some of the best known tests of evolutionary theory (Reznick et al. 1990).

Locally there has been a number of research projects for higher academic learning:

- Bernard (1979) who looked at bioaccumulation of lead by macroinvertebrates, macrophytes, and sediments;
- Moore and Karasek (1984) who looked at the organic pollutants in the Caroni River;
- T.I. Mohammed (2000) who looked at lead contamination and control for areas within the Caroni River Basin.

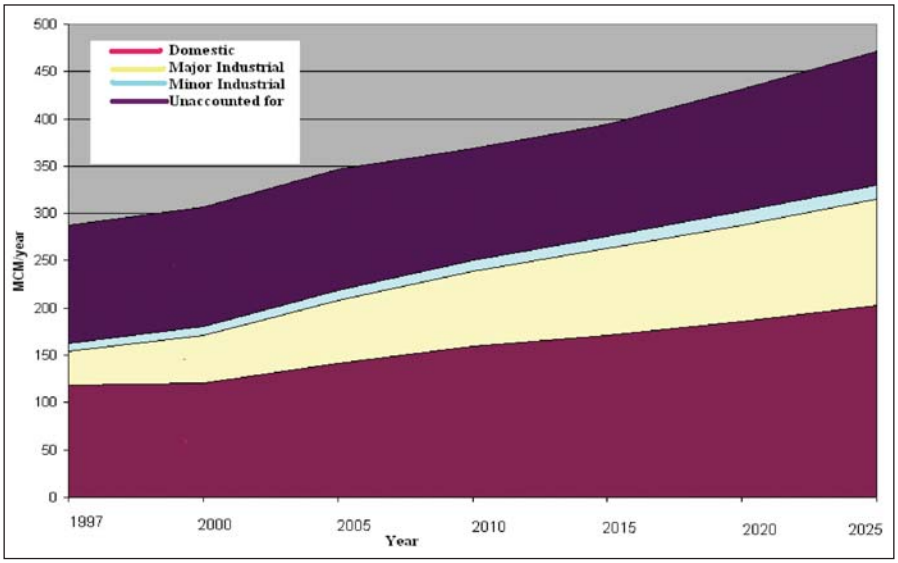
And the fish known internationally as the Guppy *(Poecilia reticulata)* was first discovered in the Northern Range by Lechmere Guppy.

6.3.3 Condition and Trends in Northern Range Freshwater Ecosystems

6.3.3.1 Water Quantity

By all accounts, Trinidad's water availability (both from surface and ground-water sources) can meet the island's freshwater demands at least until 2025, even in the driest months.
An attempt was made in the late 1990s by DHV Consultants BV (1999) to assess the water balance for Trinidad and Tobago.[42] Figure 20 shows that the projected demand was expected to increase within all sectors, and that domestic water was switched with unaccounted-for water use (40%–50%) to become the highest demand sector (WRMU 2002).

Fig. 20: Increase in Demand for Potable Water by All Sectors from 1997 to 2025



Source: DHV Consultants BV (1999)

Based on this same study (DHV Consultants BV 1999), Table 13 shows that demand is projected to increase from 28% of supply in 1997 to 48% in 2025. However, the study also indicated that supply may barely meet the demand (80% of supply) during the driest periods in 2025.

Table 13: Water Balance (MCM/year) for Trinidad for 1997 and 2025

	1997		2025	
	Year	Dry season	Year	Dry season
[1]Total available	3,691	573	3,701	583
[2]PWS demand	1,044	224	1651	328
[3]AGS demand	10	10	145	145
Total demand	1,054	234	1,796	473
Demand as % of total availability	28.6%	40.8%	48.5%	81.1%
Remaining	2,637	339	1,905	110
[4]Yearly balance	**71.4%**		**51.5%**	

Source: Adapted from DHV Consultants BV (1999)
[1]Includes natural surface flow, ground water, and from reservoirs. [2]Public Water Supply (potable water demand). [3]Agricultural Growth Scenario (irrigation water demand). [4]Percentage of yearly remaining from total available in a year.

[42] The projected domestic demand for potable water was based on a population growth rate of 1.2%, which is higher than the rate calculated from the 2,000 population census of 0.9%. Consideration was also given to increase in average consumption per capita due to higher income and change in lifestyles, increase in access to improved water supply systems (e.g., shift from roadside standpipes to in-house connections), and widening of supply network from servicing 86% of the population in 1997 to 98% in 2010 (DHV Consultants BV 1999). The demand by commercial potable water users was based on a growth rate of 1.7% (DHV Consultants BV 1999).

A similar study by the Water Resources Management Unit (WRMU I, 2001) estimated that the surface-water availability in Trinidad in the year 2000 was 3,600 MCM/year, which was more than 10 times the public water-supply demand (WRMU 2002). Compared to surface water, proven ground-water availability is small, estimated at about 545 MCM/year for the island of Trinidad; present ground-water withdrawal is estimated at around 80 MCM/year. Safe ground-water yield is estimated at 121 MCM/year, which is only 4% of the surface-water availability, indicating that surface water is a much more viable source of freshwater as compared to ground water. In fact, WRMU (2002) indicated that 68% of the water supply of Trinidad and Tobago is derived from surface-water sources. The available annual freshwater per capita in WRMU I (largely coterminous with the Northern Range) decreased from 2,764 m^3 per person in 1997 to 2,389 m^3 per person in 2000 and is expected to decline further to 1,644 m^3 per person in 2010 (WRMU I, 2001; Table 14).

Table 14: Projected Freshwater Availability Per Capita for WRMU I [43]

Year	1997	2000	2005	2010
Available annual freshwater per capita (m^3/person)	2,764	2,389	1,948	1,644

Source: WRMU I (2001)

The estimated per capita availability in 2010 (1,644 m^3/person) is above the 1,000 m^3/person international criterion used to indicate potential water scarcity in a given country (WRMU I, 2001); however, it is below the 1,700 m^3/person criterion which according to Falkenmark (1993; in WRMU I, 2001) is the level at which a country can experience water shortages. These are projections and any decrease in the availability or increase in demand may cause a shift towards a negative water balance. Additionally, it cannot be taken for granted that a surplus in availability means that Trinidad will not suffer water shortages. For instance, WRMU (2002) reported that demand in 2000 (when availability per capita was reported as being above the 1,700 m^3/person criterion) was estimated at 336 MCM while supply amounted to 300 MCM—a deficit of 36 MCM or 11 per cent. This deficit thus occurred despite an apparent abundance of water in the island, and according to WRMU (2002) 'was exacerbated during severe dry weather when low surface water flows coupled with high turbidity adversely affected the reliability of the raw water supply.'

Further, the demand, and thus available annual freshwater per capita, may be underestimated since it will not have considered water for irrigation for agriculture, as agricultural production has mainly been for sugar cane, coffee, and cocoa, which do not require irrigation. While market gardening (e.g., in Aranguez) makes use of primitive forms of irrigation, it is anticipated that modern means of irrigation will be required especially for use in the newly divested Caroni Lands that will be used for market gardening.

Analysis by the River Simulation Model (RIBASIM) also projects water stress for the north-west watersheds by 2025 (DHV Consultants BV 1999). Results showed that eleven watersheds in the western region of the Northern Range experienced water stress in 1997 (DHV Consultants BV 1999). It indicated that twelve watersheds (addition of the Chaguaramas Watershed) on the western half of the Northern Range will experience water stress by 2025.

[43]WRMU I is a hydrometric unit that includes the watersheds in the Northern Range and the Caroni Basin.

The extent of development which has occurred in the western region especially, including activities such as paving of channels, e.g., the Diego Martin River, would lead to a decrease in infiltration of rainfall, and a consequent drop in the rate of ground-water recharge. Simultaneously, surface runoff has increased causing physical pollution of the waterways and occasional flooding. Water-balance computations for the period 1988 to 1998 show an apparent slight decline in surface freshwater resources (WRMU I, 2001). The same study also showed that most of the aquifer levels have declined over the 10-year period (Table 15). However, sub-aquifers like Tucker Valley, Four Roads, and La Pastora have exhibited a slight rise in the water-table.

Table 15: Long-term Trends for Ground-water Levels from 1988 to 1998

Aquifer	Catchment	Water-level trend
Northwest Peninsula Gravels		
Tucker Valley	Chaguaramas	Slight rise
Diego Martin, Four Roads sub-aquifer Diego Martin, River Estate sub-aquifer	Diego Martin	Slight rise Decline
Port-of-Spain	Port-of-Spain	Decline
Maraval	Maraval	Constant
King George V Park	Port-of-Spain	Decline
St. Clair	Port-of-Spain	Decline
Northern Gravels		
El Socorro Gravels, upper sub-aquifer El Socorro Gravels, lower sub-aquifer	Santa Cruz	Decline Decline
Valsayn Gravels	Maracas	Slight decline
Tacarigua Gravels	Tacarigua	Decline
Arouca Gravels		Declining
Arima Gravels	Arima	Constant
Wallerfield Gravels	Talparo	Slight rise
Wallerfield Sands	Talparo	Slight decline
Valley Alluvials		
Santa Cruz, La Pastora sub-aquifer Santa Cruz, Meadows sub-aquifer	Santa Cruz	Slight rise Decline
Coastal Alluvials		
Blanchisseuse		Constant
Limestone		
Dorrington Gardens	Diego Martin	Rising

Source: WRMU I (2001)

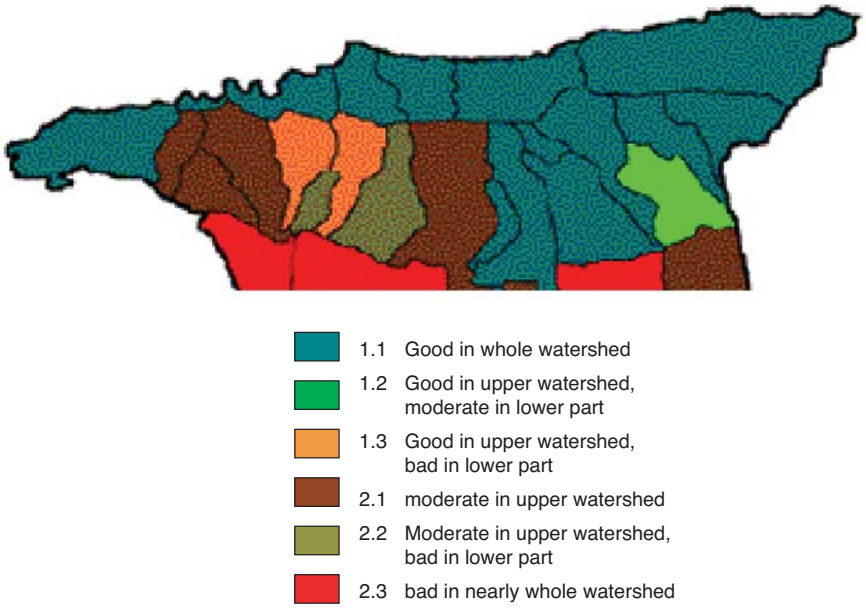
The recent discovery of deep bedrock megawatersheds in the islands of Trinidad and Tobago is significant for meeting the country's demand for freshwater in the future. The country's long experience in petroleum drilling could make it well placed to exploit these deep ground-water resources. It should be noted, however, that such deep ground-water is not a renewable resource (except over an extremely long period).[44]

6.3.3.2 Water Quality

The quality of Northern Range watersheds[45] (Fig. 21) is generally good in the eastern region and moderate towards the modified western region (DHV Consultants BV 1999).

[44]See www.watermap.com.
[45]See Annex 6 for a complete list of the watersheds of the Northern Range.

Fig. 21: Assessment of Watershed Quality (1999)



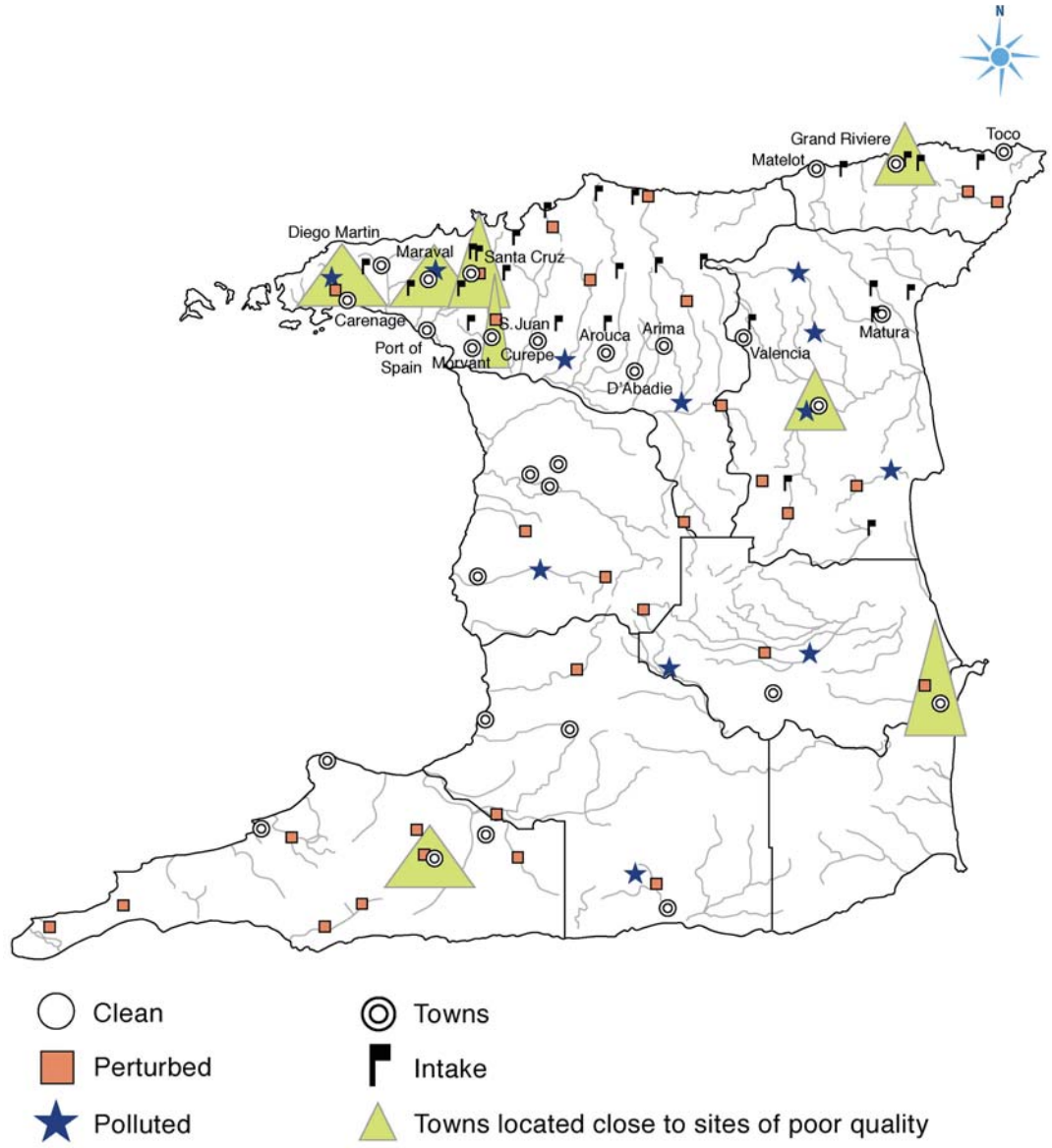
Source: DHV Consultants BV (1999)

The surface-water quality generally follows a similar trend but even in the western region, the streams are of good-to-moderate quality in the upper reaches (WRMU I, 2001; EMA 1998b). Water-quality tests have categorized the Cuesa, Diego Martin, St. Joseph/Maracas, Tacarigua, and Arima rivers as polluted and the rest of the south-draining rivers as perturbed (EMA 1998b). The rivers draining north were found to be pristine even at their point of discharge into the Caribbean Sea (EMA 1998b). The major water-quality issues with the streams in the western section of the Northern Range include moderate-to-high levels of sulphate (14–90 mg/L), phosphate (0.05–10 mg/L), BOD (28–300 mg/L), and faecal coliform (0.6–6 million/100 mL; WRMU I, 2001).

Research has been conducted on upper and lower reaches of seven rivers from Santa Cruz to Aripo, which cover areas under intense anthropogenic influence within the Northern Range. Water-quality test results concur with those cited above with the St. Joseph and Tacarigua rivers being most impacted by human activities. Data also show that the sites in the lower reaches were characterized by lower water quality than upper sites because of runoff from high-density residential and commercial areas in the East–West Corridor. Some rivers were minimally or moderately impacted by pollutants in the rainy season but tend to become very polluted in the dry season (Lucas 2003). In comparison, the sites in the upper reaches of the rivers that are dominated by forest cover exhibit good water quality in both seasons. Forest cover and conversely land conversion to residential/commercial use and agriculture were identified as the major factors affecting water quality in these watersheds (Lucas 2003; Lucas and Alkins-Koo 2004).

A nationwide survey of heavy metals in the water and sediments of rivers in Trinidad and Tobago indicates that most sites sampled in the Northern Range were perturbed with respect to occurrence of copper, nickel, cadmium, zinc, chromium, and lead. In particular, copper, zinc, and lead were of significant concern (Mahabir 2003; Surujdeo-Maharaj et al. 2004; Fig. 22).

Fig. 22: Water Quality of Selected Northern Range Rivers



Source: Surujdeo-Maharaj et al. 2004

Synthetic organic chemicals have recently been highlighted as contaminants of freshwater throughout the world from sources such as agriculture (e.g., pesticides, herbicides), industry (e.g., solvents), and even households (e.g., personal-care products). One major study of the Caroni River and some of its tributaries (Moore and Karasek 1984) concluded that these 'river waters resembled more closely those of waste waters ...' (Moore and Karasek 1984). It is noted that this study targeted sites above the Caroni–Arena Water Treatment Plant.

Low concentration of dissolved oxygen resulting from high organic loads and the presence of un-ionized ammonia account for depletion of fish life in the Northern Range watercourses. In general, pollution of surface water increases after traversing settled communities, and these upstream communities have negatively impacted on their own freshwater supply (see Box 3). There are consequences for downstream settlements as well and this can be seen with the San Juan River, which begins as the Santa Cruz River. The Santa Cruz settlement does not have a central sewerage

system and therefore the river is the ultimate destination of domestic waste-water. The river becomes more polluted after passing through the densely populated settlement of San Juan due to solid-waste dumping and effluent discharge from small and medium-sized industries. In addition to the pollution of the aquifer and the associated human health risk for those who directly use the water from the river, the surface water is used as a source of irrigation for the Aranguez Estate Irrigation Area where vegetables are grown for sale to the public (H. Phelps, pers. commun., 2004). This irrigation water has a high content of biodegradable organic matter from household and commercial wastewater. The risks for human health increase with each level of use of the contaminated surface water, from direct withdrawal for domestic use to a source of irrigation water, and from intakes for potable water to a source of aquifer recharge. Therefore all consumers of freshwater from this river are susceptible to illnesses from waterborne diseases and/or ingestion of toxic substances. The cumulative effects of pollution within a watershed or waterway of the Northern Range affects the catchment area of the Caroni River Basin which provides about 51% of the potable water for Trinidad.

Ground-water quality analyses show that the aquifers are of good quality and within the limits of World Health Organisation potable water standards (EMA 1998b). However, there are problems associated with high iron, sulphate (9–60 mg/L), and phosphate (0.03–0.14) content as well as saltwater intrusion in the El Socorro and Port-of-Spain/Cocorite Gravels due to large-scale withdrawal (WRMU I, 2001).

6.3.4 Summary of Assessment of Northern Range Freshwater Ecosystems

- ***The watershed areas of the Northern Range are the most important contributors to the freshwater supply for the island.*** Of the surface freshwater sources exploited in Trinidad and Tobago, 80% comes from the Northern Rnage (WRA 2002). On the south-facing slopes, several major tributaries contribute to the Caroni River above the intake of the Caroni–Arena Water Treatment Plant which is estimated to supply about 51% of Trinidad's potable water (WRMU I, 2001). The recent discovery of deep bedrock megawatersheds in the islands of Trinidad and Tobago will alter the freshwater supply/demand picture for Trinidad in the future. Trinidad's long experience in petroleum drilling could make it well placed to exploit these deep ground-water resources. It should be noted that such deep ground water is not a renewable resource (except over an extremely long period). So it would be necessary to protect and conserve both these deep-water resources and surface watersheds. While appropriate watershed management could protect and conserve surface and aquifer water, deep ground-water resources are not rechargeable through surface watershed management. If accessed, this body of water will need to be harvested conservatively to prolong its availability.
  - ***The eastern section of the Range contributes more than the western section and this is in part [46] attributable to the overall better state of the watersheds in the eastern sections*** (Fig. 21). There is evidence to suggest that rivers flowing from primary forests release twice as much water halfway through the dry season, and between three and five times as much at the end of the dry season as do rivers flowing from coffee plantations (Myers 1988).

- ***Current supply of freshwater exceeds demand, but this is projected to be more closely balanced by the year 2025,*** especially during the dry season (Tables 13 and 14). However, our ability to access the deep-water megawatershed would increase the supply, and public education for conservation could also contribute to management of demand and supply.

[46]Higher rainfall in the eastern section of the Northern Range may also account for this.

- ***An indicator of the high economic value of surface and aquifer freshwater provided by the Northern Range may be provided by an estimate of the cost of substituting this water with desalinated water:***
  - It is estimated that 80% of the freshwater sources in Trinidad and Tobago exploited by WASA comes from the Northern Range. It is also estimated that WASA currently spends about TT $13.4 million per month[47] to buy 10% of its water supply from a local desalination plant.[48] If WASA had to substitute the surface water supplied by the Northern Range with desalinated water at this price, it would cost in the order of TT $107 million per month (or TT $1,286 million per year).
  - With the current estimates for the decrease in water resources of the Northern Range and the projected concurrent increase in demand as a percentage of available supply, the cost of providing water can only be expected to increase if there is dependence on desalinated water to fill the gap. (This does not take into account the possibility of improvements in technology that could reduce desalination costs.)
  - It is speculated that as much as 50% of the island's water supply may be lost, after harvesting and treatment, because of old and faulty distribution infrastructure. Much saving of water and costs could be realized through investment in renewing infrastructure.

- ***Impacts on freshwater resources can be a result of activities at the watershed level (e.g., land-use change) or instream activities (e.g., channelisation, pollution).***
  - The Northern Range watersheds seem to be becoming more degraded due to deforestation for agriculture on steep slopes, housing and associated infrastructure, road construction, squatting, quarrying, and forest fires. By most expert estimates, the area of forest cover has declined overall even with reforestation (e.g., Northern Range Reafforestation Project), and resultant negative impacts to the Northern Range ecosystem continue, such as disruption to the hydrological processes and health of the aquatic ecosystems (Alkins-Koo et al. 2004). Instream activities for flood control (channelisation, dredging) are becoming more widespread as changes in watershed level promote hydrological responses, such as flooding.

- ***Though not as important to well-being as the provision of freshwater for domestic, agricultural, and industrial activities, the freshwater resources of the Northern Range also provide fish for food.*** There is a declining trend in freshwater fish catch for the country as a whole. Since most of the rivers are located in the Northern Range, the same conclusion might be made for freshwater fish catch from the Northern Range.

6.4 Coastal Ecosystems

6.4.1 Introduction to the Coastal Ecosystems of the Northern Range

Coastal conditions of the Northern Range vary from rugged high-energy rocky shorelines to low-energy depositional wetlands depending on the coastal topography and direction of prevailing waves and winds. In addition, a distinctive salinity gradient derived from the discharge of the Orinoco River in South America and heightened in the rainy season provides an additional axis of variation from low to high salinity from south to north. The prevailing north-east trade winds and direction of waves from the same quadrant result in very high-energy conditions on the north and eastern coastlines from Matura to Toco and westwards to Chaguaramas. In conjunction with a

[47]This figure represents an average price of the individual prices paid every month for the period March 14, 2002 to October 1, 2003.
[48]Official report of the Parliamentary debate, session 2003–2004. January 13th 2004. (http://www.ttparliament.org/hansard/senate/2004/hs20040113.pdf).

steep coastal topography, these environments are rugged rocky shores with high wave energy interspersed with small sand and gravel beaches where rivers enter the sea. To the west of the Northern Range, sea conditions are typical of a leeward location but, being still of a steep topography, rugged but low-energy conditions exist, e.g., the offshore islands and the Chaguaramas peninsula. Within the Gulf of Paria to the south-west of the Northern Range, low gradients in conjunction with discharge of local rivers produced mangrove wetlands which have now been extensively transformed, such as those at the mouths of the Maraval, Diego Martin, and Cuesa rivers.

6.4.1.1 Wetlands

Trinidad has several mangrove-dominated coastal wetland forests. The North Coast wetlands are freshwater swamp forest and found at the mouths of rivers flowing down the northern slopes of the Northern Range into the Caribbean Sea, and are very small in extent. The largest wetland in the Northern Range is the freshwater mangrove forest found in the Maracas Bay area, associated with the Maracas Bay River (Table 16). The mangroves on the north-west peninsula are of the estuarine type and they are under constant pressure from coastal development, e.g., the Mucurapo shoreline. Demands of development often override the need for conservation, and many of these wetlands are in danger of being degraded or destroyed.

Table 16: Location and Extent of Wetlands in the Northern Range

Wetlands of the Northern Range		
Area	**Type of wetland**	**Size (ha)**
North Coast		
Scotland Bay	Fringe mangrove	<1
Maracas Bay	Freshwater swamp forest	10–50
Tyrico Bay	Freshwater swamp forest	<1
Las Cuevas	Freshwater swamp forest	1–10
Yarra River	Freshwater swamp forest	<1
Marianne River	Freshwater swamp forest	10–50
Grand Riviere	Annual flood plain	<1
North-east Coast		
Matura River	Estuarine mangrove	10–50
Salybia River	Freshwater swamp	1–10
North-west Coast		
Bayshore / Diego Martin River	Estuarine mangrove	—
Chaguaramas	Estuarine mangrove	<1
Hart's Cut	Estuarine mangrove	<1
Cuesa River	Estuarine mangrove	<1
Mucurapo	Estuarine mangrove	1–10
Sealots	Estuarine mangrove	<1

Source: The Trinidad Guardian, 31/01/2000, p. 18; IMA 1999 (www.ima.gov.tt/cepwetlandslocations.htm).

6.4.1.2 Beaches

The beaches west of and including Maracas Bay are bay beaches with medium to coarse-grained sand (Georges 1983). Open sea beaches are typical east of Maracas Bay, except Paria and Las Cuevas, where the sand-grain sizes range from medium to coarse (Georges 1983). The beaches in Chaguaramas Bay are also of the open sea type composed of coarse sands, gravels, and pebbles (Georges 1983). Maracas, Tyrico, and Las Cuevas exhibit dynamic equilibrium where there are subsequent periods of erosion and accretion. The wave energy is moderate to high and rip currents sometimes occur at Maracas and Tyrico beaches.

6.4.1.3 Seagrass Beds

Extensive seagrass beds can be found in Williams Bay and smaller patches near the Trinidad and Tobago Yacht Club in the north-west peninsula (Juman 1998). They are also found in sheltered areas along the North Coast and as patches in the lagoon associated with the Salybia Reef on the North Coast (Kenny et al. 1997). The beds are composed predominantly of the turtle grass species. Seagrass beds provide habitats for several species of fish in their juvenile stages (e.g., snappers, groupers, and grunts) as well as many invertebrate species.[49] The latter group includes lobsters, cirrique crab, shrimp, sea urchins, molluscs, starfishes, and a range of anemone and sponge species (Juman 1998). The beds are an important food source for the hawskbill and green turtles which graze on the seagrass (Juman 1998).

6.4.1.4 Coral Reefs

There are small fringe reefs composed of finger corals that can be found around the Five Islands, Monos, and Chacachacare (Kenny et al. 1997). They develop in areas that are shallow and have vigorous circulation but little surf (Kenny et al. 1997). There are several patch reefs on subsurface rocky substrata along the North Coast and species richness seem to increase towards the east (Kenny et al. 1997). Salybia Reef on the north-east coast is a fringe reef of finger coral; smaller developments exist at Patience Bay and Toco Depot. These reefs diffuse heavy wave action which would otherwise affect the coastal strip, and thus protect the coast from erosion.

6.4.1.5 Algal Communities

The bays of the Northern Range and North-western Islands support algal communities on submerged rocks and reef formations. The communities comprise a mix of members of the Chlorophyta (green algae), Phaeophyceae (brown algae), and Rhodophyta (red algae), the last named of which are most species-rich and abundant. These communities provide habitats for species of fish in their juvenile stages as well as other marine animals. Additionally fish feed on some of the species. Species of *Gracilaria* (sea moss) are actively harvested by inhabitants in some of the coastal communities, particularly in Blanchisseuse and Matelot. However, the species is decreasing in abundance due to over-exploitation. The village of Blanchisseuse is now organizing to cultivate the seamoss.

6.4.2 Links between Coastal Ecosystems and Human Well-Being

6.4.2.1 Supply of Fish and Other Coastal Species

The coastal ecosystems support stocks of fish and crustaceans which are harvested using artisanal, semi-industrial, and industrial methods (WRA 2001). Artisanal fishing communities harvest mainly carite, kingfish, shark, and marine molluscs and crustaceans. Semi-industrial fisheries

[49]Juman, The Trinidad Guardian, 07/09/1998, p. 10.

target snappers, groupers, kingfish, dolphin fish, and sharks off the north Coast. Industrial shrimp trawlers operate off the North Coast (WRA 2001). Some of the non-fish coastal species sought for food include Queen conch (*Strombus gigas*), rock mussel (*Perna perna*), three species of pachro found on the rocky shores of the northern coast, and marine turtles (Kenny et al. 1997). The western section of the North Coast is one of three most fished areas in Trinidad (Ramnarine 2000). Traditional artisanal, recreational fishing and in recent years semi-industrial and industrial fishing all occur in the near-shore Chaguaramas area and around Gaspar Grande, Monos Islands, the Bocas, and off the North Coast (James 2001). Alcan Bay within Chaguaramas Bay is a port for a semi-industrial fleet of 201 fishermen and 150 boats, mainly pirogues that target kingfish (James 2001).

There are nine landing sites in the Northern Range (Nagassar 2000), four of which are predominantly fish-trap fisheries——Port of Spain, Carenage (which supported the most fishermen), Maracas, and Las Cuevas (F. Mohammed 2000). Fish catch data from four landing sites in the North Coast were collected from 1996 to 2002.[50] This points to the abundance in species that the northern coastal waters support for the fishing industry (Table 17).

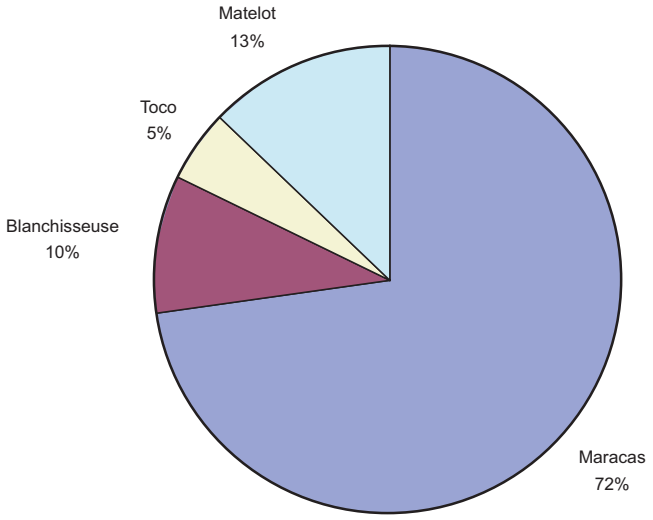
Table 17: Number of Species Identified at North Coast Landing Sites (2002)

Landing site	Maracas	Blanchisseuse	Matelot	Toco
Number of species	44	28	39	24

Source: Fisheries Division, Ministry of Agriculture, Land and Marine Resources.

The percentage distribution of fish catch for 2002 among the sites correlates with the number of species fished and the geographical location. The number of species fished (Table 17) and the fish catch (Fig. 23) decreased from the western to the eastern sites, from Maracas to Toco.[51] It is not known, however, if this trend is due to differences in fishing effort or the condition of the fish resources in these areas, but it can be treated as an indicator of use and benefits of the coastal resources for fishing communities.

Fig. 23: Proportion of Fish Catch at Four North Coast Landing Sites for 2002



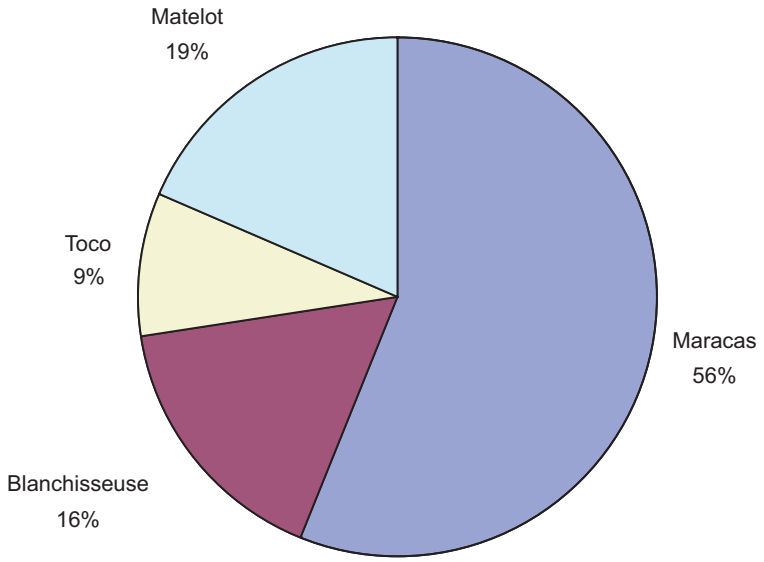
Data source: Fisheries Division, Ministry of Agriculture, Land and Marine Resources.

[50] Data were not collected during 2000 at any landing site. Data were collected from 1998 to 2002 at the Blanchisseuse site. At the Matelot and Toco landing sites, data were only collected for 2002.
[51] No information was available for Las Cuevas.

A seasonal artisanal fishery is also practised as seen in the Chaguaramas area where beach seine fishing operates during May to November and provides bait (herrings, sardines, and anchovies) for the pelagic line-fishing ventures (James 2001). Some of the part-time fishermen are also employed as tradesmen, including carpenters, boat builders, mechanics, gardeners, handymen (James 2001). Part-time/recreational fishing accounted for 12% of the annual commercial fish landing according to a 1993 study (James 2001). This type of fishing utilizes methods such as trolling, banking, and line fishing and targets pelagic and demersal fish.

Fish catch is an income earner at several levels, by the subsistence fisher folk, fish sold to the local market, and as a foreign-exchange earner for the country with exports. National figures show an increase in global demand and export from 1994 to 1996 valued at TT $48.7 million and TT $70.3 million, respectively (James 2001). The total economic value from the fish catch at four landing sites for 2002 was TT $3,494,943.4 or approximately U.S. $582,490 and the westerly sites accounted for about 73% as seen in Figure 24.

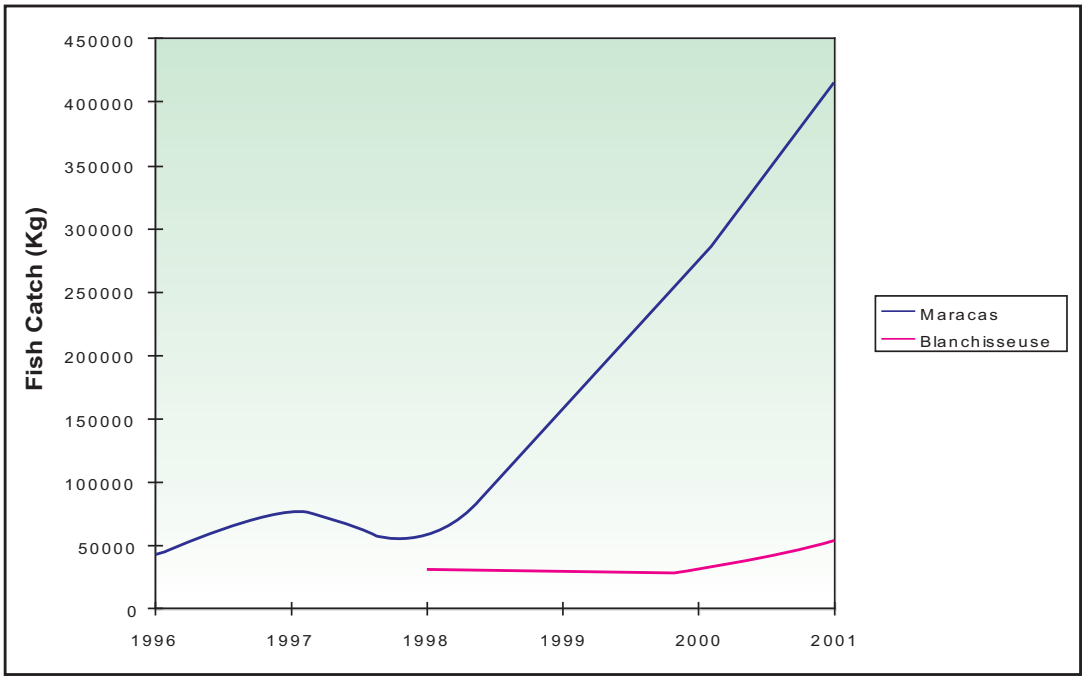
Fig. 24: Comparative Economic Value of Fish Catch at North Coast Landing Sites for 2002



Data source: Fisheries Division, Ministry of Agriculture, Land and Marine Resources

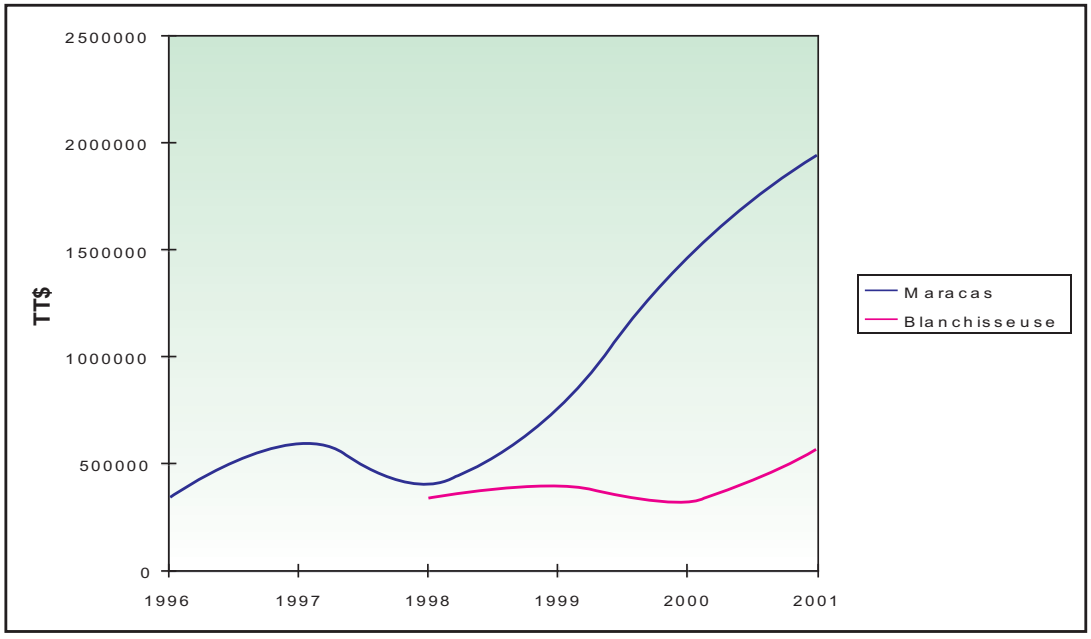
An increase in fish catch (Fig. 25) at two sites and a subsequent increase in the income earned (Fig. 26) from the local fisher folk can be traced from 1996 to 2002. Results from this study (Fisheries Division, MALMR) show that at the Maracas landing site, fish catch increased by 442% while the value of the catch increased by 223%. For the period of 1998 to 2002 in Blanchisseuse, fish catch increased by 79% and its value increased by 67 per cent. Evidently, there has been a recent trend of an increase in the income earned by the fisher folk in the North Coast fishing areas.

Fig. 25: Fish Catch at Two North Coast Landing Sites (1996–2002)



Data source: Fisheries Division, Ministry of Agriculture, Land and Marine Resources.

Fig. 26: Economic Value of Fish Catch at Maracas and Blanchisseuse Landing Sites (1996–2002)



Data source: Fisheries Division, Ministry of Agriculture, Land and Marine Resources.

The fish catch data are, however, an underestimation of the fish resources harvested in the North Coast as it has been reported that Venezuelan trawlers have been fishing off the North Coast for several years[52] in quantities far above that harvested by local boats (Mohammed and Chan A Shing

[52]Fish catch from Venezuelan trawlers have been collected from 1973 to 1996. (Mohammed, E., and Chan A Shing, C., 2003.)

2003). Therefore the condition of the fish stock and its economic value that is available for use by local fishing communities cannot be estimated correctly. There is need to reactivate the longstanding attempt to negotiate with Venezuela about joint management of this resource.

6.4.2.2 Exploitable Resources from Wetlands

Coastal wetlands are a source of exploitable resources, such as fish, softwood, thatch materials, charcoal, tannins, honey, and medicinal plants, which are used by families at a subsistence level or marketed. The bark of the red mangrove species is used in the production of glues, dyes, and stains, and in the tanning of leather. *Rhizophora* species have flowers rich in nectar, which is a good source of 'white' honey; also the leaves are brewed for medicinal teas (MALMR 1995). But there are very limited areas of mangrove left in the Northern Range. These might be more profitably conserved for educational purposes.

6.4.2.3 Provision of Safe and Natural Harbours

The protective Chaguaramas Bay in the north-west peninsula of Trinidad provides safe anchorage for boats and yachts, especially during the hurricane season. Reduced insurance premiums for boats and yachts docked outside of the hurricane belt and TIDCO's promotion of Trinidad and Tobago as a yachting destination have resulted in a large increase in the number of foreign yachts over recent years. In 1990 there were 65 recorded yachts and that figure grew to 1,008 in 1993 and 2,590 in 1997 (James 2001). A survey of foreign yachtsmen conducted by the IMA in 1996 determined the average monthly expenditure per yacht as U.S. $1,700 and an average total monthly expenditure as U.S. $0.34 million (James 2001). The money was mainly spent on boat repairs, fuel, food, entertainment, and transport. This expenditure also contributes directly to government revenue via immigration and customs fees, taxes on profits and income, Value Added Tax on goods and services, and the utilities (e.g., electricity, telephone, and public transport) for the marinas and boat yards (James 2001).

There has been a simultaneous increase in marinas and supporting boat service industries that offer skilled but relatively inexpensive labour and cheap materials. This is due mainly to private-sector initiatives and private investments in the Chaguaramas area estimated by TIDCO in 1998 as TT $60 million (James 2001). Businesses employ full-time as well as part-time workers during the peak months of June to September. Figures from the Yachting Service Association of Trinidad and Tobago and TIDCO indicate that there were 1,017 full-time jobs and 123 part-time jobs in 1996 and this increased in 1997 to 1,300 and 145 persons employed full time and part time, respectively (James 2001).

Income generation is also due to provision of services by local communities to the yachting industry, such as dive shops, and hotels/guest houses as well as sale/value of land, supplies, and services to visitors (e.g., day-trippers, who purchase food and beverages in the coastal villages, to beaches such as Maracas).

However, there are environmental impacts associated with these activities, such as pollution of the coastal waters from disposal of waste and other activities required by yachts. These negative impacts could be mitigated or eliminated if, for example, adequate waste-disposal facilities were provided (as required under MARPOL) and appropriate regulations enforced, and if the use of anti-fouling paints[53] in yachting services was banned.

[53]It is known that the yachting services make use of anti-fouling paints containing tributyltin, which is banned in the United States and Europe for causing tumors in fish and sex reversal in molluscs. Implications of this for humans from the food chain are not known at present.

6.4.2.4 Regulation of Water Quality

Both treated and raw sewage are usually discharged into coastal areas of the Northern Range. This is an example of conflicting usage. Water is a medium for disease transfer as there is potential for the direct transfer of microbes into the ears, nose, and mouth. Common transmittable diseases include cholera, typhoid fever, dysentery, other gastrointestinal diseases, conjunctivitis, leptospirosis, ringworm infections, schistosomiasis, sinus infection, and middle ear infection.

Tidal influences help to regulate water quality (Table 18). However, studies on Northern Range coastal water quality (e.g., Legarza et al. 2003) indicate that the purification capacity of coastal waters is often exceeded in popular recreational waters. Elevated levels of total coliform are found at low tide in several sites, including Chaguaramas, Welcome and Maracas bays, and Las Cuevas, along the north and north-west coast (Beharrysingh et al. 1993). Studies show that water quality is of acceptable levels for swimming at high tides but not at low tides (Beharrysingh et al. 1993)[54]. Contributions of contaminants in these cases come from land-based activities and are exacerbated by inputs from recreational activities themselves.

Table 18: Regulatory Effect of Tidal Variation on Total Coliform Contamination

Site	High-tide total coliform	Low-tide TC
Las Cuevas	16/ 0	10,000/ 1,000/ 20,000
Maracas	16/ 230	1,200/ 5,000
Staubles Bay	0	100
Welcome Bay	0	3,000
Chaguaramas Bay	0	700
Chagville Beach	500	172
Williams Bay	0	82
Dhein's Bay	10,000	300
Gasparee Island Bay	Not tested	0
Scotland Bay	Not tested	400

Source: Beharrysingh et al. 1993.

Harvesting of marine fish and fish from coastal wetlands near coastal industrial areas increases the risk of incapacitating illness in humans due to consumption of heavy metals that have bioaccumulated within the tissues of fish. Dredging is also a cause for concern as it allows sediment-bound pollutants to be made available for bioaccumulation. The dredging of Chaguaramas Bay in 1996/1997 was identified as a probable source of heavy metal pollution (Mohammed et al. 2000).

6.4.2.5 Regulation of Coastal Dynamics

Coastal mangroves act as a buffer against wind and heavy rains and provide shoreline protection and stabilization. Wetlands are important land builders by trapping the silt from river discharge. They therefore control the quality of the near-shore waters by trapping pesticides, heavy metals,

[54]According to USEPA standards (1999).

and inorganic nutrients. Turbidity in near-shore waters is lessened, and in areas where these ecosystems exist adjacent to one another, protection of reef and seagrass bed systems is possible.

Sea grass beds also function as coastal stabilizers and provide protection against coastal erosion. The sea grass slows and retards current flow, reducing overall water flow. The roots and rhizomes of the grass form a complex, interlocking matrix, which binds the sediment and retards erosion (Juman 1998).

6.4.2.6 Biodiversity Support

Coastal conditions around the Northern Range provide a range of ecological communities such as coral reefs and other sub-tidal communities. One major consideration is that the salinity of these offshore waters approaches brackish water levels in the rainy season with the increased discharge of local and South-American rivers (Kenny 2000). This imposes salinity and turbidity stress on reef-building coral species so that only a limited number of hardy species can survive to produce reefs, e.g., *Porites porites*. Reef development is therefore limited to patch and fringing reefs with the largest fringe reef being found at Salybia in the north-east. These reefs are intrinsically ecologically stressed and further changes in water quality can decimate their biota.

In certain areas (e.g., Chaguaramas and the Bocas Passage), naturally high turbidity and decreased light penetration have resulted in the unusual phenomenon of deep-water species occurring at shallow depths. For example, deep-water stony corals such as *Axhelia*, and black and other soft corals can be found at depths far shallower than in other parts of the Caribbean. This presents a unique opportunity for viewing such species that would be technically difficult elsewhere (Kenny 2000).

Seagrass communities provide habitats and nursery grounds for recreationally and commercially important finfish and shellfish. Juvenile finfish found in seagrass beds in Trinidad and Tobago include snappers, croakers, grunts, groupers, seabreams, and many others (Juman 1998). Other commercial species found in these beds are cirrique crabs, lobsters, and shrimps (Juman 1998). Queen conchs were also once found in these areas. There is a high diversity of noncommercial species found within these ecosystems due to their high productivity and nutrient cycling ability (Juman 1998). Species include sea urchins, sea cucumbers, starfishes, brittle stars, snails such as *Murex* sp., cones and olives, anemones, and sponges (Juman 1998). Seagrass beds are also grazing grounds for green and hawksbill turtles (Juman 1998).

Wetlands function as aquatic breeding grounds and nurseries for salt and freshwater organisms, especially several species of commercially important finfish and shellfish. Mangroves provide essential nutrients for juveniles as well as protection during the critical stage of their development. It is estimated that two-thirds of the commercial fish caught in Trinidad and Tobago inhabited mangroves during some stage of their development (Juman, The Trinidad Guardian, 07/09/1998, p. 10). Wetlands provide habitat for different species of wildlife.

6.4.2.7 Amenity Value

Some of the most popular recreational beaches in the island are found along the coastline of the Northern Range. These include Chagville, Scotland Bay and the Western Isles, Macqueripe, Maracas, Tyrico, Las Cuevas, Blanchisseuse, Paria, Matelot, Grand Riviere, Toco, and Salybia-Matura. The development of Maracas Beach has been one of three top priorities for TIDCO for 2004 (Valere 2004). Their vision for Maracas is “to create a state of the art facility in keeping with

internationally expected standards in sync with TIDCO's mission to promote Brand T&T and the country's vision for developed nation status by 2020" (Valere 2004).

The most common recreational uses of these areas are swimming/bathing and 'liming.' Other activities include snorkelling, diving, surfing, sailing, boat tours, fishing, camping, hiking, sightseeing, and mountain biking. Recreational fishing from shore is a popular evening/night-time activity in Chaguaramas. Camping takes place mainly on very long weekends such as Easter and Carnival.

The Northern Range coastal zone is a prized location for recreational or weekend homes. The amenities have been attracting settlers from the time of the abolition of slavery. Both traditional (see Box 7) and recent residents have expressed their appreciation of their surroundings.

Box 7: The Coast: Essential in Creating a Sense of Place in Grande Riviere

Primary school children from the Grande Riviere Anglican School made thirty-three drawings to illustrate what living in Grande Riviere means to them. All but three of the pictures depicted some aspect of their natural environment, which comprises both forests and coastal ecosystems. The most popular concept was the beach, and common elements included surfing, sea, boats, coconut trees, and sunsets. While forests were included in some of these drawings, the forest ecosystem was the main focus of the three. Of these three, two showed tree stumps and one depicted a cleared area converted to agriculture. Judging by these expressions the beach is a major part of the lives of children in Grande Riviere.

Of note as well is the development of the Chaguaramas peninsula as a premier entertainment area featuring night clubs/pubs, open-air multiplexes, and restaurants. The islands off the western peninsula can be considered unique in that throughout most of their recent history they have been used almost solely for recreation (Kenny 2002). On more than one occasion in the history of the Chaguaramas area (inclusive of the offshore islands), there have been plans of developing parts of the area for upscale tourism (Box 8), but these have largely not materialized. Exceptions may be the private guest-houses on some of the western isles.

Box 8: Nelson Island—Northern Range Historical Site

Although there are several historical sites in the Northern Range, there is one with special significance—Nelson Island and its buildings. This island is situated in the Gulf of Paria at the Five Islands, about a mile south of the village of Carenage on the coast lying at the foothills of the western Northern Range.

The Nelson Island buildings were constructed shortly after the conquest of Trinidad by the British in 1797. The three surviving buildings were built by Government slave labour, and levies on slaves from nearby estates, employing the technology of the times of casting massive walls of broken stone mined on the island and mortar mixed of sand and burnt lime. They were completed in 1802. Originally the buildings were of military and customs use but from 1865 to 1917 they served as a reception and processing centre for importation of indentured labour, processing some 114,000 persons during this period. Subsequent to 1917 the Island and its buildings were used for a variety of functions including processing indentured labourers returning to India; as a detention centre for the incarceration of Uriah Butler TC; as a detention centre for Austrian and German Jews who fled the impending Holocaust and became enemy aliens on the fall of France; as harbour defences for United States Naval

authorities; as a post-war youth camp; as a residential marine biology teaching centre for UWI students; as a detention centre for detainees, including George Weekes TC, after the 1970 uprising. Although somewhat modified over the past several decades the buildings are still roofed with twentieth century materials and are structurally sound. There are also foundation relics of several other buildings built on the island to accommodate the large numbers of persons being processed, on occasions rising into the hundreds of men, women, children, and infants. One such is the foundation of the recuperation centre/hospital where the ill people recovered from the rigours of the two- to three-month passage in sailing craft. One small building ruin may have been a Spanish fortification.

Nelson Island is regarded as being of considerable historical importance because it served as a major gateway to the peopling of Trinidad and is essentially comparable with the Ellis Island immigration facility in New York Harbour. There have long been expressions of intention to restore and upgrade the buildings for use as a National Historical Shrine and Museum, but to date these have not been pursued.

Wetlands are used in Trinidad for recreational, educational, and aesthetic purposes and this provides pleasure and intellectual stimulation to individuals, both locals and foreigners (National Wetlands Committee 2002).

Recreational fishing occurs off the coastlines and both pelagic (carite, kingfish, cavalla, wahoo, tuna, and billfish) and demersal species (snappers, groupers, sharks, salmon, and croaker) are targeted (WRA 2001). Recreational fisheries are becoming increasingly popular and there has been an increase in game-fishing tournaments, day-fishing charters, and billfishing (James 2001).

There has been increased use of recreational sites by a wide cross-section of society due to higher incomes. This increase in demand has prompted the government to propose an extension of the North Coast Road from Blanchisseuse to Matelot which would provide access to the entire North Coast of Trinidad. The popularity of the Western Isles for recreation sparked a ferry service provided at first by government, but replaced by small, privately owned boats (pirogues). The islands are also accessed by 'fete' trips on larger cabined vessels acquired for such a purpose. Examples are the Jolly Roger and Pier I cruises 'Down the Islands.' The Crews Inn cruises bring day visitors to Chacachacare. The use of these areas as a weekend getaway was at one time associated with the wealthy. Introduction of the cheaper pirogues brought access to the less wealthy who tend to make day trips rather than weekend trips. Vacation homes and holiday resorts along the north and north-east coast have become popular in recent years.

6.4.3 Condition and Trends in Northern Range Coastal Ecosystems

The organic and inorganic pollution associated with sewage and siltation from dredging and excess runoff as well as the physical damage by boat anchors and propellers continue to degrade the water quality in several locations. The significant increase in the boat and yachting industry in the north-west peninsula has caused a rapid expansion in supporting coastal infrastructure and increased sewage pollution. Bays within this area, such as Scotland Bay, as well as important recreational sites, such as Tucker Valley, have been recognized as having ecologically important habitats, which led to the designation of the Chaguaramas National Park in 1975. Part of the anchorage area is currently within the National Park (James 2001) and the problem is not the location but rather the increase in organic pollution from effluents.

The yachts remain anchored for periods ranging from less than a month to a year generating large quantities of sewage, solid waste, and grey water. Most of the yachts with holding tanks tend to be registered in the United States due to more stringent maritime regulations, but not all yachts have holding tanks so their sewage is directly discharged into the bay. There are five central sewage-treatment plants in the Chaguaramas area as well as some private septic tanks for industrial use. However, the main treatment plant in Point Gourde is nonfunctional so the wastes from yachts are either directly discharged into the bay from their holding tanks or indirectly via outfall pipes and nonfunctioning or malfunctioning plants (James 2001).

The sheltered bays of the north-west peninsula have a slow-current circulation pattern and this is compounded by the growing network of piers that decrease tidal flow through their moorings. Therefore the wastes from anchored yachts remain in the bay for about 7–9 days and impact negatively on the quality of the coastal habitats.

6.4.4 Summary of Assessment of Northern Range Coastal Ecosystems

- ***The Northern Range includes a range of coastal habitat types—wetlands, beaches, seagrasses, algal communities, and coral reefs—which are significant for ecological functions and amenity value.***

- ***Coastal ecosystems are under threat from land-based and coastal activities, including intensive use for recreational purposes. Major causes of disturbance are coastal development, land-based activities, over-exploitation of coastal resources, and natural disasters.***
  - There is evidence of increased levels of pollution in some coastal areas after intensive use for recreation with consequences for human health. Studies indicate that the purification capacity of coastal waters is often exceeded in popular recreational waters.
  - The western section of the North Coast is noted as one of the most fished areas in Trinidad (Ramnarine 2000).
  - Soil erosion combined with flooding lead to sedimentation of coastal waters with consequences for uses of the coastal strip and functioning of coastal wetland resources.
  - Continuation of the North Coast road to Matelot could exacerbate impacts.

- ***High and growing demand for these ecosystem services (recreation, tourism, food production, sea transportation), and conflicts among these activities for use of limited resources, have implications for sustainable management. The trade-offs among these are not being actively examined and managed.***

- ***The protected Chaguaramas Bay in the north-west peninsula of Trinidad provides safe anchorage for boats and yachts, especially during the hurricane season. This has spawned intensive use of this section of coastal waters. This generates jobs and income, but also contributes to pollution of these coastal waters.*** The most recent example of such movement of yachts within the Caribbean to the Chaguaramas peninsula was during Hurricane Ivan in September 2004.

7.1 Overview of Condition and Trends

Table 19 reveals that the overall trend for most services derived from forests, watersheds, and coastal resources of the Northern Range is declining:

Forests

- Forests have declined in extent and quality of cover, especially in the western section, and the eastern section is now under threat from use of land space for housing and agriculture.
- Forests are being increasingly used for recreational and educational purposes, and are presumed to be more significant for their regulating, supporting, and cultural services than for the value of their timber and wildlife harvested. Forest cover is closely associated with watershed management and surface water quality and quantity. Loss of forest cover is associated with soil erosion and exacerbated flooding.

Freshwater

- Watersheds are being affected by a decrease in water retention through loss of forest cover, and watercourses are being affected by pollution from human use and sedimentation from soil erosion. Demand for freshwater and supply from surface and aquifer sources are projected to be in balance until about 2025, but with little positive balance during dry seasons; however, recent discovery of a significant amount of deep ground-water resources, if accessed, will meet demand thereafter.

Coastal resources

- Coastal waters are under intense use and are consequently contaminated from a variety of human activities.
- Comprehensive data on fisheries are not available, although it is reported that for the Caribbean Sea as a whole, catch per unit of effort is declining (Caribbean Sea Assessment 2005, in preparation).

Given the linkages shown in Table 2, consequences of these trends for human well-being can be readily inferred. However, it has not been possible to assess quantitatively consequences associated with a given ecosystem change. Impacts on human well-being are therefore treated in a qualitative manner.

Human demands on these three components of the Northern Range, especially for their amenity value, has been increasing. Management strategies are required to ensure that user demand as well as ecological functions can be satisfied. **Maintaining amenity value would also sustain capacity for the regulating and supporting services which these components provide. This positive relationship is very relevant to policy decisions about management and use of these resources in the short and long term.**

Based on the information presented in sections 5 and 6 of this report, Table 19 shows a summary of conclusions made about the trends in Northern Range ecosystem services. These conclusions relate to the capacity of these components and not to the human demand for use of their services.

Table 19: Assessment of Condition and Trends for Major Northern Range Services

Northern Range ecosystem service	Service type - Provisioning/ Regulating/ Supporting/ Cultural	Condition	Trend	Certainty level
Forest ecosystems				
Timber and non-timber forest products	Provisioning	Fair	Declining	Medium
Land space	Provisioning	Fair	Declining, especially in the south-western regions of the NR	High
Minerals	Provisioning	Good	Declining	High
Runoff regulation and retention	Regulating	Fair	Significant decline especially in the Western NR	Medium
Soil conservation	Regulating	Fair	Declining	Medium
Water cycling and replenishment	Supporting	Fair	Declining	Medium
Amenity value	Cultural	Good	Declining, especially in the south-western regions of the NR	Medium
Freshwater ecosystems				
Water resources	Provisioning	Fair	Declining, especially in the south-western regions	High
Fisheries, aquaculture	Provisioning	Fair	Declining	Low
Waste disposal, assimilation, and treatment	Regulating	Fair	Declining	Medium
Flood regulation, water storage	Regulating	Fair	Declining, especially in the south-western regions of the NR	Medium
Amenity value	Cultural	Fair	Declining, especially in the rivers on the southern flanks	Medium
Coastal ecosystems				
Fisheries	Provisioning	Fair	Declining (as evidenced by the increase in effort per unit catch)	Low
Safe anchorage	Provisioning	Good	Stable	High
Waste disposal, assimilation and treatment	Regulating	Fair	Declining	Medium
Amenity value	Cultural	Good	Declining, especially in the south-western region of the NR	Medium

7.2 Consequences for Human Well-Being

Hillside degradation (forest clearance, conversion of land use) has major impacts on provision of water for human use (dealt with in Section 6.3.2.1), and on water-recharge capabilities. These impacts could in certain circumstances exacerbate soil loss and flooding. A study done by Angier (1993; in Faizool 2002) estimated that the total cost of deforestation is TT $144,000 per hectare. Although scientific evidence is lacking to show the direct impacts that forest-cover loss has on water recharge and thus flooding, especially in the valleys and in the Caroni Basin area, hydrological models and local knowledge support an association between deforestation and flooding incidence. The use of the HEC-1 Hydrologic Model simulated the St. Joseph flood event of November 5th, 2002 and showed a peak flow in excess of 100 m^3/s; most of this flow was from areas destroyed by recent fires (Cooper 2003). Housing settlements, which accounted for 5% of the catchment, made moderate contributions. Several future development scenarios were modelled and it was projected that there should be 3-ha of land reforested for every hectare converted to housing if current stream flows were to be maintained. This predictive capacity could be useful in the designing of land-use policies and plans.

7.2.1 Freshwater Quality and Quantity

The main link between the water resources of the Northern Range and human well-being is a continuous and dependable supply of clean water for domestic use. This highlights the importance of both supply and quality. Increasing deterioration of the catchment areas has led to marked increases in stream turbidity and pollution from poorly treated or untreated sewage, and direct discharge of domestic wastewater into the watercourses has severely decreased the quality of surface and even ground water. Soil erosion is of concern especially on the southern slopes of the Northern Range that are under heavy housing and infrastructural pressures. An attempt to rank soil erosion in the north-western watersheds indicated that the Maraval, St. Ann's, and Diego Martin basins were the most susceptible and in critical need of remedial attention (DHV Consultants BV 1999). The siltation of streams has increased the cost of potable water production. In 1992 the cost of water treatment was 20% of the production cost (Faizool 2002), and this cost is expected to rise. The pollution of waterways by sewage and other runoff also increases the cost of water purification and the availability of water. A recent incident of contamination of the Caroni River with sewage waste from an NHA housing development (in November 2003) resulted in closure of the main Caroni–Arena Water Treatment Plant and widespread disruption in public water supplies for several days. The most obvious impact of these sources of pollution is on public health through the spread of disease and ingestion of toxic materials.

"The degree of contamination presents very real risks of spreading serious diseases such as typhoid and hepatitis in addition to the minor gastro-enteritis and skin problems that occur at present" (WS Atkins International Ltd. and A De B Consultants 1993, 56). The number of cases of gastro-enteritis, which suggests conditions of poor sanitation and environmental conditions, increased 69% on the island during of Trinidad the period 1981–1992 (CSO 1996; in Kairi 1999b).

Water is a vehicle for the spread of diseases caused by micro-organisms. Water contaminated with *Vibrio cholera, Yersinia enterocolitica, Escherichia coli,* and *Cryptosporidium* can lead to waterborne epidemics. Decreased water quality can be associated with economics and geographical location. There is a tendency for lower water quality in rural areas as compared to urban communities, combined with the fact that rural communities have a higher percentage of elderly and children who are more susceptible. This creates areas of potential health crises (Welch et al. 2000). These trends were observed in Toco, Rampanalgas, Salybia, and Matura. Pit latrines are located close to the rivers which act as water sources in the communities (Welch et al. 2000). This could lead to gastro-enteritis in communities and in Trinidad as a whole where this is also common. Matura and Toco especially are in dire need of improvements in the quality of their water supply (Welch et al. 2000).

The presence of bacteria that pose severe health concerns to humans is due to contamination on several levels (Welch et al. 2000):

- Water before treatment can be contaminated and any defect in the treatment system could have negative health consequences.
- Water collected from springs, streams, and wells may not be properly treated before use.
- Water could be contaminated from use of unsanitary storage containers.
- Contaminated water used for irrigation of crops, especially those that are eaten raw, could pose a risk to health. Box 9 illustrates ways of coping with inadequate water quality and quantity by communities.

In three rivers of the Northern Range studied by Phillip et al. (2003), occurrence of the protozoan parasite *Cryptosporidium* was confirmed at raw water intakes with highest levels recorded for the Maraval River as compared with the Aripo and Quare rivers. This is a potential threat to health as this parasite can withstand chlorination of water supplies.

In addition to microbiological threats to health, a more insidious threat includes heavy metals and synthetic organic chemicals. These are known to cause a range of health impacts including gastrointestinal, severe neurological, carcinogenic, and teratogenic ill effects and death. Recent studies on the presence of heavy metals and synthetic organic chemicals in rivers in the Northern Range indicate that these are potentially serious contributors to health (Moore and Karaseck 1984; Mahabir 2003; Surujdeo-Maharaj et al. 2004). However, no firm linkages can be drawn with existing health trends since there is a lack of monitoring of such parameters in drinking water. Also, a complementary database of reported illnesses that could assess the levels of health impact does not exist. Further, lifestyle-related illnesses (coronary disease, diabetes, etc.) dominate the local health profile and make it difficult to prioritise mechanisms for monitoring and assessment of other illnesses.

On a local scale, disposal of livestock waste directly into watercourses and use of organic fertilizers, such as pig and chicken manure, result in contamination of rivers and other watercourses. There have been reports of itching and skin rashes due to exposure to these sources of contamination (Arima River). It is unclear what the causative agents are. Given these threats, it is remarkable that WASA monitors water intake for only bacteriological quality and physical parameters (Maharaj 1999). Better protection of human health associated with water quality would be achieved by ensuring that the full World Health Standards regime is met.

Box 9: Community Ways of Coping with Decreasing Freshwater Quality and Quantity

Residents of the three communities view access to freshwater of good quality and reliable supply as being important aspects of their well-being. While expressing concern about the deteriorating quality of the freshwater available from their streams, they are of the view that spring water tastes better than water supplied by the public water system (WASA) and feel that the former is better for their health. In Petit Curucaye many residents, despite having connections to the WASA pipelines, make a daily or weekly trek to the springs which are their preferred source of drinking water. Some access the spring water only at night as they feel the quality of the water is better or safer at this time as some upstream activities are halted at night. The same behaviour is exhibited by residents of Grande Riviere.

Residents acknowledge the practices within their communities (disposal of solid waste, grey water, and sewage and runoff from use of agrochemicals) which contaminate the surface and ground water that they rely on for potable water. In Petit Curucaye residents access the water in more remote upstream areas before the stream passes through the residential area. Those without access to pipe-borne water now walk further to collect clean spring water, find alternative water sources (e.g., truck-delivered water in Bon Air North and Petit Curucaye), reduce household water consumption, or continue to use the degraded water.

In Bon Air North residents pool together to finance truck-borne water, collect rain water from their roofs in the rainy season, and access spring water for domestic purposes. The stream passing through Petit Curucaye was used daily for bathing and swimming but due to the decreasing water quality over the last ten years, residents now visit less accessible bathing spots further upstream of the community. This decrease in accessibility impacts negatively on the less agile elderly and on working residents with little spare time for water collection.

The decline in water quality and quantity could expose residents of the communities to health risks associated with water-borne diseases. In all three communities residents experienced itching after bathing in the river. An interview with C. Bullock (2003) revealed that there could be bacteriological pollution in watercourses from raw sewage due to seepage from pit latrines

along or relatively close to the banks, as well as from runoff from agricultural waste. Residents in Bon Air North complain about getting rashes and infections of the skin, ear, nose, throat, and urinary tract. As a result some people stopped drinking the spring water.

In Grande Riviere residents believe that two freshwater pools have become muddy as a result of the activities of a private landowner, and by chemical effluent from farms. This is of concern to the tour guides but other residents who avoid these pools appear not to be concerned. Residents avoid swimming in the river after busy public holidays, long weekends, and in the dry season when the river estuary has not yet broken its banks. This is also the approach of other North Coast communities (eg. Toco and Blanchisseuse) where there are no sanitary facilities for the increasing number of holiday visitors.

7.2.2 Flooding and Landslides

The carrying capacity of Northern Range waterways has been exceeded frequently in the rainy season and flooding of the flatter downstream areas is becoming more frequent and economically damaging. The occurrence of floods and landslides not only have economic costs but also lower the personal security of people living in flood or landslide-prone areas. Although the upland communities of the St. Joseph catchment within the Northern Range assessment boundary did not suffer from the November 5th, 2002 flood, the land conversion in the upper parts of the catchment may have contributed to the flooding downstream on the flood plains, and incurred severe collateral damage (Box 10; Cooper 2003). Indiscriminate dumping of solid waste and improper land development in the upper reaches of the Northern Range streams contribute to flash-flooding along the East–West Corridor in the foothills of the Northern Range, especially in periods of unusually high rainfall and where drainage systems are inadequate. Soil erosion also leads to siltation, increasing the vulnerability of communities. Areas such as Woodbrook and Diego Martin, not previously affected by flooding, were inundated in the later part of the rainy season of 2003. According to the Meteorological Services Division,[55] in 1986 and 1988 severe flooding was reported in Santa Cruz, Maraval, and St. Ann's valleys and in Port-of-Spain which resulted in damage to food crops and property. In 1993 flash floods in St. Ann's, Maraval, and Port-of-Spain caused loss of six lives.

The twin effects of flooding and channel instability lead to pressures on government to construct flood-protection works and to increase the size of waterways via construction of flood embankments and pavement of channel sections. Examples of these infrastructural measures can be seen along the lower sections of the St. Ann's, Maraval, and Diego Martin rivers that traverse housing settlements. Recent river 'improvement' works in San Fernando have been estimated at more than TT $40 million with an increase in channel capacity of the Marabella River to three times its former size, accounting for TT $10.1 million. Similar work was reported as being conducted on the Caroni River (Express and The Trinidad Guardian, 24/04/2004). Such river 'improvement' works also lead to habitat and ecological changes that could severely reduce biodiversity (Alkins-Koo et al. 2004). Despite these expenditures, there is little effort to control the problem at source. However, the recently announced National Reforestation Programme, which will include the Northern Range, could be the means through which this is done. It would appear that in the past mini-dams at the foot of the Northern Range had been considered but rejected in favour of the construction of the Arena Dam. However, flooding now occurs in areas along the foothills of the Northern Range.

[55]Meteorological Sevices Division, Piarco (http://www.procicaribe.org/networks/clawrenet/reports/z_tt/tttb243.htm).

Box 10: Links between Hillside Degradation and Flooding in the St. Joseph/Maracas Catchment: a case study (Cooper 2003).

A noticeable trend in the upper areas of the Maracas/St. Joseph catchment is the conversion of estate lands to middle-income housing, and this can be expected to continue as demand increases. If this continues along with fires and clearing for agriculture, then peak flows, soil loss, and flood events are likely to increase in frequency and magnitude. However, there would be a decrease in peak or lag time which essentially means that flooding would occur faster and therefore shorten the time available to implement measures to mitigate flood events and their impacts. This trend is visible throughout the other watersheds, especially in the north-west, and the island's population is experiencing increased social, economic, and health impacts of flooding and attempts at flood control.

7.2.3 Harbour Maintenance

There are indications of a downstream problem of sedimentation. For example, the Caroni River was desilted in 1983 at a cost of TT $22 million. In 1993 a study by Angier (Faizool 2002) showed that TT $3.5 million was spent to dredge the harbour (Faizool 2002). The main cause of sedimentation here is the plume from the mouth of the Caroni River as it enters the Gulf of Paria, with an estimated load of 500,000 m^3. The same study also estimated the total costs to the country via deforestation and urbanization as TT $144,000 per hectare and TT $207,900 per hectare, respectively (Faizool 2002). The estimate considered catchment-protection measures, opportunity cost for water loss, desilting and dredging costs, and the annual loss of forests and increased urbanization. In addition any dredging activity, offshore or inland, risks mobilization of sediments and associated heavy metals and synthetic organic compounds adsorbed into those sediments, thus making them more available for bioaccumulation, entry in human food chains, and associated health risks.

7.2.4 Food Availability / Security

The loss of topsoil in steep slopes has been an inhibiting factor in reforestation efforts and the cycle of impacts continues, including shifting onto new land. A decrease in topsoil and soil fertility has caused a decline in agricultural yield which is compensated for by an increased quantity and frequency of agrochemicals usage or the shifting to a new tract of forested land. These chemicals are a major source of diffuse pollution in the surface and groundwater resources. Part time or subsistence farmers who cannot afford agrochemicals have stopped farming altogether as seen in Petit Curucaye and as a result have had to increase the percentage of income spent on food purchases. Flooding originating in the Northern Range also affects agriculture in the plains downstream, causing frequent economic losses and community dislocations. Current policy of providing some compensation to these groups hardly addresses the cause of the problem and is probably unsustainable in the long run.

Agricultural losses due to fires can also have an economic impact, especially on small-scale farmers. In the 2003 fire season, the Fire Service noted as many as 41 fires that burnt an area of 60ha of agricultural land (Singh 2003b). There is no information, however, to establish the economic value of the crops lost.

7.2.5 Amenity Value

Amenity value of the ecosystem contributes to human well-being through recreation, education, and tourism. The Northern Range is under increasing demand for recreational activities, along

the coast and in the interior due to increasing appreciation for its amenity value, and increasing accessibility, mobility, leisure time, and wealth of users. However, degradation of the Northern Range ecosystems, along with trends in harvesting, have had an impact on several Northern Range species (see Section 6.1), and this has had or can have a potential impact on the amenity value of the Northern Range and hence its potential for recreation, tourism, and education.

There are serious impacts of pollution which contribute to degradation of aquatic ecosystems and the aesthetic quality of watercourses, both of which impact on the recreational use of rivers (Alkins-Koo et al. 2004) and consequently on human well-being. Many heavily used recreational sites cater to low-income groups who may be deprived of these options in the future. Additionally, as popular recreational sites become more degraded, further incursions into more pristine areas result as users search for a better quality experience (Alkins-Koo et al. 2004). In an unpolluted river there is a balance between flora and fauna represented by species richness and diversity. Pollution disrupts this balance. Gill-breathing fish are good indicators of quality because they are are very sensitive to oxygen depletion, so as a rule if fish are absent, this is a strong indication of unsatisfactory conditions. The decreasing water quality due to upstream bacterial, chemical, and physical pollution has already deterred users of the Caura River Recreational Site (Meganck et al. 1983).

There are consequences for the quality of coastal waters and other coastal assets in the Chaguaramas area due to intensive use for yachting activities. The problem of pollution of coastal waters by yachts is exacerbated by the lack of enforcement of relevant legislation.

8.0 Importance of the Northern Range as an Ecosystem

From the foregoing discussion the following overview can be made about the Northern Range as a whole:

1. It is evident that the Northern Range is being affected by a range of factors: urbanization and pressure for housing space; increasing incomes and therefore demand for superior housing sites and recreational opportunity, facilitated by technology and mobility; land use inconsistent with land capability and characteristics especially for unplanned agriculture; lack of strict rules or lack of rigorous application in planning and authorization of activities; absence of assessment for carrying capacity of amenity sites, monitoring and management arrangements, facilities; misuse of environment; lack of understanding, care, and sensitivity by users.
2. It is evident that the western section has been seriously degraded and that this pattern continues; that the eastern section is not as disturbed but that pressures are increasing; that water sources are being depleted and waterways contaminated; that soil loss and flooding are exacerbated by forest clearance for timber, agriculture, and housing; and that downstream impacts of this pattern of use and misuse are widespread, increasing in frequency and intensity, and generating high costs for compensation and correction.
3. Though it may be less evident from empirical evidence and scientific studies, it is highly probable that the above driving forces and patterns of use and misuse would lead to a reduction of biodiversity through loss of species and changes in habitats, and eventually to a reduction in the invisible but essential supporting and regulating services which the Northern Range provides.
4. The impacts and implications for the well-being of the society—of economic, cultural, health, security, and recreational significance—are definite and perceptible even if not quantifiable on the basis of existing data.
5. It is foreseeable that conversion, degradation, and decline in the capacity of the Northern Range to provide ecosystem services would continue unless appropriate policies and management approaches and measures are applied.

9.0 Assessment of Responses

Responses refer to the range of interventions comprising policies, legislation and regulation, planning, management, implementation and enforcement, research, monitoring, and evaluation. The priority concerns for this assessment, as well as the driving forces identified earlier, provide a context in which past and current responses are selected for assessment, and further response options identified. Since no systematic process of evaluating and documenting the effectiveness of any particular response has been found, the analysis draws upon expert and practitioners' knowledge and judgements.

The responses considered include some that are specific to the Northern Range or parts of it, some that are national in scope and of general relevance, and others that are regional and international in origin to which the country subscribes but which require national interpretation and measures for application. Within these scales, the responses emanate from a variety of sources: official actions of the State or its agencies, civic, corporate, and community initiatives.

9.1 Northern Range Specific Responses

9.1.1 Official Responses

1. The Northern Range Hillside Development Policy (NRHDP)

In 1976 a Cabinet Minute (# 692 of 1976) prohibited development on lands above the 100-m (approximately 300ft) contour line with gradients in excess of 1 in 6. However, this was afterwards considered too restrictive and it was altered in the Northern Range Hillside Policy of 1988, formulated by the Town and Country Planning Division in collaboration with several ministries, to address specifically the issues of environmental degradation in the Northern Range due to physical development. The NRHDP removed the restriction of the 100-m contour, retained the gradient restriction of 1 in 6, and proposed consideration of development proposals based on individual merit.

The policy guidelines provided that designated forested areas were to remain intact, agricultural land was to be retained only for agriculture, development on steep slopes was to be controlled, and residential settlements were to be regulated. The historical, cultural, and scientific and aesthetic values were also protected and development was precluded in declared sites. Existing residential settlements were allowed to expand but no new ones were to be developed. However, in the confines of the valleys, it is not easy to distinguish between expansion and new developments and, at present, use for residential activity has overtaken agriculture in the lower valley areas. Although the policy encouraged the growth of agriculture, most of the prime agricultural lands have now been converted to settlements or left unproductive. This policy has been ineffective in its core objective as agriculture is predominantly on marginal slopes while settlements have spread and privately owned forested areas are sold to developers.

The increasing demand for the use of the finite land space of the Northern Range hillsides for built development, which is often in conflict with other uses such as catchment areas for freshwater resources, has necessitated a review of the Northern Range Hillside Development Policy. This review started in November 2003 with public consultation to understand the views and obtain recommendations of stakeholders for the development of a policy framework for hillside development throughout Trinidad and Tobago. The review process is now led by a technical advisory committee drawn from public agencies, academia, practitioners, and civic society.

2. The Eastern Northern Range Plan in Trinidad 1991–1995 (Ministry of Agriculture, Lands and Marine Resources, Forestry Division, 1991)

The Eastern Northern Range Plan was designed by the Forestry Division but not implemented. If implemented, the Plan would probably have addressed the issues relating to the use and management of the north-eastern part of the Northern Range. It included projects to promote and enhance the agricultural sector, fisheries and marine resources, forest resources, recreation, community development, and environmental protection; and also to regulate quarrying.

3. Local Area Plan: Planning for Development, Capital Region Plan (Town and Country Planning Division, Ministry of Planning and Development, 1975)

- The Capital Region Plan formulated by the Government guides the redevelopment of Port-of-Spain. Its main objectives include:
- Decentralization of economic activity
- Development of independent subregional communities
- Development of the agricultural sector via the preservation and management of prime agricultural land
- Immediate implementation of a Northern Range Reafforestation Project (NRRP)
- Development and protection of recreational and scenic values via national parks
- Development of strategies to prevent environmental degradation
- Limits to nonagricultural land use in the Northern Range valleys.

The Reafforestation Project was intended to control flooding in the capital city and in recognition that the capital's water supply depends heavily on the catchments of the watersheds within the Northern Range. There was a restriction on nonagricultural use of the valleys possibly to maintain food security of the local communities and to promote the then lucrative tree-crop agriculture (cocoa, coffee, citrus). With the general neglect of agriculture in the country and low financial returns to the cocoa and coffee industry, much of the previously cultivated land is now being converted to housing or left uncultivated. Satisfactory implementation of this Plan would have done a lot to rectify and forestall the situation in the Northern Range that is found today.

4. Draft Local Area Plan: Planning for Development, Maraval (Town and Country Planning Division, Ministry of Planning and Development, 1974)

This draft development plan was designed to promote policy objectives in line with national development goals. This area was chosen as it is a suburb to the capital city and was becoming under increased pressure from urbanization. Although this plan is still in draft form, the outlined strategies have been used in the management of land use in this valley. The management strategies are:

- Prohibited development above the 300-ft mean sea level (MSL) contour line
- Prohibited development on steep slopes
- In accordance with the NRRP, land over 700-ft MSL must be under tree cover
- Land between 300-ft and 700-ft be reserved for tree crops
- Encouragement but monitoring of chive production on the slopes in the community of Paramin
- Minimal developmental density increase
- Limit commercial activity along Saddle Road
- No development in areas impacting on water resources
- Plans must attempt to address poverty alleviation
- Implementation of watershed management to control flooding and erosion, and ensure ground-water recharge.

5. Draft Local Area Plan. Planning for Development, Santa Cruz (Town and Country Planning Division, Ministry of Planning and Development, 1976)

Santa Cruz is also a suburb to the capital city, and the valley has increasingly been under pressure from rapid urbanization. Although this plan is still in draft form, the outlined strategies have been used in the management of land use in this valley. Management of built development is especially important, as this area contains prime agricultural land and forms the Santa Cruz Watershed within the Northern Range. The management strategies are:

- To provide policy guidelines for future development
- To formulate policies in keeping with national development goals
- Reservation of fertile soils below 400-ft for agriculture
- Reservation of slopes steeper than 1 in 6 between 400-ft and 700-ft for tree crops
- Restrictions on livestock due to possible ground-water contamination
- Permitting homestead development
- Designation of areas only below 400-ft for residential development
- Preservation of natural amenity
- To keep soils under vegetation cover to ensure ground-water recharge.

9.1.2 Civic Initiatives

There is an increasing number of civic organizations, both nongovernmental (NGO) and community-based (CBO), which are being formed to take initiative and responsibility for advocacy, planning, policy analysis for management of natural resources; and to seek to influence public policy and form an approach to development that includes communities in policy consultation and in implementation. They advocate against environmental degradation and are beginning to have impact (Box 11). There is evidence of success in raising public and official awareness. The civic advocacy movement is continuing to grow in significance and impact despite constraining factors such as lack of continuous funding. They are increasingly taking initiative to work with and support communities.

Box 11: Selected Northern Range Civic Initiatives

One example of an NGO that is active within the Northern Range is the Tropical ReLeaf Foundation which is a collaborator on this assessment. The Foundation's main objective is the re-greening of the slopes of the Northern Range by providing monetary and technical assistance to participating communities, like Petit Curucaye, for reforestation projects. The work is concentrated in the north-west region because this is the area of the Northern Range that suffers the most denudation due to agriculture and housing developments.

A few examples of CBOs include Nature Seekers Inc. (NSI), Grande Riviere And Nature Tourguide Association (GRANTA), and Stakeholders Against Destruction (SAD) for Toco. The Grand Riviere and Nature Tourguide Association was initiated by the national tourism agency TIDCO and includes members from all the civic organizations in Grande Riviere. The aim of this group is to promote and conduct tourism activities in a sustainable manner and incorporate the environmental, social, and economic concerns of the entire community.

Nature Seekers Inc. was initiated by the Wildlife Unit of the Forestry Division for the protection of the leatherback turtles (*Dermochelys coriacea*). This was the response of the community of Matura to the threat to this species of turtles. The group has created a sustainable income-earning entity for the community based on turtle-watching. This is an example of co-operation between public entity and a community.

Nature Seekers Inc. is also an example of how vocal CBOs have become as evidenced by the blockade of a proposed 750-acre eco-tourism resort in Matura on the grounds that the area could not sustain such a large development (Aguillera, President NSI, 1995). Another instance of this is SAD for Toco which resisted the construction of a port in Toco which it felt would have changed the character of the community and impact negatively on the environment.

The community of Fondes Amandes in the St. Ann's Valley has for the past twenty years worked together to reforest and manage parts of the surrounding watershed successfully, protecting it from hillside fires. The community now derives income from the visits to the reforestation and nursery project, and produce from the forest gardens.

9.2 National-level Responses

9.2.1 Official Responses

1. Environmental Management Act (GoTT 2000)

The Environmental Management (EM) Act provides an environmental management framework which includes:

- Establishment, organization, and imparting of powers and duties to the national Environmental Management Authority (EMA)
- Establishment, organization, and imparting of powers and duties to the national Environmental Commission
- Implementation of a National Environmental Policy
- Establishment of the Environmental Trust Fund
- Certificate of Environmental Clearance
- Protection of natural resource strategies
- Management and control of pollution strategies
- Compliance and enforcement of rules

2. National Environmental Policy (GoTT 1998; revised 2005)

The National Environmental Policy (NEP) is broad-based and applies to all sectors and areas of activity. The goal of the policy is the conservation and wise use of the environment of Trinidad and Tobago to provide adequately for meeting the needs of present and future generations and enhancing the quality of life.

Six basic principles which govern the NEP are:

(i) Respect and care for the community of life
(ii) Improving the quality of human life
(iii) Conserving the vitality and diversity of the natural environment of Trinidad and Tobago
(iv) Keeping within the country's carrying capacity
(v) Changing personal attitudes and practices
(vi) Empowering communities to care for their own environment.

The NEP has specific objectives which are the control of pollution, the conservation of biological diversity, and the analysis or evaluation of past development decisions with the aim of correcting any decisions that may be inimical to environmental health. The NEP is quite comprehensive and addresses most of the present environmental concerns under the broad headings of:

- Protection of Natural Resources
- Pollution, Hazardous and Toxic Substances
- Assessments of Impacts, Public Health and Environmental Education

The NEP seeks to maintain the total area of land zoned for Forest Reserves and prevents conversion to other land use including quarrying.

The NEP also provides for rehabilitation programmes for mining sites which can help to mitigate the negative impact on flooding and water recharge by indiscriminate quarrying and land-abandonment practices. One of the policy's strategies is to ensure the treatment of sewage and wastewater before discharge. This is key to sustaining the environment's vital service of waste assimilation and treatment.

Establishment of the EMA to lead and guide implementation of the National Environment Policy has led to progress in a number of areas which are outlined in points 3 to 5 below.

3. Draft Water Pollution Rules 2001[56] (Environmental Management Authority, Ministry of Public Utilities and the Environment)

The Draft Water Pollution Rules seek to protect the quality of the freshwater resources via the development of standards, permits, and fines. The Rules target the industrial sector and point-sources of contamination. Therefore areas of relevance will be the control of pollution from non/partially functional sewerage plants and the boating and yachting industry. Neither the Draft Rules nor the Draft National Water Resources Policy includes ambient water quality, which would be more specific to the diffused sources of pollution from agricultural and housing activities within the Northern Range.

4. Environmentally Sensitive Areas Rules 2001 (GoTT)[57]

This was made under the EM Act 2000, sections 26e and 41. The designation of an Environmentally Sensitive Area (ESA) is based on three main objectives:

- Conservation of natural resources and protection of the environment
- Sustainable economic and human development
- Logistic support such as environmental education and information sharing.

The Rules outline several specific objectives and criteria the proposed area must meet to be declared an Environmentally Sensitive Area. There are four areas (Chaguaramas, Madamas, Matura, and Maracas National Parks), all within the Northern Range, which were proposed as National Parks by the System of National Parks and Other Protected Areas in Trinidad and Tobago (Thelen and Faizool 1980). In November 2004, Matura National Park, the largest of the four covering an area of 9,000 ha, was officially declared the first Environmentally Sensitive Area of Trinidad and Tobago.

In addition, conservation areas in the Northern Range that existed before the ESA Rules are:
Wildlife Sanctuaries—Valencia, Saut d'eau Island, Kronstadt Island[58]
Forest Reserves—St. David, Melajo, Manzanilla Windbelt, Long Stretch, Paria, Yarra, Blanchissuese, Tacarigua, Arima, Las Cuevas, Northern Range.

5. Environmentally Sensitive Species Rules 2001 (GoTT)[59]

This was made under the EM Act 2000, sections 26e and 41. The designation of an Environmentally Sensitive Species (ESS) is based on three main objectives:

- Conservation of natural resources and protection of the environment
- Sustainable economic and human development
- Logistic support such as environmental education and information sharing.

[56]EMA (2001b).
[57]EMA (2001c).
[58]But note that one half of Kronstadt Island is leased to Minerals and Barytes Ltd. for processing drilling mud.
[59]EMA (2001d).

The Rules outline several specific objectives and criteria the proposed species must meet to be declared an Environmentally Sensitive Species. Three species have been recommended for designation under these rules—the Pawi (*Pipile pipile*), the manatee (*Trichechus manatus*), and the white-tailed sabrewing hummingbird (*Campylopterus ensipennis*); the Pawi being found in the Eastern Northern Range.

6. Vision 2020

The Government has recently begun a broad-based national macro-planning process for the country, called Vision 2020. The rationale is to advance towards sustainable development, and to achieve 'developed country' status by the year 2020. The results of this exercise will need to be considered for its specific implications for the Northern Range.

7. National Physical Development Plan (Town and Country Planning Division, Ministry of Finance and Planning, 1984)

This Plan, approved by Parliament in 1984 under the Town and Country Planning Act 1968, provides for:

- An overview of physical development to year 2000
- Formulation of land-use policies
- Provision of social and physical infrastructure
- Integration of urban and local plans
- A framework for regional and local plans (e.g., Maraval and Santa Cruz valleys described above)
- Integration of spatial planning and sectoral policy.

8. Draft National Conceptual Development Plan (Ministry of Planning and Development, 1999)

This Draft Plan provides a framework for future planning of development and includes:

- A national land-use strategy for development over the next twenty years
- A balanced growth approach
- Sectoral overview and policy guidelines.

The Draft National Conceptual Development Plan initiated the development of several draft Local Area Concept plans including Sangre Grande and Chaguaramas. The plans are designed to provide the local planning framework and impacts on land space in terms of provision within the area for present and future housing expansion, infrastructural upgrades, agriculture, and industry. For example, the Sangre Grande Local Area Plan (HALCROW/Laughlin et al. 1999, p. 6) has projected that 300 ha would be needed for housing and supporting uses over a 20-year period. The Chaguaramas Local Area Concept Plan recommends the retention of 400 ha, owned by MALMR within the Tucker Valley, for agricultural use although there is little linkage with the tourism-oriented activities. The Chaguaramas Local Area Concept Plan recommended that the agricultural State lands in Tucker Valley be retained for agricultural use despite the tourism thrust in that area.

Since the preparation of the Plan, it is not clear what has been done.

9. The State Lands (Regularisation of Tenure) Act No 25 of 1998 (Ministry of Housing and Settlement)

This Act was the government's attempt to address the growing problem of spontaneous settlements on State land as well as a host of related social, economic, and environmental issues (Box 12). This Act requires approval for leases which needs the fulfilment of several criteria by the applicant

including proof of land occupation for residential purposes before January 1st, 1998. However, this policy only encompasses residential squatting and excludes agricultural squatting. The Land Settlement Agency is responsible for the administration of the policy but the granting of leases requires approval from the Town and Country Planning Division, the National Public Health Authority, and the Municipal Corporation. The Act identifies sixty-four communities within the boundaries of this assessment for tenure regularization including Bon Air North, one of the communities consulted in this assessment. Around 1997, the impending regularization policy acted as an impetus for migration into existing squatter settlements throughout the country, increasing the pressure on the slopes of the Northern Range for housing as evident in Bon Air North (Box 12).

Box 12: Consequences of the Regularization Policy [State Land (Regularisation of Tenure) Act No. 25 of 1998])

Regularization of squatters on State land is conditional upon people demonstrating that they have occupied a piece of land prior to January 1st, 1998. In Bon Air North, as in other parts of the country, the prospect of regularization has provided a stimulus for:

1. An increase in squatting or illegal land occupation as people moved onto State lands in an attempt to become landowners. Residents said that in 1997 there was a rapid influx of people from other areas in Trinidad drawn by the hope of gaining security of land tenure through the imminent regularization policy. Their claim is supported by surveys done by government agencies that reveal an increase in houses from 60 in 1993 to 250 in 1998.
2. An increase in cultivation of land. In addition to the building of houses, residents also invest time and money into cultivating the land with a mix of short- and long-term crops. This is done by few for additional income but also practised by the majority as a way of laying claim to the land by tangible investments as well as an attempt to secure rights to more than the 5,000 square feet of land.
3. Residents coming together on issues to improve their community. The challenge for the Bon Air North community will be to retain its ability to come together on common issues once people get leases to their occupied lots so that other ecosystem improvement and community development may occur, including governance arrangements, construction of physical infrastructure, and attention to other community needs for the present and future (e.g., recreational facilities, preschool, etc.)

10. Shelter Policy (Ministry of Housing and Settlement, 2002)

This document is intended to provide an action plan for government to deal with pressing housing needs and to increase interagency co-ordination in the housing-delivery system. This policy on housing and settlements has three main objectives:

- The introduction of a programme of continuous research to provide current data for policy formulation and implementation
- The creation and equipping of a system of viable settlements
- The streamlining and improvement of the institutional functions for land identification, land assembly, release, vesting, registration, and development approval.

11. Community Development Policy (Ministry of Community Development and Gender Affairs, 1996)

This Policy has enabled the formulation of the Community Development Fund (CDF) which has two key components—investment and technical assistance. Together they have impacted

positively on the well-being of communities in the Northern Range (Express, 30/09/2003, p. 39). Petit Curucaye started developing fifty years ago but it was only with monetary and technical aid from the CDF via the National Commission for Self Help Ltd. that the community began to receive pipe-borne water seven years ago. One of the CDF's strategic programmes, the NGO/CBO Grants Window Programme, has given technical assistance to the community of Fondes Amandes for the development of The Fondes Amandes Reforestation Project.

12. Draft National Water Resources Policy (Water Resources Management Unit, Ministry of Public Utilities and the Environment, 2002)

This Draft Policy establishes a framework for integrated water-resource management via its policy issues and implementation instruments to ensure a sustainable supply of clean freshwater. Issues encompass land-use planning, public water quality and supply, flooding, watershed management, coastal zone management, designated uses, and the conduct of a comprehensive water-resource assessment. One of the expected outputs is the development of a Water Resources Plan that will guide the implementation of the policy objectives. Instruments include legal, planning, economic, collaborative, participatory, educational, and research interventions.

Cabinet has approved a Water Resources Management Authority that would be responsible for the implementation and enforcement of the Policy. However, to date this has not been established as there is currently a new proposal to promote the setting up of a Water Resources and Meteorological Management Authority. The main differences between the two agencies are that the latter would not be financially autonomous and would incorporate the seemingly overlapping functions of the Meteorological Office.

13. Minerals Act 2000 (Quarries Unit, Ministry of Energy)

This Act has been passed but not proclaimed. It attempts to manage the mining activities of common and special minerals and regulate the environmental impact of the exploration, mining, and processing operations, and encourage land rehabilitation after abandonment. The Act allows the granting of mining licences and approval of mining zones to promote and facilitate the effective and efficient management of mineral resources. The Act seeks to regulate mining activities via:

- Enforcement of the rehabilitation of State lands affected by mining
- Overseeing of exploration, mining, and processing authorized by a licence
- Enforcement of regulations and monitoring of operations
- Termination of illegal mining on State and private lands
- Refusal of mining licences in areas that contain freshwater resources; on national parks, protected areas, and environmentally sensitive areas; on the foreshore and sea bed; and in archaeological sites unless approved by the Minister.

The Act requires appointment of a committee to oversee its operation but this has not happened to date.

Despite the passage of time since 2000 without proclamation of the Act or establishment of the administrative requirements (e.g., appointment of a Director, committee, and regulations), the policy relating to quarrying is now being redrafted. While this will take into account issues included in the existing Act, it will place the issues into a larger developmental context, including sensitive watersheds that need to be protected.

It is important to note also that many quarries have been in operation before they have had to obtain Certificates of Environmental Clearance (CEC) based on Environmental Impact

Assessments required under the Environmental Management Act, 2000. These now need to be regulated separately to monitor impacts of operations and to ensure rehabilitation of vegetation and restoration of terrain where possible. It is expected that such provisions will now be included in CECs for quarrying. It would be desirable if the Minerals Act being revised brings all quarries under the same regulatory framework, and in the context of a holistic plan for use of the resources of the Northern Range.

14. Draft Forest Policy of Trinidad and Tobago 1998 (Forestry Division, MALMR, 1998)

The Draft Forest Policy is a result of a review of the Forest Policy 1942. It is based on ecosystem integrity, efficient use of resources, science as a basis of decision-making, integrated decision-making, continuous improvement and innovation, partnership and consultation, accountability and equity. This response outlines policy orientation and strategies for specific areas which are listed:

- Land-use planning and forest reservation
- Legislation
- Forest management
- Forest production
- Forest protection
- Utilization and forest industry development
- National Parks and other protected areas
- Wildlife management
- Watershed management
- Forest engineering
- Forest research
- Private forestry, agro-forestry, and forestry assistance
- Forest publicity and public relations
- Forest training and human resource development.

Though this draft policy has not been approved, it guides the approach of the Forestry Division.

15. National Parks System Plan (Establishment of a System of National Parks and Other Protected Areas. 1980. Forestry Division, MALMR/OAS)

This proposal of sixty-one sites has never been approved but is used as a management guideline. A number of the originally identified areas have been developed and is managed by the National Parks Unit within the Forestry Division. There are several National Parks within the Northern Range:

- Caura Recreational Site
- Lopinot Complex
- Fort Picton
- Fort George
- River Estate
- Cleaver Woods.

These sites are used for recreation by local and foreign visitors. There are proposals for the designation of national parks which seek to protect and conserve the ecological, recreational, aesthetic, cultural, and historical values of the Northern Range. The areas identified are in Chaguaramas, Maracas, Madamas, and Matura and represent about 22% of the land space of the Northern Range. The Matura National Park was officially declared an Environmentally Sensitive Area in November 2004.

16. National Biodiversity Strategy and Action Plan for Trinidad and Tobago (Environmental Management Authority, 2001)

The ratification by Trinidad and Tobago in 1996 of the Convention on Biological Diversity has led to the development of the National Biodiversity Strategy and Action Plan. One of the main objectives is to improve treatment of biodiversity issues in sectoral policies and plans and improve policy commitment and enforcement. However, progress on biodiversity issues has often been reactionary, externally driven, and often related to trade issues and tourism. Ultimately it is the conservation of local biodiversity that will maintain a healthy ecosystem as well as ensure the survival of the species that are of special interest to visitors and nationals.

The National Biodiversity Strategy and Action Plan includes the following strategies:

- Education and awareness
- Legislation and regulations for more effective management tools
- Capacity: establish an information-sharing mechanism, strengthen the role of NGOs and CBOs in biodiversity management and conservation
- Information and research: prioritise research needs, encourage collaboration between information and research within government and other research institutions, increase access and opportunities for information sharing
- Policy and commitment: Integrate biodiversity objectives into sectoral policies, institutionalize public participation in developing biodiversity conservation and management.

17. Food and Agriculture Policy (Ministry of Agriculture, Lands and Marine Resources, 1994)

This policy refers to agricultural land, wetlands, water, forest, and fisheries resources as the natural resource base for food production. Therefore strategies that deal with the sustainable use and management of these resources were identified. One key introduction into this policy was the recognition of the importance of stakeholders, their needs and consultation.

18. Sector Policy for Food Production and Marine Resources 2001–2005 (Ministry of Food Production and Marine Resources)

This Sector Policy is a subsidiary to the National Medium Term Policy Framework 2000–2002 (Ministry of Integrated Planning and Development). Its core strategy is for agricultural development via production agriculture and the use of renewable natural resources.

Strategies to deal with production agriculture include:

- Accessing, developing, and promoting the adoption of appropriate technology to reduce production costs
- Developing and promoting the adoption of more profitable higher-valued commodities or systems
- Promoting the adoption of improved husbandry and management practices
- Improving the marketing systems
- Promoting linkages with agro-industry.

The main goal with respect to renewable land and marine resources is the sustainable management and protection of the environment. Major strategies include:

- Implementing strong management practices to ensure sustainable use while meeting the needs of users
- Development of aquaculture as an alternative and to complement marine fisheries
- Use of multi-sectoral approaches to address land-based activities that impact negatively on the marine ecosystems.

19. Draft Environmental Education Policy for Trinidad and Tobago (Ministry of Education, 1999)

This Policy aims to promote environmental sensitivity. If effective in its overall goal, a sense of environmental stewardship in the country, it could serve to improve awareness of the importance of the Northern Range as an ecosystem and the way it contributes to well-being.

20. Green Fund (Ministry of Finance, 2000)

The Green Fund was established under the Finance Act 2000 as one of the miscellaneous taxes to come into effect on January 2nd, 2001. The fund was created through a levy on all companies via a 0.1% tax on sales or receipts. This tax was introduced within a financial budget and was not discussed in a public arena. The Public Utilities and Environment Minister stated in an interview (Express, 9/11/2003, p. 14) that this response needs redesigning due to unclear disbursement and management strategies. To date it can be expected that the fund will have acquired significant resources (estimated to be over TT $400 million as of February 2005), but there has been no disclosure of whether, and for what purposes, this Fund has been used.

21. The Master Tourism Plan (Tourism and Industrial Development Company, 1996)

This is a tourism land-use plan, which identifies areas of tourism potential, determines and preserves their character/appeal and carrying capacity, and promotes the adherence to development guidelines. It recognizes the importance of sustainable development and use of the environmental goods and services necessary for the long-term success of tourism objectives for both local and foreign tourists. The plan can therefore stimulate environmental awareness and acknowledgement of the linkages between community livelihoods and ecosystem health. The earning of livelihoods from our renewable resources will only increase in importance as the reserves of, and revenue from, oil and gas resources decrease.

At the same time, eco-tourism will place an increasing onus on environmental goods and services. Although the plan states that tourism-oriented developments will adhere to the carrying capacity and development guidelines, policies to date have had little success with enforcement. Meanwhile, the government has recently announced plans to construct a north coast road between Blanchisseuse and Matelot to facilitate tourism development along the North Coast without having undertaken an environmental impact assessment.

9.2.2 Civic Initiatives

There is an increasing number of NGOs (e.g., Fishermen and Friends of the Sea, Caribbean Forest Conservation Association, Trinidad and Tobago Biological Society, Citizens for Conservation, The Cropper Foundation, many others) which are being formed and are taking initiatives and responsibility for advocacy, planning, policy analysis for natural resource management, and sustainable development. Their efforts contribute generally to improving public awareness and citizen involvement in environment and development issues, and specifically to the Northern Range and its assets. Communities are also organizing CBOs to take responsibility for conservation and management of the assets of their place. Notable among these are:

- The initiative of The Tropical ReLeaf Foundation to regreen areas in the western part of the Northern Range by enabling and facilitating communities to replant
- The Grande Riviere and Matura communities in educating about, and regulating and monitoring visits to, turtle-nesting sites
- Fondes Amandes Community reforestation and forest fire prevention
- Caura Valley Farmers Association which is implementing an integrated development initiative in the Caura Valley. This aims to address ecological, social, and economic issues

of the community. The integrated approach is reflected in the initiative's outputs, which include the development of improved technology for crop, pest, and farm management; improved livelihoods for the farmers and community; and the conservation of the watershed.

9.2.3 Corporate Initiatives

Several firms in the corporate sector sponsor or support activities that contribute generally to environment and development issues. The Royal Bank, through its Young Leaders Programme, has been supporting environmental education initiatives. The Guardian Life Wildlife Fund has supported several conservation efforts including the NSI conservation of leatherback turtles and the Fondes Amandes Community Reforestation Project. The First Citizens Bank has recently formed the Citizens in Action to Restore the Environment (CARE). These activities have potential for increasing public awareness and understanding of the importance of natural assets to well-being and in encouraging and involving communities, groups, and individuals (with priority given to younger persons) in activities that might contribute to sustaining these assets and especially the amenity value of the Northern Range.

9.3 Assessment of the Above Responses

From the foregoing discussion of those official and civic responses the following conclusions are made:

1. It is evident that there are many responses in the form of policies and plans, especially the official ones presented above, that have implications for the services of the country's ecosystems generally, and for the Northern Range specifically. Altogether the range of policy instruments of general or specific application to the Northern Range reveals awareness of the issues and intention to address them. But there is little evidence of how this array of policies and plans is being translated into action and effectiveness.
2. While links between ecosystems and human well-being are embodied in many of the documents referred to above, these links are not made explicit; nor are targets for, and impacts on, human well-being enunciated. Moreover, where these links are pursued they are done on a very sectoral basis, and not cross-referenced to the policies or activities of another sector or ecosystem service.
3. Nor does it appear that there is widespread popular understanding of the links between the natural environment and human well-being.
4. Given the conclusions presented earlier on driving forces, condition, and patterns of use and misuse of Northern Range resources, it is apparent that these policy instruments are not effective in achieving their objectives.
5. This can be explained by a variety of reasons:
    a. There is a general lack of follow through on many policies; consequently implementation is patchy, and enforcement of the stipulations of the policies is not rigorous; thus the potential of the array of responses is not realized to any great extent.
    b. The highly sectoral organization of the public administration system, in which responsibilities that have implications for the Northern Range are distributed among many government departments and statutory authorities, inhibits systemic application of these official policies.
    c. There is no co-ordinating mechanism to ensure that all agencies are operating consistently with these policies, or to make use of synergies or manage the trade-offs among their objectives.

6. There is evidence that awareness among small groups and communities is beginning to take root. Many small community-based initiatives are underway and many special-interest groups are organized as nongovernment organizations. While their impacts are localized and limited, their special initiatives are considered useful in taking responsibility, showing leadership, and motivating and mobilizing people and resources to address particular issues. They have been at the forefront of advocacy and public education for environmental protection and resource conservation. However, they have not yet attained critical mass to make a significant difference, especially as the major driving forces or potential for responding are outside their influence or capability, and their activities are not undertaken within a planning framework for the Northern Range.
7. A practice of evaluating effectiveness of policies and implementation of plans, rules, and regulations, or of monitoring and evaluating outcomes and impacts of activities, is not established within the public sector.

9.4 Regional and International Context

At any one time there is a range of international and regional treaty law and agreements to which the country subscribes that have implications for natural resource management and sustainable development, which would by extension be relevant to the Northern Range, for example, the Convention on Biological Diversity (CBD), the Convention to Combat Desertfication (CCD), the Convention on International Trade in Endangered Species (CITES), the Convention on Wetlands (Ramsar), the Cartagena Convention, etc. These are sometimes reflected in the national legislative and policy framework, as in the case of the Environmental Management Act and the National Biodiversity Strategy and Action Plan. More often they are not so reflected, even where required by the treaty, and a poor track record of implementation implies that these agreements do not significantly affect the matters that are their subject.

10.0 Options for Further Responses

Responses that may be made are discussed in the following two categories, though there is no watertight separation between them:

(i) Framework responses, which relate to the overall system of policy and public administration, and to public involvement
(ii) Multi-purpose responses which can variously address the needs for the three components of the Northern Range assessed (forests, freshwater, coastal resources), and the cross-cutting themes of biodiversity, land use, and amenity value; as well as responses that relate to specific services such as agriculture or quarrying.

No responses specifically dealing with human well-being are presented: the contribution to human well-being made by the Northern Range will accrue and be sustained to the extent that appropriate responses are made to arrest declining trends and to sustain its services.

10.1 Framework Responses

10.1.1 Implementation of Policy; Enforcement of Regulations

Section 9 presented a range of policies and instruments that are directly or indirectly relevant to the Northern Range. The range of policy responses that exists is very encouraging. However, they are largely not implemented. **Implementation of what already exists, suitably revised in the light of this composite assessment, would be the most immediate response that might be considered.**

Within the public sector, there are many ministries and public agencies involved in decision-making and implementation of policies that impact the Northern Range. Responsibility is fractured across the public system and at the political level. No particular Ministry has the responsibility for enforcement of the legislation and implementation of policies relating to the Northern Range. **The situation might be helped if there is a champion of these issues at the political level.**

Policy implementation takes place mainly through projects which channel funds to stated objectives. The various policies depend upon development and funding of projects through which they could be applied. But such projects do not automatically follow the formulation of policies, as projects have to compete for funding within the Public Sector Investment Programme or funded by an external agency. This is a major limitation to implementation. **One option is for decision-makers to require that proposed policies be accompanied by proposed implementation plans. Another is for policies of specific relevance to the Northern Range to be accompanied by commitment of dedicated funds to implement projects as a means of ensuring implementation of the policies. This would be only one aspect of clearly defined implementation plans.**

But implementation also requires human capacity, as does enforcement, especially where organizations and individuals are not self-motivated to conform and comply. Is it realistic to require better performance in these areas without addressing the human resource base of the public service, especially as there appears to be a high turnover of trained personnel out of the public sector? This pattern implies that the public-sector work place needs to be made more marketable and attractive. While the size of the public service is relatively large, whether there are suitable competencies at the appropriate levels required for implementation and enforcement is a question to be addressed.

Similarly, there is a considerable body of legislation and regulation which is not well enforced. Non-compliance with existing policies and legislative provisions occurs within public agencies and by citizens. Options for increasing conformity in both domains need to be considered.

Enforcement of regulations by the public sector might be better achieved if there is a clear location of responsibility and accountability, and if the necessary resources are provided to enable effective enforcement.

The legal process for prosecuting offenders places considerable burden on individual law enforcement officers (who must personally appear in the court in the jurisdiction in which the matter is being heard which may not necessarily be the one in which the officer is assigned) rather than on the system as a whole. Reform of this process is a prerequisite for motivating enforcement officers to prosecute offenders. Intensive and systematic public education is a prerequisite for appropriate public behaviour and for effective deterrents.

Responsibility for implementation and enforcement need not be centralized in a single authority, however, if there is greater co-ordination between ministries and agencies. For example, in relation to meeting housing needs and approving locations, the Land Settlement Agency, the Land Administration Agency of the Ministry of Agriculture, the ministries of Housing and of Planning and Development are all involved. Each seems to exercise its decision-making independently within its own sphere with little recourse to the others. Clear assignment of responsibility for implementation is a prerequisite for accountability, especially in a culture not noted for accountability at all levels.

10.1.2 Integrated Planning: Co-ordination and Collaboration

While the State has subscribed to the rhetoric of sustainable development and becomes party to many international agreements that are predicated on this approach, adjustments within the public administration system that would facilitate this approach are not evident. A highly sectoral approach to policy analysis and formulation continues. Economy, environment, and social progress are still compartmentalized.

Recognizing that Northern Range-related decision-making cuts across various sectors and ministries, one option is to consider planning and decision-making for the Northern Range as a single ecological and socioeconomic system, given the significance it has for the country as a whole. This could then lead to location of political and technical leadership, and to setting up the public administrative mechanism that would be required for oversight, coherence, and co-ordination. **One approach to this is the concept of a sustainable development council (as established in and for Tobago) applied to the Northern Range, which would be charged to oversee the Northern Range Hillside Development Policy currently under revision.** Such an approach need not be a permanent feature of the public administration system: it may, however, be an effective way to take the issues in hand until there is coherence in policy and more effective implementation and co-ordination become systemic, and until some of the negative impacts on the services of the Northern Range are arrested and reversed. A 'sunset clause' for such a council could be adopted.

Alternatively, a Sustainable Development Council for the country as a whole could be set up, which could give particular attention to the Northern Range. This has long been an expressed intention of successive governments, but has not been implemented. It would be a mechanism for bringing together all sectors to engage in policy discussion for the approach to development that the society wishes to have. If it is established under the aegis of the President of the Republic it would be free of the 'ruling party dominance' which is institutionalized in our governance system, and which inhibits participation.

Zoning of the eastern section of the Northern Range for conservation purposes might be considered while there is still time to avoid the pattern of land conversion and use that characterizes the western section. For the western section, **contour and slope limits to construction of housing could be revised in light of downstream experience to date. Whatever the stipulations, these need to be strictly enforced.**

Several designations of Environmentally Sensitive Areas[60] and Species[61] have been recommended by the Environmental Management Authority, some of which are located within the Northern Range. These designations are underpinned by scientific and technical analysis, community consultations, and opportunity for public comment. **Urgent attention to these proposals by Cabinet and Parliament, with the required management authority and arrangements being clearly established and resourced, would contribute to sustaining these areas and stabilizing these species populations. These provide a nucleus around which more comprehensive planning for the Northern Range might be undertaken.**

Formulation of local area physical development plans (required by the Town and Country Planning Act 1968) compatible with the overall plan for the Northern Range, in which

[60] There are four areas (Chaguanas, Madamas, Matura and Maracas National Parks), all within the Northern Range, which were proposed as National Parks by the System of National Parks and Other Protected Areas in Trinidad and Tobago (Thelen and Faizool, 1980). In November 2004, Matura National Park, the largest of the four covering an area of 9,000 hectares, was officially declared the first Environmentlly Sensitive Area of Trinidad and Tobago.

[61] Three species have been recommended for designation under the Environmentally Sensitive Species Rules - the pawi (*Pipile pipile*), the manatee (*Trichetus manatus*) and the White-tailed Sabrewing Hummingbird (*Campylopterus ensipennis*): the Pawi being found in the eastern Nothern Range.

process communities and local government authorities are central to the conceptualization and implementation, would yield many positive benefits for sustaining the Northern Range as an ecosystem while exploring the potential for creating and improving livelihoods within the communities.

Co-ordination among public-sector entities with responsibility and decision-making authority relating to housing, infrastructure, tourism, water, forests, mining, and community development is low to non-existent. And there are many sectoral plans that have implications for the Northern Range, for example, intentions of WASA in relation to watershed protection and rehabilitation; of TIDCO in relation to development and marketing of amenity potential; private-sector proposals for tourist and housing facilities; proposals of civic organizations for conservation and development projects; plans of the Ministry of Works and the Ministry of Public Utilities and the Environment; proposals of the Environmental Management Authority; plans of the Forestry Division, etc. **These all have to be compatible within an approach that seeks to identify and manage the trade-offs among the environmental, economic, and social aspects of development** as it pertains to the Northern Range.

There are several options for achieving better co-ordination among public entities. Recent collaboration between WASA and the Trinidad and Tobago Electricity Commission to share information that would facilitate getting plans relating to divestment of Caroni Lands off the ground is an example for other public entities. The process for obtaining Certificates of Environmental Clearance which requires the relevant agencies to come together at an early stage to discuss an application also contributes to better co-ordination. The Environmental Management Act which mandates collaboration among relevant agencies in respect of designation of Environmentally Sensitive Areas and Species is an example for building-in collaboration in other legislative instruments.

But need for co-ordination is not limited to public entities. One model for better co-ordination of what takes place in any local area of the Northern Range is that initiated by the residents of Toco, who took the initiative to develop their own local area plan and arranged consultation within the community and with the responsible authorities. Similarly, the Matura-to-Matelot Network (M2M) has held a conference and invited all relevant public and funding agencies and put forward ideas for development of communities in the area. These models could be piloted in other communities and, if successful, could be replicated across the Northern Range.

But even if successful as independent initiatives within specific communities, this does not make co-ordination systematic, which is what is required. An alternative to a sustainable development council for the Northern Range might be to set up a Cabinet-appointed Northern Range co-ordination mechanism under the Ministry of Planning and Development. The current exercise organized by the Ministry of Planning and Development to review and revise the Northern Range Hillside Development Policy might be the embryo of this mechanism. Senior representatives from the following Ministries/ Departments/ Sectors could be selected: planning and development, housing, infrastructure, utilities, tourism, water resources, forestry, mining, community development, agriculture, banking, education, UWI, private-sector firms, service organizations, local government authorities, CBOs, NGOs. The primary role of such a mechanism would be to co-ordinate State, community, and private-sector activities in the Northern Range, including policy implementation. A dedicated secretariat for this body, with funding provided, might be considered. Alternatively, secretariat functions could be contracted out to a competent NGO or community-based organization. Members of such a co-ordinating mechanism would be selected for their expertise, influence within their respective sectors, and commitment. It would be one element of a governance structure more conducive to responding to the needs.

Increased collaboration among all sectors—academic, public, civic, community—would also contribute to better co-ordination of initiatives. (The model of bringing together these various interests in the context of this assessment of the Northern Range which seeks to draw in varied inputs and to draw together various interests, might be considered for application to other issues or areas.) Respective entities are enriched in such collective engagement, communities develop experience in representing their views and interests, and self-education and self-empowerment take place. More collective initiatives (examples of which are M2M, SAD for Toco, the Northern Range Assessment, the Sustainable Development Network, and the Tobago Council for Sustainable Development) could accelerate national progress in harmonizing interests and activities relating to the Northern Range.

10.1.3 Governance Arrangements

It is well known that our governance system is highly centralized. At present there is no provision for genuine national policy debates on significant issues as distinct from the legislative agenda of the party in power. **An expanded National Senate along the lines outlined by a civic organization, the Constitution Reform Forum, would draw on the expertise, vision, and commitment of the wider society through its societal organizations.** Group election, selection, and power to recall representatives will deepen the participation process since all groups with converging and diverging interests would have to conduct internal debates to select their representatives. The expanded range of interests that would be permanently represented in such a National Senate would enable meaningful debates, covering various perspectives (policy analysis) and consensus building (policy formulation) on areas that interest and affect the citizen body, such as education, health, management of natural resources and assets, sustainable living, achievement of peace, justice, and equity in the society, etc.

Local government authority for natural resource management and environmental protection, or for provision of services that would contribute to well-being of local communities, is ill-defined or non-existent. Opportunity for public involvement in the policy process, either at the national or local level, is very limited and infrequent. **One immediate response option is to organize for policy, implementation and enforcement, and management to be devolved to the various Regional Authorities into which the Northern Range falls. This would allow for local area development plans to emerge,** and would make possible the framework for local community involvement in joint management, as discussed earlier. Positive efforts to strengthen rudimentary community governance arrangements (such as Village Councils, liberated from their historical partisan political association) would also make it possible for communities to fulfil the kind of role described.

Local participation in policy analysis and formulation could be achieved through local mini-senates, comprising representatives of civil society groups: Village Councils, sports, youth, women's and religious organizations. Mechanisms for such wider participation are necessary to compensate for the perception that Village Councils—the most widespread model of community organization in the country—are politicized groupings affiliated to particular political parties.

Devolution of authority and decentralization of services to local authorities could have many positive consequences: ability to implement, enforce, monitor, and evaluate policy decisions—whether centrally or locally formulated; enforcement through local authorities would stand a better chance of success by virtue of being closer to the ground; rationalized and harmonized delivery of municipal services. But local authorities would require adequate staff with appropriate expertise and experience, in keeping with expanded authority and responsibility, as accountability would require resources necessary for carrying out the functions.

With arrangements for local decision-making and delivery of services in place, and with adequate personnel and budgets to oversee and manage the development process in local areas, a framework for active public participation in that process would thereby exist. This would make it possible to plan and manage development for and with communities, identifying with them and providing the range of supportive measures required.

10.1.4 Joint Management of Resources

Planning, implementation, and enforcement need not be exclusively the role of the State. A combination of both command-and-control (State enforcement and co-ordination) and community involvement in management may be a solution. The former may be required, however, as an immediate response to the Northern Range issues for the short term, while allowing time for the required education and training activities to be mounted within communities and to attain critical mass so that communities might be effectively involved in the long term.

One option to compensate for lack of public-sector capacity for implementation, enforcement, and planning would be to devolve management for natural resources and assets to communities, within the framework of local government authorities, and in the context of clearly articulated national policy. While the merits of such devolution of management are well considered in the global literature, it needs to be remembered that there is not such a culture or history of involvement in Trinidad and Tobago. Devolution of management by itself is not likely to be a solution for better stewardship of natural resources and assets, or for better reflection of policy in decisions and actions. **This option is predicated on compatible and facilitative local government arrangements, on effective education and training, and on easy and continuing access to technical support, to equip local government authorities and communities for this role.**

It is unlikely that communities and community-based organizations would engage in implementation, management, or monitoring for compliance if there are no financial or economic returns to them, or if their community needs and interests are not thereby advanced. Seed funding could be provided from government and corporate sources while incentive schemes are designed and economic returns realized. This approach would require efficient use of public financing. It could also foster public/private partnerships, with communities participating as third parties.

Community motivation and engagement would be more likely to occur if communities were involved in a consultative process about policies that would affect them or their space. Such involvement has not traditionally been a feature of our public process, nor is it at present. Moreover, information is not generally available in a reliable manner, and communities and their organizations have limited mechanisms (letters to editors, demonstrations to call attention to situations, passive resistance to public requirements) for voicing concerns or alternative approaches.

Managing natural resources and assets could be organized with various combinations of inputs and roles among public, corporate, civic, and community sectors. **There need not be total devolution of management responsibility at once or in all situations; and government's role in implementation could be designed to decrease in tandem with the increase in competencies of the local authorities and civic/community sector.** The process of thinking through such joint implementation would itself reveal the need and mechanisms for self-empowerment by communities and their organizations (The model of engagement between the Wildlife Unit of the Division of Forestry and the residents of Matura and Grande Riviere communities that has led to

the formation and continuing operation of Nature Seekers Inc. and Grand Riviere Education and Conservation Trust illustrates this).

While co-management of natural resources and assets is a potentially effective approach to increase conformity with policy and enforcement of regulations, it is equally important as a way of contributing to the overall development of the society: by increasing citizen responsibility and self-reliance in communities, by transforming complacent citizens into conscious and caring stewards of the country's natural assets, by creating opportunity for release of creative energies, by engendering entrepreneurship, and by creating options for sustainable living. This approach of co-management is still in its infancy in Trinidad and Tobago, though there is a considerable body of experience from elsewhere to draw upon if we wished to exercise this option. A few pilot undertakings within the Northern Range may be desirable in the first instance, with a research overlay that could accelerate the process of making this approach more widespread for the Northern Range and eventually systemic to planning and managing development in the country.

One practical advantage of early involvement of the public in policy planning is that various interests and competencies would emerge more clearly, and could then be reflected in the options to be considered. The balancing of economic, social, and environmental factors also becomes more possible in such a participatory framework, with explicit identification of conflicting interests, trade-offs required, and distribution of costs and benefits among groups in the short and long term.

Similarly, mechanisms that allow for inclusion of representatives of parliamentary opposition groups would more likely contribute to the overall public interest by assuring continuity of policies and approaches over time. It is very likely that for the society as a whole, sustaining the natural resource base as well as the well-being of the society and of communities transcend short-term political-party considerations.

Early involvement of the private sector is also likely to affect conformity with official policy positively. Its decisions and actions are of central importance in an overall societal approach to sustain ecosystem services and to assure continuous progress in human well-being. (It appears that involvement of the private sector from the outset in the Vision 2020 process is highly motivating for its representatives to contribute to the long-term development goals of this planning exercise.)

10.1.5 Public Responsibility and Public Education

Processes for open discussion of these observations, better public understanding of the rationale for policies and regulations, and transparency in public decision-making could positively affect attitude and behaviour of the public.

It would appear that public understanding of how natural resources are related to the long-term development of the country and to the well-being of the society is quite superficial. Surveys of public opinion on environmental problems repeatedly reveal that the public considers that litter is the main problem. The need for deeper public understanding of both environmental and resource issues, and specifically of the many benefits we enjoy from the services of the Northern Range which we take for granted, as well as the long-term consequences of our actions and activities on the supply of those benefits, is indicated. So is better public awareness of the impact of informal decisions taken by individuals, firms, and communities on the Northern Range. Without these measures, decisions based solely on economic need, coupled with environmental/resource ignorance, are likely to continue to degrade Northern Range resources and

jeopardize well-being of both society and communities, regardless of formally adopted policy decisions made in support of sustainability.

But public responsibility has to be predicated on awareness of the issues and understanding of how they matter to human well-being. This in turn requires intensive and systematic public education.

While there are pockets of public education effort largely initiated by civic organizations, they are sporadic and discontinuous, and have not attained critical mass. Must public education on these issues so important for sustainable living depend exclusively on the financial resources of civic society organizations? Financial support for their activities from public sources would strengthen and sustain them. This would capitalize on their initiative, energy, and expertise and would complement the rudimentary efforts possible within the formal education process, given an overloaded formal education curriculum.

Such civic-led educational activity could augment the space for public dialogue on issues of importance within the society. The process might facilitate sub-sectors or local authorities to take the initiative and the responsibility for drafting citizens' agendas that cover both the constraints and action plans for that sub-sector or physical area. This can then serve as the basis for active and widespread debate, including via the Internet. This implicitly accepts the legitimacy of citizens' perception of how to bring about change and can shift reliance for propelling such change from government to the society.

Public education could be accelerated through a national sustainable development education strategy and action plan, designed to incorporate existing initiatives and actors, and supported as necessary by materials and technical assistance.

Better public understanding combined with a sense of involvement and opportunities for constructive participation might also lead the public to demand more accountability for enforcement from individuals, firms, communities, politicians, and public entities. **More cultivation of, and reliance on, public will, as opposed to political will, might work in favour of enforcement.** (An example of such public will is the recent case of the Caura Valley community taking issue with dumping of garbage in the Caura Valley and organizing itself to regulate this practice.) Public involvement could also be effective in "guarding the guards," as incidents of law enforcement officers contravening the rules (e.g., buying wild meat in the prohibited season or buying illegally harvested timber) are apparently known to occur.

The Environmental Management Act, 2000 (Section 69) provides for private party action that allows the public an option of bringing an action to the Environmental Commission, the judicial body set up under the Act. **This is an instrument that could be put to use by an informed and committed citizen body to achieve better enforcement.**

10.1.6 Financing Management of Natural Resources

More attention to the use to which funds are put, rather than to availability of funds, may be useful. Where the question of availability of funds persists, the policies and responses that are being considered need to be designed to be more financially autonomous. (For example, the approach of the EMA, made possible under the Environmental Management Act of 2000, in proposing a regime of fees for obtaining Certificates of Environmental Clearance and in the draft Water Pollution Rules is a device for financing the requirements of processing, monitoring,

evaluation, and enforcement of these regulations.) The government's Consolidated Fund need not be the only or ultimate source of financing for implementation and enforcement of specific Northern Range policy. Arrangements need to be built in to decrease dependency on government's central funds and therefore on the vagaries of political will for policy implementation and enforcement. **In this regard, the transparent activation of the Green Fund is long overdue.** It has been established specifically for such purposes, and investment of the accrued funds, through a Trust Fund, would yield a stream of income that could be used for recurrent expenditures related to, among other similar needs, management of the Northern Range. User fees, and fines for non-compliance with site regulations would be a source of financing for specific amenity sites and for developing desirable habits in relation to the use of sites.

10.1.7 Research and Documentation

Data and information of the type, range and continuity required for an assessment of this kind and for effective management of the Northern Range are currently inadequate. The data limitations for this assessment were discussed earlier in Section 3. Some data that are available may even be of dubious value if the documentation of methodology is not available for scrutiny, making rigorous time-series analysis and comparison impossible.

Research organizations might consider a series of possible responses:

- Working to increase the independence of research organizations
- Focussing research resources on public-interest issues instead of personal research interests
- Developing a research ethic that embodies sustainable development principles
- Designing research that is interdisciplinary and multi-sectoral
- Collaborating in research with other entities, including communities (e.g., SAD for Toco enlists the members of the Toco community to collect data on the water quality of the Toco reef), as part of a public educational process.

The University of the West Indies at St. Augustine could take a leadership role in reflecting the above characteristics in its research approach and agenda, especially as it is one of the sponsors and leaders of this assessment in which a number of its personnel are involved.

Research by publicly funded organizations might also help to define development standards and establish good practice. Public interest-oriented research needs to be balanced with 'publishable' research that satisfies the expectations and criteria of the University as an academic entity. The University might also explore standards for collaborating with communities in research exercises as a way of guiding this collaboration. It would greatly help future assessment activities of this kind if research results relating to the Northern Range held by various government departments from consultancies, along with those from the University and other research organizations, could be available in a central location in hard copy and also via the Internet. Information about the country, especially that garnered at public expense and by agencies which supposedly serve the public, should be public information.

The proposed UWI St. Augustine Centre for Biological Diversity is expected to consolidate information on the theme of biodiversity. Public access to this facility and governance that embraces interests external to the University would provide useful outreach and necessary public education on the important if largely invisible role of biological diversity.

Public access to data and information even where they exist is very difficult to obtain. Much information is not recorded in a form that is readily accessible, requiring a laborious process to

obtain. In some instances it is regarded as personal property of its custodians. A culture of public disclosure, which would require systematic documentation of decisions, and of monitoring and evaluating results does not exist.

One option is to make mandatory a commitment to such documentation, disclosure, and access in project documents, with monitoring and evaluation reports deposited in a central public registry, available to the public with discretion relating to sensitive documents. "Jargon free" technical reports and audio-visual documentation would facilitate public understanding.

If processes for public involvement are to be effective, transparency and freedom of information will be required.

10.1.8 Monitoring and Evaluation

Monitoring and evaluation of the impact of policies are not entrenched in our public administration system. Better practice here might be attained in the wake of clearer location of responsibility and accountability for implementing policies. If decision-makers knew that their decisions would be monitored and consequences evaluated they would likely be more circumspect in their decision-making. Civic organizations have a pivotal role in creating the public consciousness and confidence that would demand this standard of practice.

A systematic approach to monitoring and evaluation of impacts of national policies and programmes on the Northern Range is required which would provide necessary feedback into successive rounds of assessment, research, and policy formulation.

10.2 Multi-purpose and Specific Responses

A summary of response options for multi-purpose or specific issues, many of which have been mentioned earlier in this report, is presented below. They relate to cross-cutting themes as well as specific Northern Range ecosystem services. It will be readily seen that the measures identified would be symbiotic and can be expected to be most effective if undertaken in the context of the Framework response options discussed above.

10.2.1 Biodiversity

- Accelerate the designation of the recommended Environmentally Sensitive Areas and Species.
- Zone the eastern section principally for conservation including designation as a biosphere reserve; apply and enforce more rigorous standards for housing and agriculture where allowed than have been used for the western section.
- Institute a moratorium on all hunting; when lifted, strictly enforce applicable regulations; increase penalties for violation; increase revenue from sale of licences and invest into enforcement capacity.
- Promote cultivation of selected species that are or could be commercially used, including floriculture; establish sustainable use basis for wild specimens.
- Provide the necessary resources to manage and protect Environmentally Sensitive Areas.

10.2.2 Amenity Value

- Give more focus to internal tourism with clear policy and incentives, and appropriate facilities at heavily used sites.

- Plan and regulate use of amenity sites on the basis of carrying-capacity analysis.
- Use the special character of the Northern Range as an ecotone between Continental and Antillean systems to 'brand' the tourism product of Trinidad and Tobago.
- Establish/increase user fees and apply to maintenance of recreational areas; manage separately from the Consolidated Fund.
- Upgrade the Toco Main Road to provide an incentive for developing the Matura-to-Matelot area in response to the growing demand for development, and as an alternative to constructing another north coast road given the vulnerabilities to the Northern Range that could easily ensue from such construction; retain hiking and small ferry services for hard-to-reach sites as another feature of the tourism product and for creating the basis for livelihoods.
- Develop Nelson Island as a major historical site for Trinidad.

10.2.3 Land Use

- Develop and implement plans for the Northern Range in the context of zoning the eastern section, and within the local government framework.
- Revise contour and slope regulations for housing construction in the western section and strictly enforce (including on private lands); increase penalties to be more effective as a deterrent.
- Formulate regulations, where appropriate, that are specific to certain watersheds.
- Base land use on land capability.
- Reserve high-quality pockets of soil for high-priced niche commodities.
- Encourage bequests of Northern Range private holdings to the national estate (as has been done for Peake, Asa Wright and Grafton holdings) with caveats to conserve in perpetuity.
- Revise the land capability classification system.

10.2.4 Forest Resources

- Revise, approve, and implement the Draft Forest Policy (1998).
- Establish a moratorium on commercial forestry on State lands and on private lands until forest cover on exposed and vulnerable locations is recovered; thereafter manage through a policy of allowable cuts.
- Support private landowners who are replanting on their properties by providing incentives such as waiving land taxes.
- Involve communities, including unauthorized settlements, in reforestation activities and establish incentives for their continued care and protection of the trees.

10.2.5 Freshwater Resources

- Approve and implement the Draft Water Resources Policy (2002).
- Arrange mechanism for co-ordination of plans among public entities, for identifying and managing trade-offs.
- Clarify policy about management of watersheds and arrange for more rigorous management; emphasize protection and restoration of watersheds rather than reliance on the high cost option of desalination; better monitoring of water intake into the water-treatment operation.
- Implement the comprehensive World Health Organisation standards for water quality monitoring.
- Approve the draft Water Pollution Rules to institute standards, monitoring and penalties for pollution.

- Involve the approximately sixty communities to be regularized under the State Regularisation Act, 1998 in the management of the watersheds in which they are located.
- Refurbish the water distribution infrastructure to reduce the heavy loss of treated water.
- Provide facilities for heavily used amenity sites.
- Increase public education for water conservation.

10.2.6 Coastal Resources

- Accelerate negotiations for assessing and managing the fisheries stock.
- Develop appropriate coastal infrastructure: better facilities at beaches along with the implementation of user fees to maintain these facilities, including lifeguards.
- Discourage use of the coastal strip for commercial purposes that are not coastal/marine related.
- Revise the policy of no-net-loss for mangroves to one of no-further-loss.
- Encourage communities to cultivate heavily used species (e.g., sea moss) to avoid over-exploitation (and possible irreversible loss) of wild specimens.
- Develop a management plan for the yachting services and facilities at Chaguaramas.
- Assess the specific needs of seaside amenity sites and make appropriate responses.

10.2.7 Agriculture

- Re-orient small farmers to growing high-priced niche-market crops; subsidize these where possible; offer competent advice through well-managed agricultural extension services.
- Confine agriculture mainly to the remaining flat areas with medium-sized farms where possible; where allowed on sloping land apply strict soil-conservation requirements.
- Re-orient existing cultivation of herbaceous crops on steep slopes to be more restorative and preventative, through appropriate agro-forestry; require use of modern techniques; offer incentives for appropriate agriculture and forestry; encourage terracing.
- Develop a policy to make farming a better livelihood basis, taking into account size of farm, type of crop, and desirable technology and techniques.
- Discourage further cultivation on hillsides of valleys; use flat lands where available.
- Upgrade all established agricultural trails and traces.
- Consider cocoa and coffee as the preferred agricultural tree crops given suitability and long history of cultivation.
- Enforce the Agricultural Fires Act.
- Penalize slash-and-burn practice.

10.2.8 Quarrying

- Accelerate the revision (in process) of the Quarrying Policy and increase the threshold for good practice in this sector.
- Give priority to rehabilitation and restoration where possible of abandoned quarry sites to arrest erosion and water runoff; create sites of amenity value for use by communities; create community employment and basis for livelihoods in process.
- Disallow further quarrying within the Northern Range and, if necessary, import the aggregate required.
- Bring into the regulatory framework quarries that pre-existed the Environmental Management Act.

ANNEX 1: Northern Range Geology and Soils

The Northern Range of Trinidad is an extension of the Coastal Mountains of Venezuela—an eastern branch of the Andean Mountain Range which runs through Colombia and Venezuela. There are three main groups of geological materials found in the Northern Range (Brown and Bally 1966; see Fig. 2):

1. Metamorphic rocks
2. Igneous rocks
3. Colluvial and alluvial deposits

Metamorphic Rocks

Metamorphic rocks constitute the most important rocks of the Northern Range, and four distinctive groups occur (micaceous schists and phyllites, carbonaceous schists and phyllites, calcareous schists and limestones, and schists with quartzitic grits).

- The micaceous schists and the phyllites are the most abundant; they are platy or laminated, strongly folded in parts, and soapy to the feel. They are dark grey to black when fresh, depending on the amount of carbonaceous material which is incorporated; they weather to yellow or red colouration with a silvery luster. There is a series of rocks ranging from schists to phyllites depending on the degree of metamorphic activity.
- Limestones are found in many locations in the Range such as Laventille, Diego Martin, Lopinot, Maraval, along the Blanchisseuse Road, and on the offshore islands of Gaspar Grande, Kronstadt, Carrera and the Five Islands. The massive limestone has a crystalline appearance, is dull grey in colour, and fractures in a pseudoconchoidal manner. The limestone grades into calcareous schists and phyllites. The calcareous rocks of the Range are extensively quarried and used in construction generally.
- In some places such as in the Toco district, thick beds of quartzitic grits are intercalated among the schists. These are generally very hard, coarsely crystalline rocks forming conspicuous headlands such as at Galera Point; finer grained beds approaching quartzites occur in the central and western parts of the Range as at Blanchisseuse and Maracas.
- In addition to the stratified rocks, injected quartz veins occur in many parts of the Range as white veins cutting across the stratification of the host rocks; they vary in thickness from a few millimetres to many centimetres. These veins are important as a source of quartz boulders and other aggregates which make up the colluvial terraces and river gravels of the Northern Range rivers. These materials are extensively used in construction.

Igneous Rocks

There is only one small outcrop of igneous rocks which occurs at Sans Souci in the Toco area and it is related to the older volcanic rocks of the Windward islands, being basaltic and andesitic in nature. The rocks are massive and fine-grained and green to dark grey in colour; they are deeply weathered and give rise to only one soil, the Sans Souci series.

Colluvial and Alluvial Deposits

Colluvial and recent alluvial deposits are found in the valleys and flood plains of most of the rivers flowing through the Range and constitute the parent materials for particular soils.

Table 20: Pedological Classification of the Soils of the Northern Range[62]

Soils on non-calcareous schists and phyllites	
81	Maracas—Orthoxic Tropudults, clayey, oxidic (extensive)
181	Matelot—Orthoxic Tropudults, fine loamy, micaceous (extensive)
281	Spring Hill—Orthoxic Tropohumults, clayey, kaolinitic (moderately extensive)
Soils on calcareous rocks	
82/L	Diego Martin—Eutropeptic Rendolls, coarse loamy, carbonatic (inextensive)
182/L	La Pastora—Oxic Tropudalfs, fine, kaolinitic (inextensive)
282/L	Maraval—Oxic Tropudalfs, fine, kaolinitic (inextensive)
382/L	Platanal—Typic Eutropepts, fine, kaolinitic (moderately extensive)
Soils on igneous rocks	
91	Sans Souci—Typic Tropudalfs, fine, mixed (inextensive)
Terrace soils with free drainage	
41	Blanchisseuse—Typic Tropudalfs, fine, mixed (inextensive)
141	Galera Sand—Typic Dystropepts, loamy-skeletal, mixed (inextensive)
43	Acono—Orthoxic Tropudults, clayey, kaolinitic (inextensive)
143	St. Augustine—Orthoxic Tropudults, clayey, kaolinitic (inextensive)
243	Santa Cruz—Typic Eutropepts, loamy-skeletal, mixed (inextensive)
Terrace soils with restricted internal drainage	
53	Anglais—Orthoxic Tropudults, clayey, kaolinitic (moderately extensive)
153	Cleaver—Orthoxic Tropudults, clayey, kaolinitic (inextensive)
253	Streatham—Plinthic Tropudults, clayey, kaolinitic (inextensive)
55	Piarco—Aquoxic Tropudults, clayey, kaolinitic (moderately extensive)
255	Valencia—Typic Troporthods, coarse-loamy, siliceous, ortstein (moderately extensive)
59	Long Stretch—Plinthic Tropaquults, clayey, kaolinitic (moderately extensive)
Deep alluvial soils	
123	Guanapo—Typic Eutropepts, fine-loamy over sandy or sandy skeletal, micaceous (moderately extensive)
223	River Estate—Fluventic Eutropepts, fine-loamy, micaceous (moderately extensive)
323	St. Joseph—Typic Tropofluvents, coarse-loamy, micaceous, nonacid (inextensive)
423	Tacarigua—Fluventic Eutropepts, coarse-loamy, micaceous (inextensive)
24/L	Grande Riviere—Typic Tropofluvents, fine-loamy, micaceous, acid (inextensive)

Source: Smith (1983)

[62]The numbers are those assigned by Brown and Bally (1966) to indentify the various soils.

Table 21: Main Features of the Soils of the Northern Range (compiled from Ahmad et al. 1967)

Soil series	Altitude and topography	Drainage through the soil	Natural fertility	Factors limiting root penetration	Erosion under arable crops	Suggested land use	Special soil management problems
Maracas	Moderate to very steep (30–1,000m)	Free	Moderate to low	Parent material in shallow phase	Moderately to very severe	Tree crops, food crops, forest	Erodibility, occasional stoniness
Matelot	Moderate to very steep (30–1,000m)	Free	Moderate to low	Parent material in shallow phase	Moderately to very severe	Tree crops, food crops, forest	Erodibility, occasional stoniness
Spring Hill	Moderate to very steep (30–600m)	Free	Moderate to low	None	Severe	Tree crops and forest	Erodibility, occasional stoniness
Diego Martin	Moderate to very steep (30–600m)	Free	Moderate	None	Moderately to very severe	Vegetable and food crops	Erodibility, stoniness
La Pastora	Moderate to very steep (30–600m)	Free	Moderate to low	None	Severe	Cocoa, citrus, forest	Erodibility, occasional stoniness
Maraval	Moderate to very steep (30–600m)	Free	Moderate to low	Stoniness in shallow phase	Moderately to very severe	Vegetable, food crops, forest, scrub	Erodibility, occasional stoniness
Platanal	Moderate to steep (160–660m)	Free	Moderate to high	None	Moderately to very severe	All crops, forests	Erodibility, occasional stoniness
Toco	Hilly to very steep (30–600m)	Moderate	Moderate to high	Partly weathered rocks in subsoil	Moderately to very severe	All crops, forests	Erodibility, occasional stoniness
Sans Souci	Hilly to very steep (30–600m)	Moderate	Moderate to high	Partly weathered rocks in subsoil	Moderately to very severe	All crops, forests	Erodibility, occasional stoniness
Blanchisseuse	Moderate (<600m)	Free	Moderate to low	Parent material at 75cm	Moderate	Tree crops, forests	Erodibility
Galera	Gentle (<160m)	Free	Moderate to low	None	Slight	Coconut	Droughtiness, stoniness
Acono	Gentle to moderate	Free	Low	Gravelly and bouldery subsoil	Slight to moderate	Tree crops, shifting cultivation	Droughtiness, stoniness

Table 21: Main Features of the Soils of the Northern Range (compiled from Ahmad et al. 1967) *continued*

Soil series	Altitude and topography	Drainage through the soil	Natural fertility	Factors limiting root penetration	Erosion under arable crops	Suggested land use	Special soil management problems
St. Augustine	Gentle to moderate (<30m)	Free	Low	Gravelly and bouldery subsoil	Slight	Tree crops, shifting cultivation	Droughtiness, stoniness
Santa Cruz	Gentle to moderate (<160m)	Free	Moderate to low	Gravelly and bouldery subsoil	Moderate	Tree crops	Some droughtiness, stoniness
Anglais	Moderate to steep	Moderate	Moderate to low	None	Slight to moderate	Tree crops, forests	Erodibility
Cleaver	Gentle to moderate (<80m)	Slow	Very low	Gravelly and bouldery subsoil	Slight	Scrub forests	Droughtiness, drainage
Streatham	Gentle	Slow	Low	Compact subsoil	Slight	Food and vegetable crops	Droughtiness, drainage
Piarco	Flat to gently undulating	Slow in subsoil	Very low	Dense argillic horizon	Slight	Scrub forests	Droughtiness, drainage
Valencia	Flat to gently undulating	Free in top soil; slow in subsoil	Very low	Cemented pan	Slight	Scrub forests	Droughtiness, drainage
Long Stretch	Flat to gently undulating	Free in top soil; slow in subsoil	Very low	Pan	Slight	Scrub forests	Droughtiness, drainage
Guanapo	Flat (<30m) trenches at higher elevations	Free	Low	Gravel in subsoil	None	Vegetables, some tree crops	Droughtiness, stoniness
River Estate	Flat to gentle slopes (<30m)	Free	Moderate	None	Slight	Most crops	Droughtiness
St. Joseph	Gentle (<30m)	Free	Moderate to low	Gravel in subsoil	Slight	Vegetable and food crops; some tree crops	Droughtiness, stoniness
Grande Riviere	Flat (<30m)	Free	Moderate	None	None	Some tree crops, vegetables, and abandoned land	Occasional flooding, droughtiness

ANNEX 2: Sources of Information on Northern Range Biodiversity and Forests

Sources of Information on Northern Range Biodiversity

Faunal Diversity

While data on the number of faunal species in Trinidad and Tobago as a whole can be found in several scientific studies and published documents (Kenny 2000; Kenny et al. 1997; EMA 1997; Huber and Meganck 1987; Barcant 1970; Murphy 1997; Alkins 1979; Alkins-Koo and Soomai 1993; Wood and Gillman 1998), it is very difficult (in some cases impossible) to extract Northern Range specific data in a quantitative form. Some documents do provide quantitative information on Northern Range biodiversity (e.g., Temple 1996; Murphy 1997; Lall and Hayes 2000), and information can be inferred from both scientific reports, such as those listed above, and from other unpublished documents (e.g., AWNC 1999; Bharose, The Trinidad Guardian, 04/06/95, p. 14; Leotaud, Express, 20/11/97, p. 24), but generally the body of data relating to Northern Range faunal diversity is relatively poor both in quality and historical continuity. Much of the information that exists is of a qualitative nature, based more often on expert opinion and 'best guesses' rather than on scientific research and figures.[63] No indicator species for identification of biological thresholds for wildlife in the Northern Range have been established.[64] Moreover, in the case of fauna, data and information most often pertain to larger, more conspicuous species, and neglect smaller ones (such as the soil dwellers), which are often fundamental to the operating of the ecosystem. One can appreciate the bias in data collection, however, given the difficulties involved in recording and documenting the more inconspicuous species.

At present, there is no single, up-to-date, comprehensive document on the Northern Range biodiversity (Nathai-Gyan, pers. commun., 2004). The most in-depth and comprehensive information on Northern Range fauna is available in the Eastern Northern Range Plan—a project undertaken by the Forestry Division in 1991 (Nathai-Gyan, pers. commun., 2004).[65] No similar studies have ever been conducted for the Western Northern Range, nor has there been a more up-to-date study for the Eastern Northern Range (Nathai-Gyan, pers. commun., 2004). It means therefore that most of the information is available for the section of the Northern Range which is least impacted by humans—the Eastern Northern Range, and this very much limits the assessment of the links between driving forces, biodiversity resources, and human well-being (that go beyond causality), which are known to be much more pronounced in the westernmost sections of the range. At the same time, however, the eastern sections of the Northern Range are less disturbed, and therefore this information would be important in assessing the nature of responses that might sustain the fauna. Very little information is available for the islands off the north-west coast of Trinidad.

[63]It is noted that 'Although far from comprehensive and with many gaps and voids, the knowledge base of the biological diversity of Trinidad and Tobago is relatively extensive. Much of this knowledge is of the terrestrial and near-shore environment and relates particularly to species. Several terrestrial, freshwater and marine habitats and ecosystems have been characterized qualitatively at various levels of detail. Genetics of local species is poorly documented and mostly limited to plant material, particularly of crop and horticultural significance.' There is no comprehensive listing of how many floral and faunal species there are in Trinidad and Tobago (EMA 2001a) but it is noted that the flora is far better documented than the fauna, largely because the flora has been systematically evaluated and documented over a period of seventy-five years (EMA 1997). The main gaps in published information lie with the lower plants, ferns, and grasses and terrestrial invertebrates, especially insects and arachnids (Kenny et al. 1997).

[64]It may be possible to use existing theoretical models to look for critical population and fragmentation thresholds for certain keystone species and communities. Thus, it may be possible to use an umbrella species such as the ocelot (*Felis pardalis*), the largest terrestrial carnivore in the country, to determine if current levels of forest cover can support a viable population of this cat. Such population viability analyses (PVAs), done for several species where data are available, could provide information on where key population thresholds may lie, and by extension an index for ecosystem services.

[65]This document examined the wildlife resources of the Eastern Northern Range, the value of these resources and their management in the long term using qualitative data collection and reporting techniques.

Floral Diversity

Most of the information on Northern Range floral diversity included in this report was obtained from the National Herbarium. The data contained from the plant collections housed at the National Herbarium relate to the population distribution of plant species for the islands of Trinidad and Tobago as a whole, and although data specific to the Northern Range are available, it would require substantial inputs of time to separate them from the mass of data. The available data relate mainly to the presence of species and the frequency with which these species have been recorded. The data do not indicate species densities over time.

A preliminary attempt was made to comb the collection records for species that occur or occurred in the Northern Range by consulting Accession Books (these record specimens that are incorporated into the collection at the National Herbarium). Starting with the Accession Book currently in use (which is the most recent of five books, the earliest of which dates back to the 1800s), the first 1,400 entries (or specimens) were examined and it was found that 300 of these were collected in the Northern Range. This is greater than 20% of the entries, indicating that the Northern Range is one of the more sampled regions of Trinidad. This is explained largely by the close proximity of the Northern Range to population centres in the East–West Corridor and The University of the West Indies (UWI) and before that to the Imperial College of Tropical Agriculture (ICTA) which allows easier access by plant collectors. The species in places such as the Arima–Blanchisseuse Road and the hills and valleys behind Port-of-Spain are particularly well collected due to relative ease of access.

Genetic Diversity

Information on genetic diversity for Trinidad and Tobago as a whole is scarce and exists only in terms of its commercial application in the agricultural sector (EMA 2001a), especially as it relates to cocoa. There are therefore no available data on genetic composition of important tree or wildlife species in the Northern Range with which to define specifically critical thresholds. It is therefore impossible to speak to the nature and value of genetic diversity of the Northern Range, and so this assessment does not include information on diversity at this level of organization.

Sources of Information on Northern Range Forest Ecosystems

The assessment of the forest ecosystems of the Northern Range drew upon several data and information sources; however, several gaps are noted:

Changes in Northern Range Forest Cover

Accounts of land cover in the Northern Range are dated as far back as the late 1400s when Europeans began colonizing Trinidad; since then several records have been catalogued in various forms (Chalmers 1981).

The first attempt to classify and document comprehensively the extent and composition of the forests of Trinidad and Tobago was made by Beard in 1946. Today, his figures are still being used to represent the extent of forest types in Trinidad. Other inventories since the time of Beard have either not been thoroughly compiled and assessed, or have been based on outdated material making them no more useful than Beard's 1946 information.

- Estimates for land cover and land use have been derived from aerial photography spanning the period 1969 to 1994. There has been in-depth analysis of the data from the

1960s, upon which basis the Forestry Division produced a map in 1980. This map, however, only includes information for State lands and does not include certain key areas of the Northern Range such as Chaguaramas. The data from 1994 have not been fully analysed (S. Baban, pers. commun., 2004), and reliable maps based on these data are not currently available.

- Although the Forestry Division conducted an inventory of forest cover in 1980 similar to the one conducted by Beard in 1946, and there is information available specifically for the Northern Range, the data are still in a raw form requiring compilation and assessment.[66] An attempt was made to compare Beard's 1946 inventory with the Forestry Division's inventory during the course of this assessment, but this comparison yielded very little information about the trends in the density of timber species because the overlap in species sampled in the two inventories is limited, and because different data-collection techniques were used.
- The 1979/1980 Canadian International Development Agency (CIDA) National Forest Inventory was based on pre-existing 1969 aerial photography and so, even at the time that the study was conducted the material was outdated (Kenny et al. 1997).
- The FAO assessments (FAO 1999, 2000) provide figures for changes in forest cover for Trinidad and Tobago as a whole, but extracting data specific to the Northern Range is not possible.
- Aerial photography data for 2003/2004 apparently do exist but are also not accessible. Even if separate land-cover maps were available for the period 1969 to 2003, it would be difficult to detect perceptible trends in land cover and land use given the very short time frame of data collection. However, a comparison of these maps would illuminate any extreme events that occurred during the period (S. Baban, pers. commun., 2004).
- At present there is work being conducted at UWI to map land use and land cover in Trinidad based on 2001 Landsat 7 imagery (A. Chinchamee, pers. commun., 2004), but because the results of this research have not yet been published, they are unavailable for use in this assessment.

Perhaps the most verifiable up-to-date source of information on land use and land cover in the Northern Range (and Trinidad as a whole) is a map produced by the US Geological Survey in 2001 based on a regional map assessment done for the islands in the West Indies (Baban 2001). This map is based on a compilation of previous work done in Trinidad. There are, however, no time-line data available to determine trends in land use or forest-cover changes. The activities to which forests are converted are known (agriculture, housing, and degraded forest from fires) but the areas and rates of change have not been determined (S. Ramnarine, pers. commun., 2004). If all development activities were to follow the planning process in the country, then this process would be a source of updated information. However, this is not always the case and the available information is an underestimation of land-use conversion rates over a given time period.

Fires

The body of data on fires in Trinidad and Tobago deserves special mention because it is probably the most in-depth, consolidated body of empirical data relating to drivers of change in Northern Range ecosystem services. Two main data sources are noted (The Forestry Division and the Fire Service Division of Trinidad and Tobago), but this assessment draws mainly on the data from the Forestry Division.

[66]The Forestry Division's 1980 inventory was based on actual on-the-ground measurements, and used Beard's 1946 classification for the identification of forest types (see Table 23 in Annex 4). The information was collected on a plot basis, and so data is available by plots. To date, no publicly available compilation of the information is available.

The Forestry Division has been systematically recording and reporting on the occurrence and distribution of fires in Trinidad since 1987.[67] The location, size, and cause of each fire are recorded, and this information is then aggregated and assessed on both a county and conservancy basis. For the purpose of this assessment, county and conservancy statistics were used to estimate the number of fires within the Northern Range.[68]

Information on fires and fire damage in Trinidad is also available from the Fire Service of Trinidad and Tobago, but these data are more difficult to access. When compared with the data from the Forestry Division, discrepancies in the number of fires reported by these two sources arise because the Forestry Division usually reports on fires in forested areas, whereas the Fire Service more often records fires in urban settings (K. Singh, pers. commun., 2004).[69] Given this, there tends to be little overlap in the fires reported by these two bodies and so, it is possible to add the figures reported to get a better idea of the total number of fires in Trinidad (and in some cases within the Northern Range).

[67]It is important to note that given limitations in capacity and the safety concerns associated with investigating the causes of some fires, not all fires that occur are reported.

[68]Note that the conservancy and county statistics provide a basis for approximation.

[69]When data sets from the Forestry Division and the Fire Service Division are compared for 1997 and 2003, there are apparent differences in what is recorded. For example in 1997, though the Forestry Division reported a total of 156 fires across all conservancies in Trinidad, the Fire Service noted as many as 2,120 bush fires which burned a total of 2,193 ha (Forest Fire Protection Unit Annual Report 1998). Similarly, in 2003, while the Forestry Division reported a total of 347 fires that burned an area of 4,723.1 ha, the Fire Service reported a total of 4,292 bush fires which burnt ab area of 6,407 ha (Singh 2003b).

ANNEX 3: Information on Key Faunal Species of the Eastern Northern Range

(Based on Forestry Division Eastern Northern Range Plan, 1991)

Common name *(Scientific name)*	Family name	Condition	Trends	Major threats (with supporting information)
Forested Zones				
Pawi or Trinidad piping guan (*Pipile pipile*)	Cracidae	As at 1988, only five population centres were recorded in the Eastern Northern Range—Grand Riviere, Fig Wharf, Quare, Cumaca, Madamas. Birds were usually seen in groups of two or solitary. The maximum-sized group recorded comprised three individuals	Historical reports suggest that: populations were once present on all of the steep-sided slopes of the Eastern Northern Range and each population comprised approximately 15 individuals	Timber felling, facilitated through the granting of licences by the Forestry Division, and resulting in habitat alteration occurred in study sites where the Pawi was observed Overhunting in Matura/Salybia, Grand Riviere, Platanal
Red howler monkey (*Alouatta seniculus insularis*)	Cebidae	Small troops (5–8 individuals) were observed in certain localized areas of the Eastern Northern Range, with regular sightings only in the Matura/Salybia Reserve, in Quare, Cumaca, and Madamas	Up to 1970, howler monkeys existed in large groups (12–14 individuals) throughout the Eastern Northern Range	Howler monkeys are arboreal, coming to the ground only on rare occasions for water. Regular and/or continuous breaks in the forest canopy, which occur in areas of heavy timber harvest, affect the movement of colonies
Wild hog or quenk (*Tayassu tajacu*)	Tayassuidae	Both the sizes of individual herds and the overall population were being reduced	Historically, herds of over 15 individuals were common	This species requires a large home range to support its foraging and breeding activities. Habitat alteration and unsustainable hunting practices are considered the major threats to the species
Channel-billed toucan (*Ramphastos vitellinus*)		Still well represented	Well represented	—
Collared trogon (*Trogon collaris*)		Still well represented	Well represented	—

ANNEX 3: Information on Key Faunal Species of the Eastern Northern Range

(Based on Forestry Division Eastern Northern Range Plan, 1991) *continued*

Common name (*Scientific name*)	Family name	Condition	Trends	Major threats (with supporting information)
Forested Zones				
Ocelot (*Felis pardalis*)	Felidae	Still well represented	Numbers dwindling	Large tracts of good forests required to support the population. The species is shot illegally by night hunters
Bearded bellbird (*Procnias averano*)		Common throughout most of the ENR	—	—
Caves				
Oilbird or guacharo bird (*Steatornis caripensis*)	Steatornithidae	Fairly stable	—	Occurs in the Oropouche and Aripo caves and is sensitive to human disturbance and habitat loss in its foraging range
Sandy Beaches and Coral Reefs				
Leatherback turtle (*Dermochelys coriacea*)	Dermochylidae	Good populations recorded in Paria, Madamas, Grand Tacaribe, Grand Riviere, Matura, and Fishing Pond	—	Nests in large colonies on sandy beaches. Feeds off of the rich sea grass beds in large numbers during February–August annually
Green turtle (*Chelonia mydas*)	Cheloniidae	—	—	Nests singly or in small groups at Paria Bay, Matelot Bay, San Souci Bay, Toco Bay, Cumana, and Balandra Bay
Hawksbill turtle (*Eretmochelys imbricata*)	Cheloniidae	—	—	—
Olive Ridley turtle (*Lepidochelys olivacea*)	Cheloniidae	—	—	—
Loggerhead turtle (*Caretta caretta*)	Cheloniidae	—	—	—
Rivers and Streams—Fish				
Mountain mullets (*Agonostomus monticola*)	Muglidae	Notable populations recorded in the Madamas, Paria, Matelot, and upper reaches of the Shark and Grand Riviere rivers	—	—

ANNEX 3: Information on Key Faunal Species of the Eastern Northern Range

(Based on Forestry Division Eastern Northern Range Plan, 1991) *continued*

Common name ***(Scientific name)***	**Family name**	**Condition**	**Trends**	**Major threats (with supporting information)**
Gobies (*Sicydium punctatum*)	Gobiidae	Notable populations recorded in the Madamas, Paria, Matelot, and upper reaches of the Shark and Grand Riviere rivers	—	—
Sand fish (*Awaous taiasica*)	Gobiidae	Notable populations recorded in the Madamas, Paria, Matelot, and upper reaches of the Shark and Grand Riviere rivers	—	—
Cling fishes (*Gobiesox nudus*)	Gobiesocidae	Notable populations recorded in the Madamas, Paria, Matelot, and upper reaches of the Shark and Grand Riviere rivers	—	—
Rivers and Streams — Mammals and Birds				
Lappe (*Agouti paca*)	Agoutidae	Found along banks of most rivers of the ENR	—	Highly dependent on water for survival, burrowing along river banks. Also found at the Hollis Reservoir
Tattoo (*Dasypus novemcinctus*)	Dasypodidae	Population levels high around banks which receive regular overflows of water	—	Dependent on moist forest floor habitat
Water opossum (*Chironectes minimus*)		Found along banks of most rivers of the ENR		Highly dependent on water for survival, burrowing along river banks
Manatee *(Trichechus manatus manatus)*	Trichechidae	Individuals occasionally found in the lower reaches of the Oropouche River	Healthy populations once occurred in the coastal region of the Matura and Oropouche rivers	Heavy siltation of the Oropouche River within the period 1986–1991, eliminated most of the foraging habitat for this species. Illegal fishing practices increased in the years prior to the study and resulted in the slaughter and strangulation of individuals

ANNEX 3: Information on Key Faunal Species of the Eastern Northern Range

(Based on Forestry Division Eastern Northern Range Plan, 1991) *continued*

Water rat (*Nectomys squamipes*)		Often seen in rivers of ENR	—	May form an important link in the forest food chain
Green kingfisher (*Chlorocerye americana)*		—	—	—
Pigmy kingfisher (*Chloroceryle aenea*)		—	—	—
Man-made Lake – Hollis Reservoir				
Swallow-tailed kite (*Elanoides forficautus*), Anhinga or snakebird (*Anhinga anhinga*), crab hawk, least grebe				
Cultivated, Semi-cultivated, and Abandoned Agricultural Lands				
Brocket deer (*Mazama americana trinitatis*), iguana (*Iguana iguana*); manicou spp. (*Didelphis marsupialis insularis*; *Marmosa* spp; *Caluromys philander*); porcupine (*Coendu prehensilis longicaudatus*); tattoo, ocelot, tayra, squirrel (*Sciurus granatensis*); wild hog; parrots; toucans; hawks, spectacled owl (*Pulsatrix perspicillata*); bellbirds bearded (*Procnias averano)* and white (*Procnias alba*)				

ANNEX 4: Northern Range Forests

Brief Characterization of the Forests of the Northern Range

The most recognized classification of the forest types of Trinidad and Tobago is that proposed by Beard in 1946. Beard (1946) used a physiognomic approach for classification and recognized two major controlling factors that influenced distribution—climatic and edaphic. The climatic factors considered were moisture, temperature or elevation (warm to cool), and wind. The edaphic factors considered were soil type, and the nature and proximity of the underlying water table. In the Northern Range, communities are defined by climatic rather than edaphic factors and they are categorized as seasonal, dry evergreen, and montane formations.

Beard's (1946) classification of Trinidad's forests involved only mature or primary forest types, however. Much of the Northern Range, especially the westernmost part, has been converted by development in the last forty years (including plantations). Areas destroyed by fires or abandoned after exploitation have regenerated and secondary forest with vegetation at various stages of succession now exists.

The following descriptions of Northern Range forest types are based mainly on the work of Beard (1946), but other sources have been drawn upon in the cases of Elfin Woodland, and secondary and plantation forest types.[70]

Montane Forests

Montane forests include all the natural forest cover above the 240-m contour line in the Northern Range and can be further subdivided into Lower Montane, Seasonal Montane, Montane, and Elfin Woodland. In moving from lower to higher elevations, temperatures decrease and moisture levels increase. Rainfall levels in Montane forests can be as much as 400cm per annum above the 760-m contour line. Lower Montane, Montane, and Elfin Woodland occur on schist soil while Seasonal Montane is found on limestone above 450m.

At elevations above 850m, Elfin Woodland (or Cloud Forest) occurs where wind exposure becomes an important factor. There is also continuous cloud cover and high rainfall in these regions. These conditions have resulted in the stunting of trees, and thus a decrease in the height of the tree canopy. There are also fewer species in the Cloud Forest when compared with surrounding Montane Forest [the dominant species in some places being the mountain mangrove (*Clusia intertexta*) so called because of the well-developed stilt roots], but the striking feature of the ground cover and epiphytic vegetation is the preponderance of mosses, lichens, wild pines, aroids, and clumps of wild bamboo. In some areas there are thickets of small palms and tree ferns. In many places the floor of the forest consists of spongy mats of leaf litter and humus devoid of vegetation.

The only examples of Cloud Forest in Trinidad are found in the Northern Range. Small patches may be found on the leeward north-east side of the summit of El Tucuche, and even smaller patches on the adjacent Naranjo and Piedra Blanca (Kenny 2003). The only significant Cloud Forest is located on Cerro del Aripo along the ridge at its highest points and this only extends for a few hectares.

[70]A summary of the description of the forests in the Northern Range is given by Armstrong (2001).

The Cloud Forests serve to protect the soil in the wettest part of Trinidad and are also of considerable recreational and scientific importance. They support a number of species of plants that are thought to be endemic to the Northern Range, and this is where the endemic golden tree frog, *Phyllodytes auratus*, is found.

Evergreen Seasonal Forest

This forest type has a multi-layered canopy with emergent trees up to 45m in height and occurs in areas where rainfall averages 3,000mm per annum. This forest remains evergreen throughout the year. In undisturbed portions, the interior is open in the understory with moderate ground vegetation and little accumulation of leaf litter. The larger trees possess buttress roots and there are some epiphytes and lianas growing on the trunks and branches. Typical plant species include *Carapa guianenis, Mora excelsa, Ceiba pentandra, Spondias monbin, Pentaclethra macroloba,* and *Brownea latifolia* (ffrench 1991). The most extensive examples of Evergreen Seasonal Forest in the Northern Range can be found in the north-eastern Matura Forest Reserve which is dominated by mora.

Semi-evergreen Seasonal Forest

This forest type shows physical changes during the dry season with some of the upper canopy trees being deciduous (on average about one-third of the species) while most understory species remain evergreen where moisture conditions are more favourable. This forest type occurs in drier areas where annual rainfall averages around 1,800mm. Mature trees branch lower on the main stem, between 6m and 9m, than do similar sized trees in seasonal evergreen forest where branching begins around 15m. Buttressing is not a prominent feature in semi-evergreen forest. This is mainly a near-coastal forest type in Trinidad's north-west peninsula, and north and north-east coasts, but it can also be found on the south-western flanks of the Northern Range.

Deciduous Seasonal Forest

This is the driest forest found in Trinidad where annual rainfall rarely exceeds 1,250mm. This results in an open, low canopy forest of small trees, with emergents, often with smaller leaves, barely reaching 20m in height. Common trees in the emergent layer are saltfishwood, yellow savonette, and incense while in the understorey, yellow poui, wild tamarind, and wild gauva are abundant. The character of the vegetation reflects the drier condition that prevails. Most trees shed their leaves in the dry season while the evergreen component tends to have small leathery leaves. Deciduous Seasonal Forest is confined to areas in the Northern Range such as the offshore islands, Pointe Gourde, and lower slopes of the north-west peninsula.

Dry Evergreen Forest

This forest type occurs behind beaches, along cliffs and headlands and shows the ravages of coastal exposure with wind-trimming and stunted growth on the seaward side. The vegetation is dense—almost impenetrable—and lianas are sometimes well established. The evergreen vegetation displays salt spray adaptations with thick, leathery cutinized leaves and is present along the north-east coast. Cacti and century plant (*Agave evadens*) are also common.

Secondary Forests

Natural regeneration or secondary succession in forests of the Northern Range tends to re-establish the climax through a series of communities unless deflected by grazing, repeated burning, or cultivation. It begins with herbaceous weeds, vines and creepers, shrubs, and small, rapid-growing, short-lived trees. These are followed by larger trees typical of second-growth forest which are usually light-demanding and rapid-growing, and finally by mature forest. Generally the most characteristic woody species, especially in the early stages of regeneration are *Cecropia peltata* L. and *Ochroma pyramidale* Urb., followed by species of *Vismia* and *Ficus.* In the Eastern Northern Range, especially at Melajo, the post-fire vegetation also incudes the following as the dominant genera: *Cordia, Rourea psychotria, Miconia, Piper, Isertia, Mora, Inga,* and *Rollinia.* The most abundant herbaceous genera include: *Blechnum, Nephrolepis, Calathea, Ischnosiphon, Monotagma, Philodendron, Calyptrocarya solanum, Scleria, Sabicea, Heliconia,* and *Mikania* (Homer 1996).

Plantation Forests

Commercial plantations in Trinidad were established in 1925–1927 with the introduction of monoculture stands of teak (*Tectona grandis*), using what is described as the taungya system. Caribbean pine (*Pinus caribaea var. hondurensis*) was subsequently established in 1956, and became one of the species used for reafforestation in the Northern Range. Pine was considered especially favourable because of its ability to buffer against forest fires. These two species are today the two most important commercial timber species in Trinidad. Other species of hardwoods that are of commercial importance include cedar (*Cedrela odorata*), cypre (*Cordia alliodora*), mahogany (*Swietenia macrophylla*), and apamate (*Tabebuia rosea*), which are all planted in either monoculture or mixed stands (Forestry Division 2003).

Apart from timber species of commercial value, there is a growing interest in agro-forestry as a means of reforesting more localized areas of the Northern Range, while at the same time providing food and a source of income for low-income households on the Northern Range hillside, especially the south-western slopes (Cropper 1997).

Table 22: Summary of Area by Forest Type for Trinidad and Tobago (based on Beard's 1946 inventory)

Forest types	Trinidad (ha)	Tobago (ha)
Evergreen Seasonal Forest	**98,180**	
Crappo–debasse	19,560	
Crappo–fineleaf–carat	43,076	
Crappo–fineleaf–cocorite	8,829	
Crappo–blackheart–cocorite	5,784	
Mora	20,931	
Semi-evergreen Seasonal Forest	**13,928**	
Purpleheart–incense–poui	53	
Purpleheart–bois lissette	4,888	
Acurel–moussara–jiggerwood	4,594	
Acurel–gommier	4,139	
Moussara–figuier	254	
Deciduous Seasonal Forest	**3,617**	
Naked Indian–incense–poui ecotone	3,617	
Dry Evergreen Forest	**495**	
Seagrape–manchineel	69	
Palmiste–balata	426	
Seasonal Montane Forest	**926**	
Pois doux–redwood	926	
Montane Forest	**21,619**	
Serrette–bois gris (lower)	20,560	
Bois bande–mount, guatecare (rain)	1,030	
Mountain mangrove (elfin)	29	
Secondary Forest	**16,631**	**6,019**
Crappo	7,690	
Mora	7,768	
Purpleheart	187	
Acurel–moussara	290	
Naked Indian	521	
Serrette–bois bande	175	
Plantation	**20,753**	646
Teak	10,530	—
Pine	5,758	20
Other	4,465	626
(Edaphic) Swamp Forest	**16,731**	58
Palm swamp	996	—
Herbaceous swamp	6,634	—
Mangrove	5,285	58
Swamp forest	62	—
Savannah	355	—
Marsh forest (secondary–ecotone)	3,390	—
Other areas	**52,859**	3,226
Fire-burnt site	724	88
Clear-cut site	3,149	—
Agricultural encroachment	18,971	1,671
Agricultural land	16,270	788
Non-forested areas	11,845	223
Bamboo	316	212
Water	1,584	29
Abandoned plantation		167
Mixed conversion forest		48
Total	**245,739**	**9,949**

Source: Forest Resources Inventory Management, Forestry Division, Ministry of Public Utilities and the Environment

Table 23: Ecosystem Types in the Northern Range

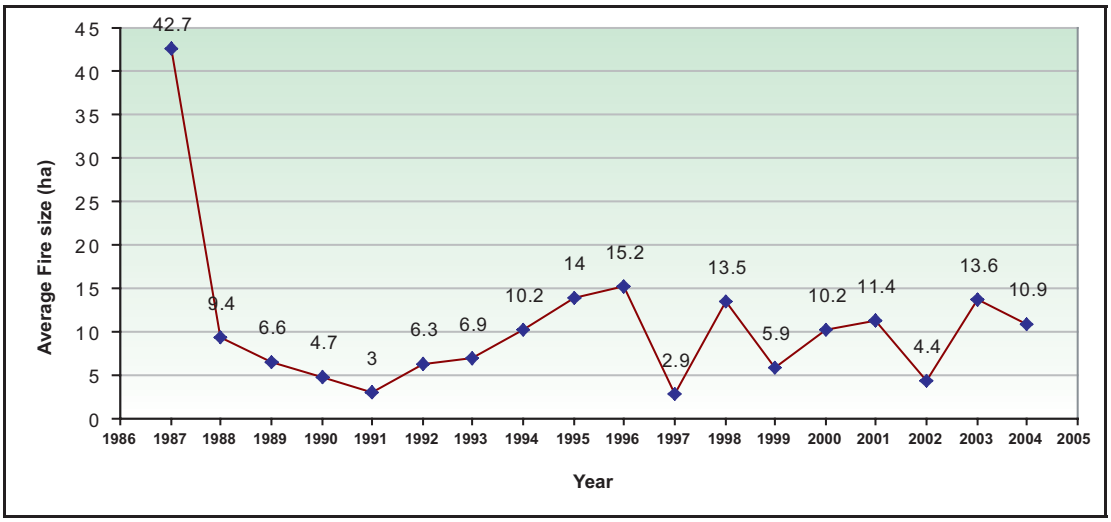
[according to Beard (1946) and the National Forest Inventory of 1980]

Beard (1946) ecosystem types			NFI (1980) ecosystem types		
Formation	**Association**	**Code**	**Formation**	**Association**	**Code**
Lower Montane Rain Forest	Serrette – wild debasse: Bois gris type (*Byrsonima spicata-Licania biglandulosa: Licania ternatensis*)	15	Montane Forest Lower	Serrete – Bois gris	ML
Montane Rain Forest	Bois bande-mountain guatecare *(Richeria grandis – Eschweilera trinitensis*)	16	Montane Forest	Bois bande-mountain guatecare	MR
Elfin Woodland	Mountain mangrove *(Clusia intertexta)*	17	Montane Forest	Mountain mangrove	ML (SC)
Deciduous Seasonal Forest	Naked Indian-savonette: incense – poui ecotone *(Bursera simaruba –Lonchocarpus* sp: *Protium guianense-Tabebuia serratifolia*)	12	Deciduous Seasonal Forest	Naked Indian-incense – poui ecotone	NIP
Evergreen Seasonal Forest	Crappo – Guatecare : wild debasse type *(Carapa guianensis – Eschweilera subglandulosa: Licania bigladulosa)*	2	Evergreen Seasonal Forest	Crappo –debasse	Cd
Evergreen Seasonal Forest	Crappo-Guatacare : mora type *(Carapa guianensis – Eschweilera subglandulosa: Mora excelsa)*	1	Evergreen Seasonal Forest	Mora	Cm

ANNEX 5: Trinidad's Forest Fires

The 'average fire size' statistic, used by the Forestry Division, indicates the ratio of area burnt to the number of fires.[71] A high ratio means that a few large fires are responsible for widespread damage, while the opposite is true of a low fire area : number ratio. The long-term trend (1987–2003) for average fire size for the island of Trinidad shows that, contrary to what is generally believed and perceived, there has been no steady increase in average fire size in Trinidad over the last sixteen years. Rather, the average fire size has fluctuated between a minimum of 2.9ha and a maximum of 15ha since 1988 (Fig. 27).

Fig. 27: Long-term Trend of Average Fire Size (ha) (1987–2004)



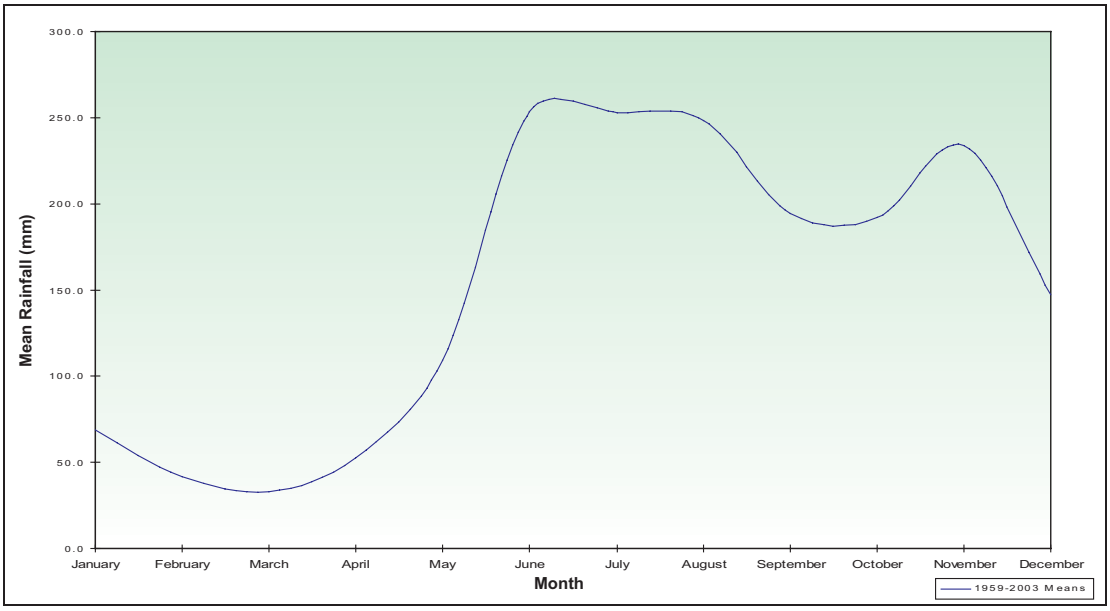
Source: Singh (2003b); Singh (pers. commun., 2004)

The 'average fire size' statistic should be interpreted with caution, however. A higher value does not necessarily mean that there were more fires that affected a larger area. For example, if one compares the annual average fire size figures for the years 1994 and 2000 (which are both 10.2ha) with the actual figures for the areas burnt (1994—2,600ha, 2000—927ha) and number of fires (1994—256; 2000—91), it is obvious that both the number of fires and the area burnt were much lower in 2000.

Two factors are known to contribute to average fire size—rainfall, and the responsiveness of the relevant authorities charged with the responsibility of fire control and prevention. There seems to be a direct relationship between rainfall and the occurrence of fires in Trinidad and, because of this, rainfall is considered an indicator of fire danger (Singh 2003b) as rainfall and moist vegetation would generally not support the process of combustion. On a month-by-month basis for the period December–June, for the years 1998–2003, there seems to be a correlation between mean monthly rainfall (Fig. 28), and the occurrences of forest fires (Fig. 29), with most fires usually occurring in the months of February, March, April, and May. Though Figure 28 shows that January is also a dry month, the most probable cause for the lower occurrence of fires in this month is the moisture that is retained in the soil and vegetation following the long wet seasons from June to December.

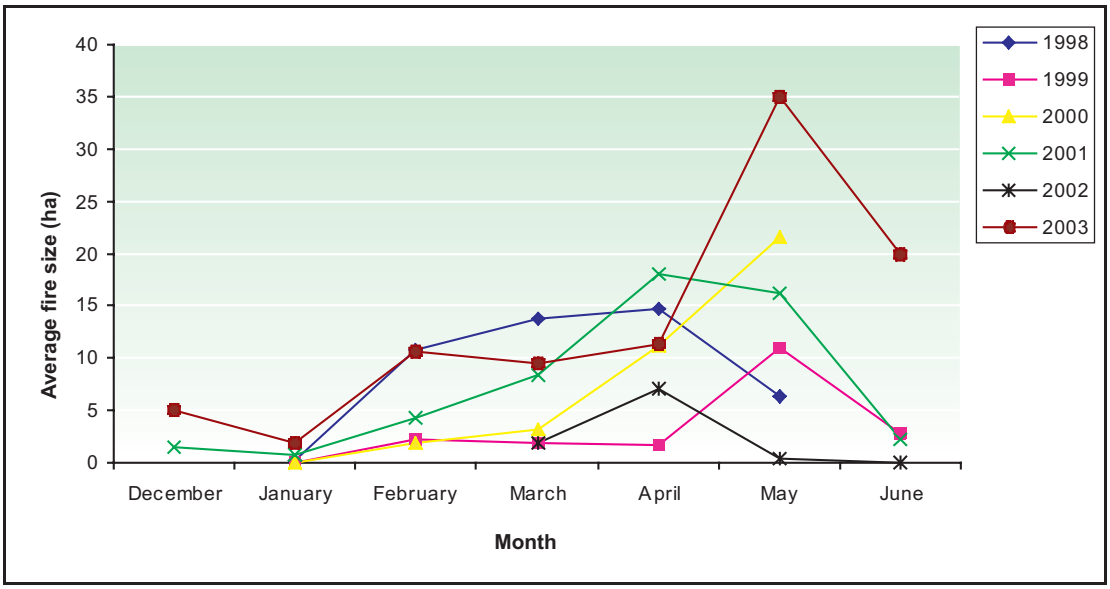
[71]Average fire size is calculated by dividing the area burnt by fire (ha) by the number of fires

Fig. 28: Piarco's Mean Monthly Rainfall (1959–2003)



Source: Piarco Meteorological Office (pers. commun., 2004)

Fig. 29: Monthly Distribution of Forest Fires in Trinidad (1998–2003)



Data sources: Forest Fire Protection Unit (1998); Singh (1998, 2002, 2003a, 2003b)

Further evidence to support the relationship between rainfall and fire occurrences is provided by comparing average fire sizes across years. In the year 2002, for instance, the average fire size for Trinidad was very low—4.4 ha (Fig. 27). Incidentally, the average rainfall for that year was relatively high (see Fig. 8). Conversely, if we examine the rainfall and fire data for 2003, which was a remarkably dry year, the incidence of fires was considerably higher than it was in 2002.

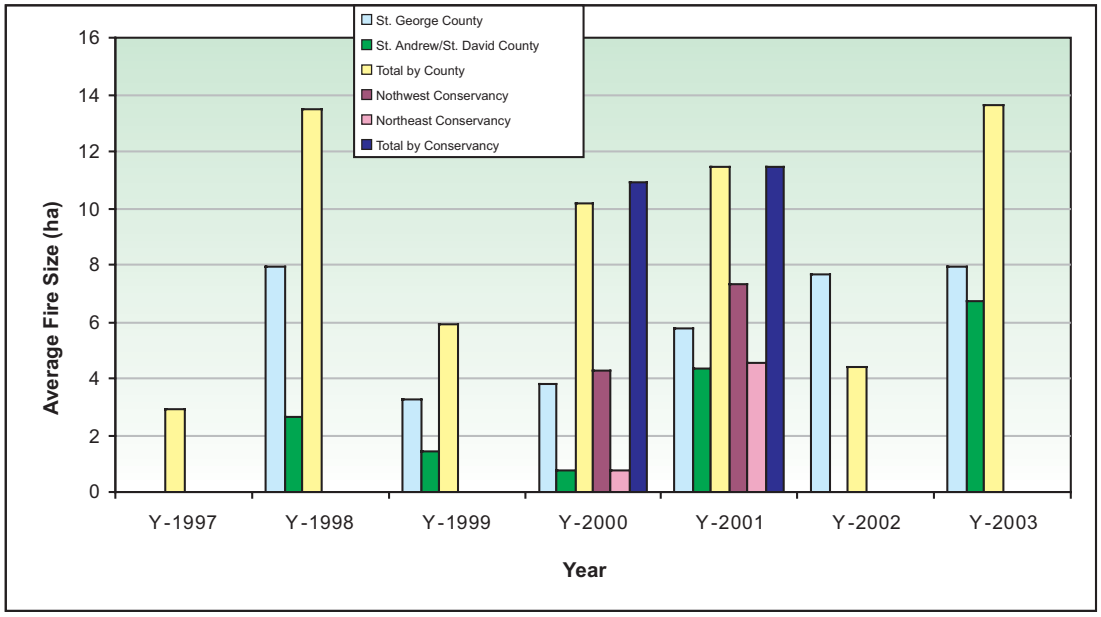
The responsiveness of authorities to fires also contributes to average fire size and as such the statistic is a good indicator of responsiveness (K. Singh, pers commun., 2004). The importance of this factor is borne out by the sharp drop-off in average fire size noted between 1987 (42.7 ha)[72]

[72]The figures for the number and size of fires for 1987 were based largely on estimates, but it is believed that the numbers are reflective of the situation on the ground (K. Singh, pers commun., 2004).

and 1988 (9.4 ha), evident in Figure 27. Though 1987 was a considerably dry year, which no doubt would have contributed to the high incidence of fires, there was very little organized effort on the part of authorities to prevent and control the spread of fires during the dry season (K. Singh, pers commun., 2004). The resulting damage proved to be an eye-opener and led to immediate on-the-ground action, which was responsible for a significant reduction in the number and extent of forest fires in 1988 (K. Singh, pers commun., 2004).

Specific to the Northern Range, aggregated data and information on the distribution of forest fires by month can be extrapolated from county (and in some cases Conservancy) data for the period 1998–2004, as shown in Figure 30. Generally what the figure indicates is that the number of fires in the more westerly regions was higher than in easterly regions for all years.

Fig. 30: Average Annual Fire Size for Trinidad's Northernmost Counties and Conservancies



Source: Forest Fire Protection Unit (1998); Singh (1998, 2002, 2003a, 2003b)

The Forestry Division has also been recording and reporting the main causes of fires in Trinidad, and it is possible that these national level data can be extrapolated to the situation in the Northern Range (since no data specific to the Northern Range exist). Five major causes have been identified: malicious acts, agriculture, hunters, smokers, and 'other' which includes various negligent acts (Singh 1998). All fires whose causes cannot be identified are classed as unknown. The trend over the last five years for Trinidad as a whole has been for malicious acts and agriculture to be the two major causes of fires. For all years but 2002 (when agriculture was recorded as the leading cause of fires), malicious acts have been the leading identifiable cause accounting for as many as 61.5% of the fires in 1998 (Singh 1998, 2002, 2003a, 2003b). In 2004, data specific to the St. George County showed that agriculture was the leading (identifiable) cause of fires, followed by smoking, and then by malicious acts. This may indicate that while agriculture may not be the number-one source of conflagration in Trinidad as a whole, it may be the leading cause in the Western Northern Range.

A few considerations may help to explain the higher incidence of fires caused by agriculture in the westernmost reaches of the Northern Range. Firstly the slopes closer to the urban centres on the southern flanks of the Western Northern Range are more accessible and are more attractive for

agricultural activities. Rainfall is also higher in the north-eastern parts of the Range, making the western regions more vulnerable to fires (see Fig. 3). A long history of burning has also resulted in the growth of savannah vegetation, including grasses in the Western Northern Range. This vegetation type burns more easily than forest vegetation and so is an easier choice, especially for hillside farmers (K. Singh, pers commun., 2004). There is data to indicate that savannah-type vegetation and grasses are increasingly becoming the main type of vegetation being burnt in Trinidad, with an increase from 16.4% of all fires affecting this vegetation type in 1998 (Singh 1998) to 69% in 2002 (Singh 2002), but then falling to 41% in 2003 (Singh 2003b).

The most common agricultural method utilized in Trinidad, and certainly the one that most directly contributes to hillside fires, is 'slash and burn' agriculture, which involves the piling of vegetable matter and setting fires that are usually monitored by the farmers. Agricultural squatting and setting fires without permits are illegal. However, foresters are forewarned by farmers about these preparations and assist whenever possible in controlling the fires. In recent times, however, there has been a deviation from more traditional methods, and it has become more common to set fire to the dry forests, especially in the dry season (K. Singh, pers. commun., 2004). This new trend of setting fires involves little or no monitoring by farmers, who do not provide warning signs to the authorities, and does not involve the piling of vegetation which means that there is no discontinuity in the fuel (K. Singh, pers. commun., 2004). The result is that fires sometimes run out of control, degrading large tracts of primary forests and agricultural or plantation plots (Faizool 2002). This is what has led to large areas of secondary growth forest and savannah vegetation, not only on mainland Northern Range, but also on Monos Island (Leach and Fairhead 2001).

There is an increasing pattern of forest degradation due to fire moving downward on the valley slopes of the Northern Range. The moisture within the Northern Range valleys helps, in part, to control the spread of forest fires, but as the burning of savannah vegetation on the more exposed ridges grows closer and closer to forest margins on valley slopes, there has been increasing loss of primary forest to fires from the top of the valley downwards (K. Singh, pers. commun. 2004).

It is noteworthy that based on all available evidence, virtually no forest fires in Trinidad are induced by natural causes such as lightning (Singh 2003b). The argument against lightning as a source of conflagration is a simple one—most if not all lightning storms in Trinidad are accompanied by precipitation, and rain would tend to extinguish fires before they can cause widespread damage. There is certainly evidence for lightning causing very localized damage (for example, a single tree and the vegetation immediately surrounding it), but there is no evidence to date to indicate that lightning-induced fires have ever spread to appreciable sizes (K. Singh, pers commun., 2004).

ANNEX 6: Northern Range Watersheds

Watershed No.	Watershed Name	Area (ha)
1	Chaguaramas	2,895
2	Tucker Valley	1,753
3	Carenage	495
4	La Horquette	404
5	Diego Martin	3,790
6	Maraval	2,750
7	Port-of-Spain	1,990
8	Malick	872
9	Santa Cruz/ San Juan	5,406
10	Maracas	4,220
11	Tunapuna	2,230
12	Tacarigua/ Caura	4,836
13	Arouca	3,618
14	Arima	3,626
15	Guanapo	3,201
16	El Mamo	673
17	Aripo	2,683
18	Hollis	2,339
19	Turure	1,920
20	Oropouche	7,667
21	Rio Grande	1,480
22	Matura	4,280
23	Salina/Rio Seco	3,480
24	Balandra	3,765
25	Tompina	3,317
26	Toco	3,471
27	Grande Riviere	3,758
28	Shark River	2,710
29	Matelot	3,552
30	Madamas	5,070
31	Paria	2,546
32	Marianne	4,645
33	Yarra	4,139
34	Quebrada/Las Cuevas	2,604
35	Maracas Bay	2,834
TOTAL		**109,019**

Source: Faizool (2002).

GLOSSARY[73]

Abundance	The total number of individuals of a taxon or taxa in an area, population, or community. Relative abundance refers to the total number of individuals of one taxon compared with the total number of individuals of all other taxa in an area, volume, or community.
Afforestation	Planting of forests on land that has historically not contained forests. (*Compare Reforestation.*)
Agroforestry systems	Mixed systems of crops and trees providing wood, non wood forest products, food, fuel, fodder, and shelter.
Aquaculture	Breeding and rearing of fish, shellfish, or plants in ponds, enclosures, or other forms of confinement in fresh or marine waters for the direct harvest of the product.
Biodiversity (a contraction of "biological diversity")	The variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part. Biodiversity includes diversity within species, between species, and between ecosystems.
Biomass	The mass of tissues in living organisms in a population, ecosystem, or spatial unit.
Coastal system	Systems containing terrestrial areas dominated by ocean influences of tides and marine aerosols, plus near-shore marine areas. The inland extent of coastal ecosystems is the line where land-based influences dominate, up to a maximum of 100 kilometres from the coastline or 100 metre elevation (whichever is closer to the sea), and the outward extent is the 50-metre-depth contour.
Community (ecological)	An assemblage of species occurring in the same space or time, often linked by biotic interactions such as competition or predation.
Community (human, local)*	A collection of human beings who have something in common. A local community is a fairly small group of people who share a common place of residence and a set of institutions based on this fact, but the word 'community' is also used to refer to larger collections of people who have something else in common (e.g., national community, donor community).

[73]All definitions included in this Glossary are adopted from MA (2005b) unless otherwise stated.

Condition (of an ecosystem)	The capacity of an ecosystem to yield services, relative to its potential capacity.
Condition of an ecosystem	The capacity of an ecosystem service to yield benefits to people, service relative to its potential capacity.
Conservancy[74]	Geographical region in Trinidad (of which there are five—North-East, North-West, South-Central, South East, South-West) designed for the purpose of forest management.
Constituency	Electoral districts in Trinidad and Tobago, the basis upon which general elections are organized.
Constituents of well-being	The experiential aspects of well-being, such as health, happiness, and freedom to be and do, and, more broadly, basic liberties.
County	Administrative division employed under colonial administration.
Cultural services	The nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience, including, e.g., knowledge systems, social relations, and aesthetic values.
Decision-maker	A person whose decisions, and the actions that follow from them, can influence a condition, process, or issue under consideration.
Deforestation	Conversion of forest to non-forest.
Degradation (of an ecosystem service)	For *provisioning services*, decreased production of the service through changes in area over which the service is provided, or decreased production per unit area. For *regulating and supporting services*, a reduction in the benefits obtained from the service, either through a change in the service or through human pressures on the service exceeding its limits. For *cultural services*, a change in the ecosystem features that decreases the cultural benefits provided by the ecosystem.
Degradation (of ecosystems)	A persistent reduction in the capacity to provide ecosystem services.
Determinants of well-being	Inputs into the production of well-being, such as food, clothing, potable water, and access to knowledge and information.

[74]Chalmers (1981).

Driver	Any natural or human-induced factor that directly or indirectly causes a change in an ecosystem.
Driver, direct	A driver that unequivocally influences ecosystem processes and can therefore be identified and measured to differing degrees of accuracy.
Driver, endogenous	A driver whose magnitude can be influenced by the decision-maker. Whether a driver is exogenous or endogenous depends on the organizational scale. Some drivers (e.g., prices) are exogenous to a decision-maker at one level (a farmer) but endogenous at other levels (the nation-state).
Driver, exogenous	A driver that cannot be altered by the decision-maker. See also endogenous driver.
Driver, indirect	A driver that operates by altering the level or rate of change of one or more direct drivers.
Ecosystem	A dynamic complex of plant, animal, and micro-organism communities and their nonliving environment interacting as a functional unit.
Ecosystem approach	A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use. An ecosystem approach is based on the application of appropriate scientific methods focused on levels of biological organization, which encompass the essential structure, processes, functions, and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.
Ecosystem assessment	A social process through which the findings of science concerning the causes of ecosystem change, their consequences for human well-being, and management and policy options are brought to bear on the needs of decision-makers.
Ecosystem management	An approach to maintaining or restoring the composition, structure, function, and delivery of services of natural and modified ecosystems for the goal of achieving sustainability. It is based on an adaptive, collaboratively developed vision of desired future conditions that integrates ecological, socioeconomic, and institutional perspectives, applied within a geographic framework, and defined primarily by natural ecological boundaries.

Ecosystem services	The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth. The concept "ecosystem goods and services" is synonymous with ecosystem services.
Endangered species	Species that face a very high risk of extinction in the wild.
Endemic (in ecology)	A species or higher taxonomic unit found only within a specific area.
Endemism	The fraction of species that is endemic relative to the total number of species found in a specific area.
Equity	Fairness of rights, distribution, and access. Depending on context, this can refer to resources, services, or power.
Freedom	The range of options a person has in deciding the kind of life to lead. Freedom is similar to the concept of capability and can be used interchangeably.
Governance	The process of regulating human and group behaviour in accordance with shared objectives. The term includes both governmental and nongovernmental mechanisms.
Health, human	Strength, feeling well, and having a good functional capacity. Health, in popular idiom, also connotes an absence of disease. The health of a whole community or population is reflected in measurements of disease incidence and prevalence, age-specific death rates, and life expectancy.
Institutions	The rules that guide how people within societies live, work, and interact with each other. Formal institutions are written or codified rules. Examples of formal institutions would be the constitution, the judiciary laws, the organized market, and property rights. Informal institutions are rules governed by social and behavioural norms of the society, family, or community.
Isohyet	A line on a map connecting points having the same amount of rainfall in a given period.
Land cover	The physical coverage of land, usually expressed in terms of vegetation cover or lack of it. Influenced by, but not synonymous with, *Land use.*

Land use	The human utilization of a piece of land for a certain purpose (such as irrigated agriculture or recreation). Influenced by, but not synonymous with, *Land cover.*
Nutrients	The approximately twenty chemical elements known to be essential for the growth of living organisms, including nitrogen, sulphur, phosphorus, and carbon
Nutrient cycling	The processes that allow elements to be extracted from their mineral, aquatic, or atmospheric sources or recycled from their organic forms, converting them to the ionic form in which plant uptake occurs, and ultimately returning them to the atmosphere, water, or soil.
Policy-maker	A person with power to influence or determine policies and practices at an international, national, regional, or local level.
Population, biological	A group of individuals of the same species, occupying a defined area and usually isolated to some degree from other similar groups. Populations can be relatively reproductively isolated and adapted to local environments.
Population, human	A collection of living people in a given area (*cf community, human*).
Poverty	The pronounced deprivation of well-being. How well-being or poverty are experienced and expressed depends on context and situation, reflecting local physical, social, and personal factors such as geography, environment, age, gender, and culture. Income poverty refers to a particular formulation expressed solely in terms of per capita or householdincome.
Precautionary principle	The management concept stating that in cases "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation," as defined in the Rio Declaration.
Productivity (biological)	Rate of biomass production by an ecosystem, generally expressed as biomass produced per unit of time per unit of surface or volume. Net primary productivity is defined as the energy fixed by plants minus their respiration.

Provisioning services	The products obtained from ecosystems including, for example, genetic resources, food and fibre, and freshwater.
Regional Corporation	Public body entrusted with the administration of services for a defined geographical region in Trinidad.
Regulating services	The benefits obtained from the regulation of ecosystem processes including, for example, the regulation of climate, water, and some human diseases.
Responses	Human actions including policies, strategies, and interventions to address specific issues, needs, opportunities, or problems. In the context of ecosystem management, responses may be of legal, technical, institutional, economic, and behavioural nature and may operate at local or micro, regional, national, or international level and at various time scales.
Social costs and benefits	Costs and benefits as seen from the perspective of society as a whole. These differ from private costs and benefits in being more inclusive (all costs and benefits borne by some member of society are taken into account) and in being valued at social opportunity cost rather than market prices, where these differ. Sometimes termed "economic" costs and benefits.
Species	The 'biological definition' is an interbreeding group of organisms that is reproductively isolated from all other organisms, although there are many partial exceptions to this rule, in particular taxa. The 'operational definition' is that a species is a generally agreed fundamental taxonomic unit, based on morphological or genetic similarity, which once described and accepted is associated with a unique scientific name.
Squatter	Person who is in actual occupation of State land without probable claim or pretence of title thereto.
Supporting services	Ecosystem services that are necessary for the production of all other ecosystem services. Some examples include biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat.
Sustainability	A characteristic or state whereby the needs of the present and local population can be met without compromising the ability of future generations or populations in other locations to meet their needs.

Sustainable use (of an ecosystem)	Human use of an ecosystem so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations.
Taungya system	A system where local gardeners help to clear the site to be planted by the Forestry Division with timber tree crops and at the same time plant their own crops between the tree crops, which they can harvest for up to 18 months[75]
Threshold	A point or level at which new properties emerge in an ecological, economic, or other system, invalidating predictions based on mathematical relationships that apply at lower levels. For example, species diversity of a landscape may decline steadily with increasing habitat degradation to a certain point, then fall sharply after a critical threshold of degradation is reached. Human behaviour, especially at group levels, sometimes exhibits threshold effects. Thresholds at which irreversible changes occur are especially of concern to decision-makers.
Time-series data	A set of data that expresses a particular variable measured over time.
Trophic level	A number, usually ranging from 1 to 5, expressing the position of organisms within food webs, with plants having a trophic level of 1, herbivores 2, first-order carnivores 3, etc. Because some predators, such as marine fish and invertebrates, usually have a mixed diet taken from different trophic levels, the trophic level of predators generally takes an intermediate value, e.g., 3.6, 4.1, etc.
Value systems	Norms and precepts that guide human judgement and action.
Vulnerability	Exposure to contingencies and stress, and the difficulty in coping with them. Three major dimensions of vulnerability are involved: (1) exposure to stress, perturbations, and shock; (2) sensitivity of people, places, ecosystems, and species to the stress or perturbation, including their capacity to anticipate and cope with the stress; and (3) resilience of the exposed people, places, ecosystems, and species refers to their capacity to absorb shock and perturbations while maintaining function.

[75]Source: W.S. Chalmers in collaboration with S. Faizool. FAO/Caricom Tropical Forestry Action Programme: Trinidad and Tobago National Forestry Action Programme: Report of the country mission team. p. 50.

Water scarcity	A water supply that limits food production, human health, and economic development. Severe scarcity is taken to be equivalent to 1,000m^3 per year per person or greater than 40% use relative to supply.
Well-being	A context- and situation-dependent state, comprising basic material for good life, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience.

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