A Rapid Ecological Assessment of

JAMAICA

Phase 1
An Island-Wide Characterization and Mapping of Natural Communities and Modified Vegetation Types

Conservation Data Center—Jamaica

The Nature Conservancy

Rural and Physical Planning Unit of the Ministry of Agriculture, Jamaica

JAMAICA: A RAPID ECOLOGICAL ASSESSMENT

PHASE 1

AN ISLAND-WIDE CHARACTERIZATION AND MAPPING

OF NATURAL COMMUNITIES AND MODIFIED VEGETATION TYPES

by

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Front cover is a mosaic of the two Landsat Thematic Mapper images used in the Rapid Ecological Assessment of Jamaica.

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Summary

There is at present a coordinated effort underway in Jamaica to identify, inventory and conserve the natural heritage of this biologically and ecologically diverse island.

In 1991, a Rapid Ecological Assessment (REA) project was implemented by The Nature Conservancy to support this effort. An REA is a process of inventory using consecutively finer steps of resolution. This directs the cost effective acquisition of biological and conservation data that is needed to guide conservation actions. This report summarizes the Phase 1 island-wide component of the REA. Phase 2, supported by the Jamaica Agricultural Development Foundation, will follow with in-depth inventories and mapping of the John Crow/ Blue Mountains and Montego Bay pilot parks.

Landsat Thematic Mapper (TM) satellite imagery was used to generate a land cover map for the island. Aerial surveys provided a quick overview reconnaissance, which was followed by ground truthing using Global Positioning Systems (GPS). The field work was performed by The Nature Conservancy and Conservation Data Center--Jamaica staff between July and December, 1991.

A classification of the natural and modified communities was compiled to support this inventory and mapping effort. The updated classification produced 69 types under the headings: FOREST [22], WOODLAND [5], SCRUB [12], TERRESTRIAL HERBACEOUS [17], DESERTS AND OTHER SCARCELY VEGETATED COMMUNITIES [7], AQUATIC [4] and URBAN/INDUSTRIAL [3].

A map was produced to delimit the natural and modified communities. Detailed descriptions were written for all categories. These products will provide critical up-to-date information to support conservation planning and further ecological studies in Jamaica.

This project was a cooperative undertaking with the Conservation Data Center--Jamaica, Rural and Physical Planning Unit, University of the West Indies, the Planning Institute of Jamaica, and the Jamaica Defence Force.

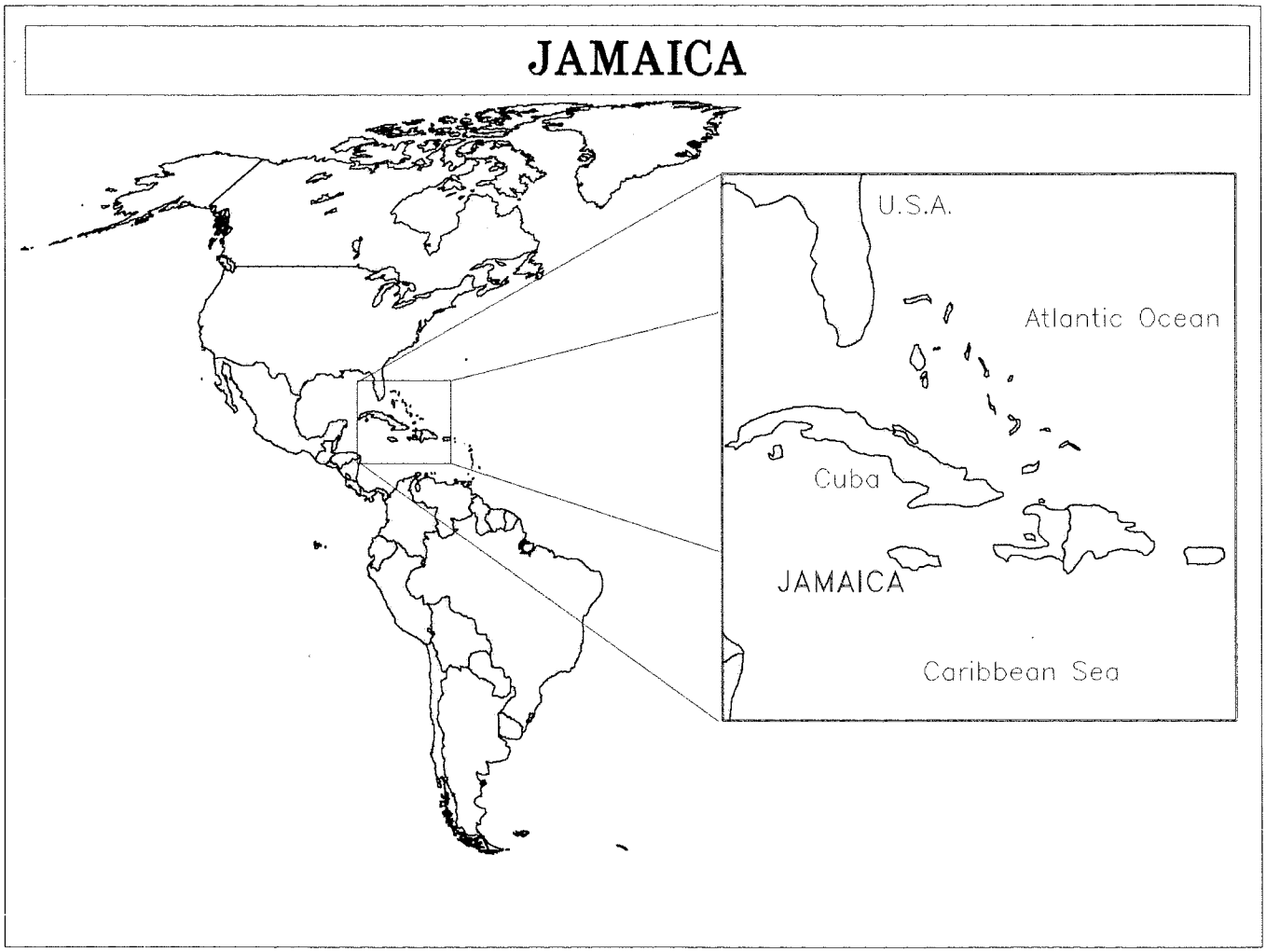

Figure 1. Location Map: Jamaica

Introduction

A. Project Background

Jamaica has an exceptionally high level of biological diversity and endemism. This rich natural heritage is threatened by pressures for development and exploitation in the absence of a comprehensive conservation plan. Strong conservation objectives are now being integrated into the national planning process. These initiatives are not solely based on biological and environmental values; nature-based tourism is a primary source of revenue for Jamaica.

The Government of Jamaica (GOJ) and the United States Agency for International Development (USAID) have joined in an effort to protect the biological diversity of Jamaica with the Protected Areas Resources Conservation (PARC) Project. One goal of this project is to lay the foundation for a new Jamaica National Park and Protected Area System. Integral to this goal is the development of a national parks system plan, and the establishment and management of two pilot parks, the Montego Bay Marine Park and the Blue Mountains/John Crow Mountains National Park. The development of successful models for the inventory, design and management of the pilot parks will provide valuable experience for the entire National Parks and Protected Areas system.

The Nature Conservancy (TNC) is providing technical assistance to the PARC project in the areas of institutional development, protected area design and management, scientific information management, and trust fund development. In collaboration with the Rural and Physical Planning Unit of the Ministry of Agriculture (RPPU), and the Conservation Data Center of the University of the West Indies (CDC - JA), TNC is carrying out a Rapid Ecological Assessment (REA) of Jamaica. This REA was designed to assist with the protected areas activities sponsored under the PARC project. It will provide project planners with reliable and up-to-date information on important biological and ecological resources in the form of maps, digital databases and reports.

B. Overview of Biological Inventories

Jamaica is located in the Greater Antilles, the third largest island in the Caribbean with a total land area of 10,938 square kilometers (4,411 sq. miles, Figure 1). Well-developed reefs and beaches and extensive coastal plains surround a plateau and backbone of peaks across the island. Over half the island lies over 300 meters above sea level (GOJ, 1987), the highest point being Blue Mountain Peak at 2,257 meters.

Jamaica emerged as an island 10 to 15 million years ago and has never been connected to any other land mass. This has resulted in the development of a unique flora and fauna composed of a high percentage of endemics. Of the approximately 3,000 flowering plant species known from the island, almost 28%

are endemics. Of the approximately 100 breeding bird species in Jamaica, 25 are endemic, a figure higher than any other West Indian islands, including Cuba and Hispaniola. Due to this isolation, its size, and the range of elevation and habitats, Jamaica may well possess greater biological diversity than any other country in the Caribbean.

The earliest botanical collections made in Jamaica were those of Sir Hans Sloane around 1700. Many significant collections were made from Jamaica in the 18th and 19th centuries by such eminent botanists as Swartz (1784-1786), Macfadyen (1837), Urban (1898) and Harris (1894-1917). Sloane wrote the first account of the natural history of Jamaica in the early 1700s. In 1814 Lunan described some of Jamaica's indigenous plants. This was followed by Macfadyen's flora of Jamaica (1837), which was improved upon by Fawcett and Rendle, who published a number of volumes for a flora of Jamaica between 1910 and 1936. This publication remains incomplete. However, a resurgence of taxonomic expertise in Jamaica culminated in the publication by C.D. Adams of "The Flowering Plants of Jamaica" in 1972. Subsequent additions to the flowering plant flora were published by Proctor in 1982. Proctor also published "The Ferns of Jamaica" in 1985.

C. Review of Ecology and Vegetation Classification in Jamaica

A Danish naturalist, Ørsted, produced a diagram of the topographic distribution of the different vegetation types in Jamaica in 1846. Some descriptions of Jamaica's natural history followed (e.g. Thomas, 1891), but the first comprehensive categorization of all Jamaican plant communities was that of Asprey & Robbins (1953). Their system largely followed that of Beard (1944, 1955) for the vegetation of the Caribbean.

Beard's system described five formation-series, as shown in Table 1. Because temperatures in the tropics are not limiting to plant growth, moisture availability becomes the chief factor controlling vegetation development. Thus the vegetation type developed under optimum conditions (constant water supply) is tropical rain forest. Table 1 shows how the different formation-series diverge from rain forest as habitat conditions become progressively more adverse. With increase in severity of permanent drought, the dry evergreen formation series is followed. With increase in severity of seasonal drought, the seasonal formation-series is followed. As soil becomes more and more waterlogged in a uniform fashion throughout the year, the swamp formation-series is followed, and in areas where waterlogging is seasonal, there is a seasonal swamp formation-series. With increase in altitude, conditions become cooler and often more exposed to wind, and the montane formation-series emerges.

Table 1. Formation types across environmental progressions according to Beard (1955).

	Seasonal formations	Montane formations	Dry evergreen formations	Seasonal swamp formations	Swamp formations
1	Evergreen seasonal forest	Lower montane rain forest	Dry rain forest	Seasonal-swamp forest	Swamp forest and Mangrove forest
2	Semi-evergreen seasonal forest	Montane rain forest	Dry evergreen forest	Seasonal-swamp woodland	Swamp woodland
3	Deciduous seasonal forest	Montane thicket	Dry evergreen woodland	Seasonal-swamp thicket	Swamp thicket
4	Thorn woodland	Elfin woodland	Dry evergreen thicket	Savanna	Herbaceous swamp
5	Cactus scrub	Paramo	Evergreen bushland		
6	Desert	Tundra	Rock pavement vegetation		

In the description of Jamaican communities given by Asprey and Robbins (1953), the vegetation of the island is broadly divided into Coastal, Lowland and Montane. As a categorization of the vegetation of the entire island, this paper has not been superseded. The main community types of Asprey and Robbins are compared with the equivalent Formation-Series of Beard in Table 2.

Table 2. The main vegetation types recognized by Asprey and Robbins (1953) and their equivalents in Beard's (1955) formation-series (adapted from Table 6, Asprey & Robbins (1953)).

Main vegetation types recognized in Jamaica (Asprey & Robbins)	Equivalent vegetation types in Beard's formation series
	1. OPTIMAL FORMATION
No equivalent	Rain forest
	2. SEASONAL FORMATIONS
Wet limestone forest?	Evergreen seasonal forest
Dry limestone scrub forest	Semi-evergreen seasonal forest
Thorn scrub	Thorn woodland
Cactus-thorn scrub	Cactus scrub
	3. DRY EVERGREEN FORMATIONS
Strand woodland	Dry evergreen woodland
	4. MONTANE FORMATIONS
Lower montane rain forest	Lower montane rain forest
Montane mist forest	Montane rain forest
Elfin woodland	Elfin woodland
Montane sclerophyll	No equivalent
	5. SWAMP FORMATIONS
Herbaceous swamp	Herbaceous swamp
Mangrove woodland	Mangrove forest
	6. SEASONAL SWAMP FORMATION
Marsh forest	Seasonal swamp forest
Palm-sedge marsh	Seasonal swamp woodland

However, further studies of individual community types in Jamaica have indicated that the categorization of Asprey and Robbins needs revision. These subsequent works are listed in Table 3.

Table 3. Detailed studies of Jamaican community types .

AUTHOR(S)	DATE	COMMUNITY
Adams & du Quesnay	1970	Hellshire hills vegetation
Asprey & Loveless	1958	Coastal formations
Loveless & Asprey	1957	Coastal formations
Coke et al.	1982	Morass vegetation
Grubb & Tanner	1976	Forests in the Blue Mountains
Healey	1990	Forests in the Blue Mountains
Howard & Proctor	1957	Vegetation over bauxite soils
Kapos	1986	Dry limestone forests
Kelly	1985	Epiphytes in wet limestone forest
Kelly	1986	Wet limestone forest
Kelly et al.	1988	Limestone forests
Loveless & Asprey	1957	Coastal vegetation
Proctor	1964	Morass vegetation
Proctor	1970	Savanna vegetation
Proctor	1986a	Cockpit Country vegetation
Proctor	1986b	Morass vegetation
Snell	1991	Forests in the Blue Mountains
Shreve	1910	Cays and mangroves
Shreve	1914	Forests of the Blue Mountains
Tanner	1986	Forests of the Blue Mountains

In view of the expansion of knowledge about Jamaican vegetation since the work of Asprey and Robbins (see Table 3), it is necessary to update and expand their classification. A contribution towards a new detailed classification scheme for Jamaica has been made during this Rapid Ecological Assessment.

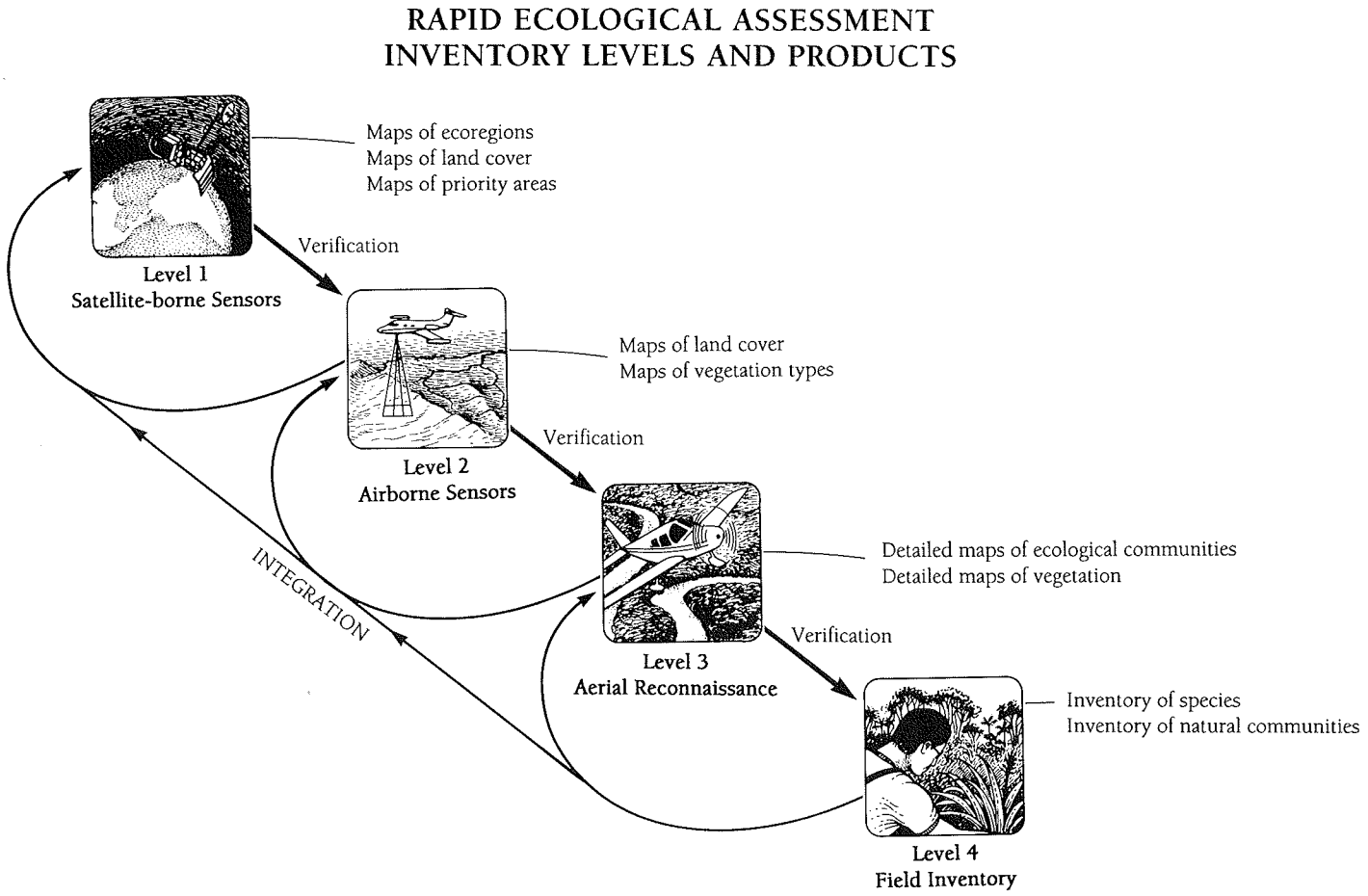

Figure 2. Rapid Ecological Assessment

D. Review of Resource Inventories Based on Imagery and Spatial Information Systems in Jamaica

Resource inventory and other applications based on aerial photography have been used successfully in Jamaica. The Rural and Physical Planning Unit (RPPU, 1988) used both black and white and color-infrared (CIR) aerial photography from 1979/80 and 1985/86 to perform comparative land use surveys. These surveys quantified land use changes for agricultural, forestry and watershed protection planning purposes. Kohout *et al.* (1979) used color and CIR photography and thermal imagery to detect submarine springs in the coastal waters of Jamaica. Huddleston (1979) applied remote sensing analysis to develop a sampling approach for agricultural and

resource assessment. Dual polarization synthetic aperture radar (SAR) imagery has also been used for vegetation type mapping in Jamaica (Keifer and Wessman, 1985).

In 1982, RPPU initiated a program to develop a national spatial resource database, the Jamaica Geographic Information System or JAMGIS. The original system was modeled after the Comprehensive Resource Inventory and Analysis System (CRIES) from Michigan State University. The current configuration of JAMGIS includes ARC/INFO, a vector GIS, and ERDAS, a raster GIS and image processing system. This sophisticated spatial data processing center enables RPPU and the Government of Jamaica to input and export data in most formats and to perform complex overlay analyses. Many of the REA tasks have been coordinated through RPPU.

E. Rapid Ecological Assessment

REA is an integrated methodology developed by The Nature Conservancy to direct the cost-effective acquisition, analysis, and application of conservation information. It has been developed in response to the need to carry out conservation planning in areas that are either expansive, poorly known, or are exceptionally diverse at a habitat or species level.

The REA process consists of a series of increasingly detailed analyses, with each step further defining those sites of high conservation interest (see Figure 2). Analysis of up-to-date imagery enables the development of an accurate characterization of the biological, physical, and social components of the landscape. This process is carried out through the sequential analysis of satellite images, aerial photographs, and existing thematic maps to delineate priority areas and potential threats.

The integration of airborne and satellite imagery analysis with additional thematic maps and tabular data significantly improves the accuracy of the classification (Saterwhite *et al.*, 1984; Wheeler and Ridd, 1985). The analytical products from appropriate imagery (aerial photography, videography and satellite imagery), are combined with existing information to direct cost-effective biological and ecological data acquisition through stratified field sampling. Field sampling stratified from the classification provides an efficient inventory approach that supports further analysis, monitoring, and planning needs (Franklin, 1987). The field studies efficiently build up more detailed biological and ecological information across the study areas.

The spatially referenced information is optimally managed through Geographic Information System (GIS) technology for ease of analysis and generation of map products (Koeln *et al.*, 1991). Other conservation information is managed through manual files and the Biological and Conservation Data (BCD) relational database system developed and supported by The Nature Conservancy.

Components of these REA methods have proven to be effective in classifying diverse landscapes throughout the western hemisphere. The Nature Conservancy has used REA to characterize the biological components of a barrier islands ecosystem in Virginia (Muchoney et al, 1991), and is currently applying REA to support conservation planning and inventory in Mato Grosso, Brazil, South Carolina, Georgia, New Mexico, and Venezuela. Within the Caribbean Basin, ecological studies based on multisensor approaches using accompanying field surveys have been undertaken in Puerto Rico (Sader et al, 1985). These approaches have also been used in Costa Rica (Sader and Joyce, 1985). The Virgin Islands Resource Cooperative uses aerial photography and map data to assess marine habitats and communities (Beets et al, 1986). Florida river flood plains have been monitored using Landsat data and aerial photo analysis with extensive field surveys (USGS, 1983).

Rapid Ecological Assessments are primarily applied by TNC to complement the information generation, analysis, and dissemination activities carried out by Conservation Data Centers and Natural Heritage Programs. A CDC has been established at the University of the West Indies in collaboration with the Planning Institute of Jamaica, the Jamaica Conservation and Development Trust, and The Nature Conservancy. This CDC provides an ideal environment to synthesize information generated by the REA, and will incorporate this information into the park planning process associated with the PARC project. The TNC database management system, Biological and Conservation Data system, installed at the CDC provides the capability to manage this conservation information.

The Jamaica REA is being conducted at two levels. A coarse-filter island-wide analysis will provide input into the system-wide national parks planning effort, and a detailed analysis of the two pilot parks will provide site specific inventory information for management and monitoring. Land cover/land use maps are being produced and special elements of biological diversity are being inventoried and characterized to establish long-term protection, management, and monitoring plans.

This report documents the process and results of Phase 1 of the REA, an island-wide characterization and mapping of the natural communities and modified vegetation types of Jamaica.

F. Project Objectives

There were five primary objectives of the island-wide REA of Jamaica:

1. To develop a classification and description of the natural communities and modified vegetation types of Jamaica.

2. To map these natural communities and modified vegetation types of Jamaica using current, high-resolution remote sensing data in conjunction with field inventory and verification.

3. To foster cooperative relationships among conservation partners in the inventory, management, analysis, and application of ecological and conservation data.

4. To provide classified map products, digital data sets, and written descriptions to conservation partners in Jamaica. Digital data sets will be archived at RPPU and CDC--JA to ensure their availability and hence, utility.

5. To develop data sets for later use in more detailed inventories and ecological characterization of individual parks in Jamaica under Phase 2 of the REA.

Methods

A. Development of Community Classification

The classification presented here (see Results section) follows the outline of major plant formations accepted by UNESCO (see Mueller-Dombois & Ellenberg, 1972). According to this system, the structure and spacing of the vegetation is of primary importance. The categories of major formations are listed below.

I. Closed forests
II. Woodlands
III. Scrub
IV. Terrestrial herbaceous communities
V. Deserts and other scarcely vegetated areas
VI. Aquatic plant formations (except marine)

In addition, an Urban/Industrial Class (VII) was used.

Within these major formations, the communities are differentiated using physiognomic as well as floristic criteria, which are influenced by environmental characteristics such as microclimate, topography and edaphic factors associated with site. As far as was possible, the published literature on Jamaican and other Caribbean vegetation types has been used for the characterization of the different communities. The literature review was reinforced though observations taken during the ground-truthing fieldwork that was associated with the verification of the imagery classes. Published accounts of ruderal and other "modified" communities are rare, and in this instance observations made in the field played a more prominent role in developing community descriptions. The major monocultures of commercial crops are included. A list of the community types is given at the start of the results section. The name of each of the smallest subdivisions is followed by a letter denoting affinity to the Cowardin et al. (1979) system as follows:

L = Lacustrine

P = Palustrine

R = Riverine

E = Estuarine

T = Terrestrial

M = Marine

Modified and secondary communities are marked with an asterisk. Urban and Industrial land cover classes are listed after the vegetated categories. Urban and Industrial lands are defined as those areas which have been so disturbed from their natural condition that they cannot be considered as natural or modified communities. This is a subset from a land cover classification developed by Anderson et al. (1976) and refined by Muchoney et al. (1990) to represent a comprehensive and continuous description of the landscape.

B. Application and Analysis of Spatial Data

Landsat Thematic Mapper (TM) data were acquired for the Island of Jamaica. The TM sensor acquires data relating to seven portions of the electromagnetic spectrum. The TM sensor and platform parameters are listed in Table 4. The image data for the island east of Kingston were from 22 November 1988 (Landsat WRS Path/Row 12/047 and 11/048) and those for the west from 12 December 1989 (Landsat WRS 12/047 and 12/048; Figure 3). These data sets were radiometrically corrected, rectified and registered to the prevailing Lambert Conical Orthomorphic map projection using the Jamaica Metre Grid with a 18 degree North Standard Parallel and the Clarke 1866 spheroid. The data were also merged to create a mosaic and used to produce a natural color photographic image. The root mean square error of the transformation was less than one pixel (28.5 meters).

Table 4. Landsat Thematic Mapper Sensor/Platform Parameters

Landsat 5

Orbit: Sun-synchronous

Orbit inclination angle: 98.22 degrees

Altitude: 705 kilometers (438 miles)

Swath: 185 kilometers

Standard Scene: 170 x 185 kilometers

Thematic Mapper

Spatial Resolution: 30 meters

Spectral Resolution:

BAND	WAVELENGTH (Micrometers)	DESCRIPTION
1	.45 - .52	Visible Blue
2	.52 - .60	Visible Green
3	.63 - .69	Visible Red
4	.76 - .90	Near-Infrared
5	1.55 - 1.75	Mid-Infrared
6	10.4 - 12.5	Thermal Infrared
7	2.08 - 2.35	Mid-Infrared

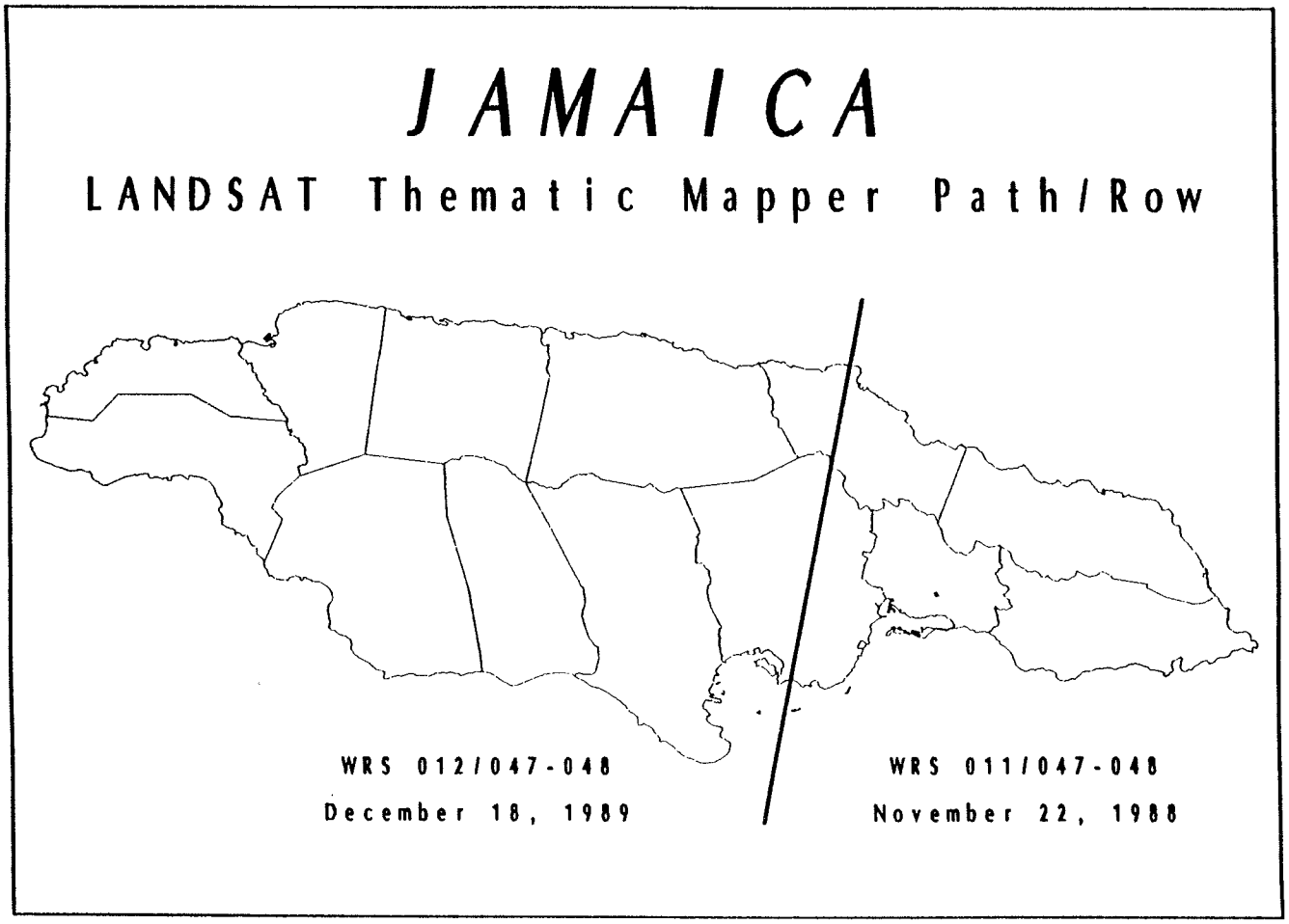

Figure 3. Satellite Imagery Acquired for Analysis

Collateral data were also obtained for the analysis from the GIS at RPPU. These data sets included digital terrain and soils data. The digital terrain data were used to generate slope, aspect, and elevation classes to use in describing and classifying the communities. The existing 1:250,000-scale geology map (Jamaica Geological Survey, 1984) was digitized and coded by TNC in ARC/INFO GIS format.

C. Image Processing and Classification

The island-wide characterization of land cover was performed using the Landsat Thematic Mapper data. The analysis was performed using ERDAS GIS and image processing software and ARC/INFO GIS software on SUN and PC work stations. There were two distinct components of the classification. The first was to use the TM

and collateral data to stratify the image for field sampling. The objective was to ensure that the complete range of natural and anthropogenic communities were being efficiently identified and sampled. The second component was to incorporate the field data into training statistics to guide the classification of the image data. Both computer generated and analyst-defined training statistics were used to classify the image data using a maximum-likelihood decision rule.

D. Field Verification

The field work comprised visiting representative examples of the communities to collect current information on the biological and ecological community, topography (slope, aspect, elevation), soils, and geology. These data were also used to verify the accuracy of the community classification maps. The field research was carried out by Susan Iremonger and Douglas Muchoney, with the assistance of Peter Reeson, Margaret Jones, Elaine Foster, and Jonathon Littau of CDC--JA, and Tom Goodland of the University of North Wales.

Data describing the biological, ecological, and environmental characteristics of the natural communities were collected. Systematic data collection using standardized forms ensured accuracy and the ability for data synthesis and analysis. This will also enable resampling at later dates as part of monitoring activities.

E. Accuracy Assessment

Reconnaissance flights and field inventory were undertaken to assess the accuracy of the land cover map and to evaluate potentially significant natural areas. The reconnaissance and field surveys were designed using stratified sampling of the computer-generated classes, which were further refined using topographic, soils and geologic data.

Mapping accuracy refers to polygons being correctly identified as a cover class. A quantitative assessment of accuracy will report within-class accuracy including errors of omission and commission.

Results

A. Community and Land Cover Classification

Plant Communities and other Land Cover Types: Outline

Modified and secondary communities are marked with an asterisk. The name of each of the smallest subdivisions is followed by a letter denoting affinity to the Cowardin et al. (1979) system.

I. CLOSED FORESTS
- Ia. Lower montane rain forest
  - Ia1. Wet limestone forest (T)
  - Ia2. Gully forest over shale or volcanic substrata (T)
  - Ia3.* Disturbed wet limestone forest (T)
  - Ia4.* Disturbed gully forest (T)
- Ib. Upper montane rain forest
  - Ib1. Forest over shale or volcanic rocks
    - Ib1.1. Typical type
      - Ib1.1.a. Typical variant (T)
      - Ib1.1.b. Selaginella variant (T)
    - Ib1.2. Mor ridge forest type (T)
    - Ib1.3. High altitude forest type (T)
  - Ib2. Upper montane wet limestone forest (T)
  - Ib3.* Disturbed forest over shale or volcanic rocks (T)
- Ic. Evergreen seasonal forest
  - Ic1. Mesic limestone forest (T)
  - Ic2.* Disturbed mesic limestone forest (T)
- Id. Dry semi-evergreen forest
  - Id1. Dry limestone forest (T)
  - Id2.* Disturbed dry limestone forest (T)
- Ie. Swamp forest
  - Ie1. Swamp forest (P)
  - Ie2. Riparian forest (P)
  - Ie3.* Disturbed swamp forest (P)
- If. Mangrove forest
  - If1. Mangrove forest (E)
  - If2.* Disturbed mangrove forest (E)
- Ig.* Commercial forest plantations
  - Ig1.* Pine plantations (T)
  - Ig2.* Broadleaved timber plantations (T)
  - Ig3.* Biomass plantations (T)

II. WOODLANDS
- IIa. Tropical woodlands
  - IIa1. Strand woodland (T)

IIa2.* Palm woodland (T)
IIa3.* Disturbed strand woodland (T)
IIa4.* Plantation woodlands
IIa4.1.* Citrus grove (T)
IIa4.1.* Coconut palm plantation (T)

III. SCRUBS
IIIa. Dry semi-evergreen thicket
IIIa1. Dry limestone thicket (T)
IIIa2.* Disturbed dry limestone thicket (T)
IIIb. Partly deciduous thorn thicket
IIIb1. Thorn thicket (T)
IIIb2.* Disturbed thorn thicket (T)
IIIc. Cactus thorn scrub
IIIc1. Cactus thorn scrub (T)
IIId. Montane scrub
IIId1. Montane limestone thicket
IIId1.1. Typical variant (T)
IIId1.2. Blue Mountains variant (T)
IIId2.* Disturbed mesic/dry scrub over shale (T)
IIIe. Mangrove scrub
IIIe1. Mangrove scrub (E)
IIIf.* Mixed subsistence agriculture with dwellings (T)
IIIg.* Commercial shrub plantations
IIIg1.* Coffee plantations (T)
IIIg2.* Papaw plantations (T)

IV. TERRESTRIAL HERBACEOUS COMMUNITIES
IVa. Tall-herb savanna
IVa1. Tall-grass flood savanna
Iva1.1. Sedge savanna (P)
Iva1.2. Riparian swale (P)
IVa2. Tall-grass montane savanna (T)
IVa3.* Guinea grass savanna (T)
IVa4.* Tall fern-dominated sward (T)
IVa5.* Tall herbaceous commercial crops
IVa5.1.* Sugar cane field (T)
IVa5.2.* Rice padi (P)
IVa5.3.* Banana plantation (T)
IVb. Short-herb savanna
IVb1. Mud flat
IVb1.1. Estuarine mud flat (E)
IVb1.2. Freshwater mud flat (P)
IVb2. Herbaceous salt marsh (E)
IVb3.* Molasses grass hillsides (T)

IVb4.* Short fern-dominated swards (T)
IVb5.* Pastures (T)
IVb6.* Pathside, bank and trail vegetation
IVb6.1.* Montane trail vegetation
IVb6.1.a.* Sunny montane trail vegetation (T)
IVb6.1.b.* Shady montane trail vegetation (T)
IVb6.2.* Lowland to mid-altitude trail vegetation (T)

V. DESERTS AND OTHER SCARCELY VEGETATED FORMATIONS
Va. Bare rock, with or without sparse vegetation
Va1. Bare rock (T)
Va2. Limestone pavement vegetation (T)
Vb. Bare sand, with or without sparse vegetation
Vb1. Bare sand (T)
Vb2. Pioneer beach vegetation (T)
Vc. Cliffs and landslides
Vc1. Seed plants and ferns predominant (T)
Vc2. Lichens and bryophytes predominant (T)
Vd.* Rock rubble and walls
Vd1. Rock rubble
Vd2.* Rocky wall vegetation

VI. AQUATIC PLANT FORMATIONS
VIa. Free-floating non-rooted fresh water communities (R/L)
VIb. Rooted floating-leaf communities (R/L)
VIc. Rooted underwater communities (R/L)
VId. Non-rooted underwater communities (R/L)

VII. URBAN/INDUSTRIAL CLASSES
VIIa. Residential/Business
VIIb. Industrial
VIIc.Transportation/Communication

Plant Communities and other Land Cover Types: Descriptions

I. CLOSED FORESTS

Communities formed by (generally scapose) trees at least 5m tall with their crowns interlocking. In tropical conditions the lowest canopy height that is still considered a forest would be 1.5m at high altitudes, and up to 8 or 10m in the lowlands where the trees grow to a higher stature, (Richards, 1952).

Ia. Lower montane rain forest (Beard, 1944; Richards, 1952; Grubb & Tanner, 1976)

Tree strata two, canopy between 15 and 33m, and a lower story 3-16m. Leaves are predominantly simple, notophyll or mesophyll, drip tips frequent or occasional, cauliflorous species rare. Thick-stemmed woody climbers are rare but other climbers often frequent, and vascular epiphytes are abundant.

Ia1. Wet limestone forest (Kelly *et al.* 1988)

Canopy 26-28m, understory 10-13m and a tree fern-dominated third stratum at 2-7m. Epiphytes and ground herbs are abundant. Soil colour yellowish brown, soil depth ca. 17.5cm, Ph 6.4 towards surface; 7.3 lower down, raw humus layer absent. Diagnostic species combination: *Calophyllum calaba, Calyptronoma occidentalis, Drypetes alba, Heliconia caribaea, Cyathea grevilleana. Pilea* spp. are abundant in the herb layer.

Ia2. Gully forest over shale or volcanic substrata (Grubb & Tanner 1976, Shreve 1914)

This forest type is considered an impoverished form of lower montane rain forest because it combines features of the true type (notophyll and mesophyll leaf size preponderance, some trunk buttressing, and a thick-stemmed woody climber), yet it is smaller in stature and has fewer species than well-developed representatives of this type, such as category Ia1.

Canopy height is 12-18m, with three species, *Laplacea haematoxylon, Solanum punctulatum and Turpinia occidentalis* contributing significantly to the forest structure. There is an understory in which smaller trees such as *Mecranium purpurascens, Psychotria corymbosa and Cestrum hirtum* are well represented, and tree ferns are very frequent, particularly *Cyathea pubescens*. This layer includes *Boehmeria caudata*, which is absent from the other forest types in the area (Ib1). The shrub layer includes *Besleria lutea, Piper arboreum, Piper fadyenii, Acalypha virgata* and *Tournefortia glabra*, and the thick-stemmed woody climber *Marcgravia brownei* is present. The windward (north-facing) gullies differ from those in the leeward (south-facing) gullies most noticeably in the abundance of pendent bryophytes and filmy ferns, as well as a more hygrophilous ground flora.

Soils have a discontinuous litter layer overlying a dark brown clay-loam with poor crumb structure to 10cm, gradually becoming lighter in colour with depth, pH 4.5-5, loss on ignition ca. 36%. This covers a yellow brown clay, pH 4.5-6, which reaches depths of 70cm-1m+.

Ia3.* Disturbed wet limestone forest

The forest Type Ia1 has been selectively cut for timber in some areas, leading to a less diverse flora and a structurally diminished form of the forest. Old forestry plantations occur with this Type; *Hibiscus elatus* or *Cedrela odorata* being the primary introduced economic species. Other cultivated species are *Musa* spp. (Banana) and *Cocos nucifera* (Coconut).

Ia4.* Disturbed gully forest

Gullies in the Blue Mountains tend to be less disturbed than slopes or ridges at a similar altitude. However in many gullies tall trees are no longer found, and tall weedy shrubs and small trees replace the original structure and species composition.

Ib. Upper montane rain forest (Richards, 1952; Grubb & Tanner, 1976; Grubb *et al.* 1963)

Tree strata one or two, 1.5-18m tall, dominant leaf size class microphyll. Trunk buttresses and cauliflorous species usually absent, Compound leaves on trees, drip tips and climbers usually few or none, and vascular epiphytes frequent.

Ib1. Forest over shale or volcanic rocks (adapted from Grubb & Tanner, 1976; Shreve, 1914)

Canopy height ranges from 1.5-13m, and trees characteristically lean over in sloping areas or in places with deep peat soil (see Mor ridge forest, Type Ib1.2). The dominant leaf sizes are microphyll and notophyll. Constant tree species are *Alchornea latifolia*, *Clethra occidentalis*, *Clusia havetioides*, *Cyrilla racemiflora*, *Ilex macfadyenii* and *Podocarpus urbanii*, although *A. latifolia* and *C. occidentalis* are absent at high altitudes (Type Ib1.3). In most areas there is a well developed but discontinuous shrub layer at 2-3m, composed chiefly of *Psychotria corymbosa* and *Palicourea alpina*. The herb layer is generally well developed, the most common being ferns and orchids, and the graminoids *Rhynchopora polyphylla* and *Zeugytes americana*. *Chusquea abietifolia* forms occasional dense thickets, and in places the cushion moss *Leucobryum giganteum* is locally abundant (Type Ib1.2). Thick woody climbers are absent, and climbers and scramblers are generally few in number. Woody hemiparasites such as *Dendropemon parvifolius*, *Dendrophthora opuntioides*, *Phoradendron*

flavens and *Eubrachion ambiguum* are probably frequent, but not readily visible.

With the exception of the soils in the Mor ridge forest type (Ib1.2), soils have a discontinuous layer of litter and a brown to dark brown clay loam A horizon extending to 10-30cm, Ph 3.5-4.6. This overlies a yellowish clay B horizon, ph 4.5-6. On slopes, the number of stones and rocks throughout the soil is noticeable. In the Mor ridge forests the soil is very different, having a continuous litter layer 1-2cm thick, and a deep (20-50cm) organic (LOI ca. 96%) horizon composed of acid mor humus, pH 2.8-3.5, overlying a yellowish clay B horizon.

Ib1.1. Typical type (Grubb & Tanner, 1976; Shreve, 1914)

This includes the forest types Mull Ridge, Wet Slope, and Very Wet Ridge described by Grubb & Tanner, and the Windward and Leeward slopes and most of the Ridge type described by Shreve. It is recognizable from the general description given above for Ib1. Characteristics which distinguish it from type Ib1.2 are the different soil types (see Ib1, above) the higher, more closed canopy (8-13m), fewer epiphytes, the presence of the tree species *Hedyosmum arborescens* and *Calyptranthes rigida*, and the tree ferns *Cyatha pubescens*, *C. furfuracea* and *C. woodwardioides*.

Ib1.1.a. Typical variant

This excludes the Very Wet Ridge forests described by Grubb & Tanner in the Mt. Horeb region. *Selaginella denudata* does not cover the forest floor as it does in those forests, and the shrub *Cephaelis elata* is absent.

Ib1.1.b. *Selaginella* variant

Differentiated from the above in the abundance of *Selaginella denudata* on the forest floor, the greater abundance of epiphytic bryophytes, and the presence of *Guzmannia fawcettii* and *Cephaelis elata*. Described by Grubb & Tanner (1976) as Very Wet Ridge Forest.

Ib1.2. Mor Ridge forest type (Grubb & Tanner, 1976).

This type is infrequent. The features which distinguish it from type Ib1.1 are the soil (see description in Ib1 above), a rather open canopy 5-7m tall with most of the trees leaning in all directions, the presence of the tree ferns *Blechnum underwoodianum* and *Cyathea gracilis*, and the composition of

the ground layer, in which are found an abundance of bromeliads and other plants which only grow epiphytically in the Typical type (Ib1.1), as well as *Leucobryum giganteum* cushions.

Ib1.3 High altitude forest (adapted from Shreve, 1914 and Grubb & Tanner, 1976)

The structure of this type is dominated by the stunted and gnarled morphology of the trees, and the abundance of the pendent moss *Phyllogonium fulgens*. Canopy height ranges from 1.5m to 6m, Floristically the forest is distinct from Types Ib1.1 and .2 in that some of the species of the lower altitude forests are absent, and others take their place. *Clethra occidentalis* is replaced by *Clethra alexandri*. *Alchornea latifolia* is absent, and *Eugenia alpina*, *Ilex obcordata* and *Myrsine coriacea* are abundant. The high altitude shrubs *Senecio swartzianus* and *Lobelia martagon*, and the tree fern *Cyathea harrisii* are present.

Ib2. Upper montane wet limestone forest (Grubb & Tanner, 1976)

Canopy 8-11m, trees upright, no buttresses or prop roots. Few trees with DBH >15cm. Notophylls and mesophylls dominate the leaf size spectrum. Ground layer may be dominated almost exclusively by *Diplazium costale*, 10-15 cm. Climbers are frequent, and epiphytes abundant. Many species of the lower forest type (Type Ia) are present such as *Calyptronoma occidentalis*, *Cordia elliptica*, and *Ardisia brittonii*, as well as *Solanum acropterum*, which has not been recorded in other montane forest types.

Ib3.* Disturbed forest over shale or volcanic rocks

The most notable feature of these disturbed forests is perhaps their vulnerability to invasion by certain aggressive introduced species. These plants threaten the forests not only by occupying the niche of one or two native species, but by their domination of the entire vegetation type by forming dense cover and preventing native species from regenerating. The most well-known and widespread of these are *Pittosporum undulatum*, *Hedychium gardneranum* and *Polygonum chinense*. In some areas the native forest vegetation has completely disappeared, and in its place is a monospecific scrub-land, described below (Type IIId2.*). Where forest was cleared for agriculture and then abandoned, grasslands dominated by the alien species *Melinis minutiflora* occur (described below, Type IVb3.*).

In areas where the structure of the vegetation is still forest, weedy disturbance indicator species such as *Cecropia peltata* and *Bocconia frutescens* occur. Some areas support old broadleaf plantations such

as *Hibiscus elatus*, which now form a structural framework for native forest plants.

Ic. Evergreen seasonal forest (Beard 1944, UNESCO 1972)

Trees mainly evergreen but some foliage reduction during the dry season is noticeable. Canopy height 14-30m with occasional emergent trees, understory 3-10m. Lianas are fairly abundant and epiphytes are rather well developed. Some buttressing. Predominant leaf size mesophyll, ground vegetation abundant.

Ic1. Mesic limestone forest (Kelly *et al.*, 1988)

Canopy 16-20m, with emergents to 24m. Floristically this forest is rich, and many tree species have equal importance in the canopy, although there are areas in which one may gain dominance. There is also great floristic variation in these forests, not only between hilltop, midslope and valley, but also between nearby sites of identical topographic situation. There is a high number of local endemic species, which may be confined to one hill in the countryside, despite having similar forest stands (i.e. habitat types on adjacent hills. As more studies are carried out in these forests they will undoubtedly be subdivided into some more definitive subtypes, according to differences in local species composition and structure, e.g. the presence/absence of *Podocarpus purdieanus* may be a sub-type indicating a lack of disturbance.

These forests have a precipitation regime between those of forest types Ia1 and Id1, and contain species characteristic of each of these communities. Some of the more frequent species are *Guapira fragrans*, *Bumelia nigra*, *Nectandra patens*, *Pisonia subcordata*, *Coccoloba swartzii* and *Cinnamomum montanum*. *Terminalia latifolia* and *Cedrela odorata* are occasional emergents. *Swietenia mahagoni* was frequent in these forests in the past, but is now rare. There are no tree ferns, and although the other fern flora is diverse, they do not contribute substantially to the cover of the ground layer. Epiphytes are abundant, and tank bromeliads occur down to ground level.

These forests lie over well-drained limestone karst hilly terrain. Soil is predominantly a reddish clay loam with accumulations of humus which can reach a depth of over 30cm.

Ic2.* Disturbed mesic limestone forest

Structurally this vegetation is less developed than the natural forest. The canopy generally is lower, and composed of many *Piper* spp. and melastomaceous shrubs. *Rhytidiadelphus squarrosus* and *Themeda arguens* are frequent in more open places. Ferns are abundant in the ground layer, and may even dominate, with virtually monospecific swards (see below, Types IVa4.* and IVb4.*).

Id. Dry semi-evergreen forest (adapted from Beard, 1944; 1955, Kelly *et al.*, 1988)

This is a forest type with canopy at 8-15m, with emergents. There is no pronounced shrub layer, but tree height varies within the canopy. Climbers are rare and there are few epiphytes. There is an extensive if patchily distributed seedling flora, but very few herbs. About 25% of the species are deciduous, and the predominant leaf size is microphyll.

Id1. Dry limestone forest (Kapos, 1986, Kelly *et al.*, 1988)

Well developed dry limestone forest has a canopy height of 8-15m with some emergents. A lower layer may or may not be present, and ground vegetation is sparse, except for the patchy seedling flora. In some areas *Thrinax parvifolius* becomes dominant both in the canopy and as juvenile individuals at lower levels. Common trees are *Metopium brownei*, *Ateramnus lucidus*, *Drypetes laterifolia*, *Bumelia salicifolia* and *Diospyros tetrasperma*. *Bursera simaruba* is a conspicuous emergent. Smaller phanerophytes include *Guettarda elliptica*, *Capparis flexuosa*, *C. ferruginea*, *Portlandia grandiflora* and *Oplonia armata*. *Stenocereus hystrix*, a stem succulent, is occasional locally, and the succulent climbers *Hylocereus hystrix* and *Selenicereus grandiflorus* are locally frequent. The orchid *Broughtonia sanguinea* is a noticeable epiphyte. This community grades into community Type IIIa., (dry semi-evergreen thicket) in coastal areas.

Soil is often only represented by accumulations of humus in the grykes of the limestone karst. Where mineral soil is present, it is generally of a reddish clay loam type.

Id2.* Disturbed dry limestone forest

Depending on the type of disturbance, the result may be a degraded forest or a scrub. The secondary forest becomes richer in thorny leguminous phanerophytes, giving the community a superficial resemblance to partly deciduous thorn thicket (Type IIIb). Epiphytes are less common than in the primary forest type. On limestone islands in the Negril and Black River morasses, *Sabal jamaicensis* is often dominant in this vegetation type.

Ie. Swamp forest (Beard, 1944)

Forest with a single tree story 20-30m high and rather open underneath. The ground is waterlogged for over half the year (frequently more) and the trees show root specializations such as stilt roots. There is little or no ground vegetation in the wetter areas, but in drier places the canopy thins and herbs become more frequent.

Ie1. Swamp forest (Asprey & Robbins, 1953; Beard, 1944; Coke *et al.*, 1980)

Canopy closed to rather open, dominated by *Symphonia globulifera* and *Roystonea princeps*, the latter becoming dominant in some areas. *Grias cauliflora* and *Calyptronoma occidentalis* are conspicuous as smaller trees, and herbs range from being absent to rather well-represented (graminoids) in more open stands. In many areas climbers are a prominent feature, including lush aroids as well as weedier species in more disturbed places.

Ie2. Riparian forest (Proctor, 1986)

This community has probably been completely destroyed, but its dominants were apparently an undescribed species of *Lonchocarpus*, and *Crudia spicata*. Other species included *Nectandra antillana*, *Eugenia fadyenii* and *Andira inermis*. The introduced *Haematoxylum campechianum* is now frequent, and the climbers *Combretum robinsonii* and *Tanaecium jaroba* are present. The herbs layer is often represented by *Crinum americanum*, *Hymenachne amplexicaulis* and *Panicum elephantipes*.

Ie.3.* Disturbed swamp forest

When swamp forest is disturbed but not completely changed (e.g. drained and planted over for agriculture) the canopy is less dense, and climbers are even more abundant than in the primary Type. The ground layer may become better developed, sedges an other herbaceous heliophytes increasing. *Roystonea princeps* is generally infrequent or absent, and the introduced species, *Spathodea campanulata*, has often colonized these areas.

If. Mangrove forest (UNESCO, 1972)

These forests are only found in areas with brackish water. They are composed almost entirely of evergreen sclerophyllous broadleaved trees and shrubs with either stilt roots or pneumatophores. Epiphytes are generally rare, except lichens on the branches and adnate algae on the lower parts of the trees.

If1. Mangrove forest (Beard, 1944; Asprey & Robbins, 1953)

Canopy can be up to 25m high, and is frequently a more or less monospecific stand of *Rhizophora mangle*. This species greatly influences the structure of the forests with its stilt roots. The forests usually have only one tree layer, and often have no ground layer because of the high water levels. Other mangrove species may be present, such as *Conocarpus erectus*, *Avicennia germinans*, and *Laguncularia racemosa*, but these are usually found in the mangrove scrubs (Type IIIe).

If.2.* Disturbed mangrove forest

Trees are generally shorter, and do not reach as far out into the water. Dominant species may be *Conocarpus erectus* instead of *Rhizophora mangle*.

Ig.* Commercial forest plantations

Ig1.* Pine plantations

Frequent in the Blue Mountains and in the centre of Jamaica, Pine plantations consist more or less exclusively of *Pinus caribbea*, although *P. hondurensis* is also found. There is no understory, and the condition of the shrub and ground layers depend upon the prevailing forestry practices.

Ig2.* Broadleaved timber plantations

Eucalyptus spp., *Hibiscus elatus*, *Cedrela odorata* and *Swietenia mahagoni* occur in old plantations. They generally are idle now and are reverting to secondary forest, or have been under-planted with coffee, as in the Blue Mountains.

Ig3.* Biomass plantations

These are experimental plantations of *Leucaena leucocephala* and *Calliandra portoricensis*. There is no ground layer.

II. WOODLANDS (Open stands of trees)

Formed by (generally scapose) trees at least 5m tall, with most of their crowns touching each other, but covering at least 30% of the surface; grass cover sometimes present. Height criteria vary as for CLOSED FORESTS.

IIa. Tropical woodlands

Ground layer varies from being a thick tangle of climbers over herbs to herb-dominated, to virtually absent.

IIa1. Strand woodland (Asprey & Robbins, 1953)

Relatively species-poor woodland, ca. 4-8m tall. Predominant tree leaf size is mesophyll. Constant tree species are *Coccoloba uvifera* and *Thespesia populnea*, which are often in combination with *Conocarpus erectus*, *Dalbergia ecstaphyllum*, *Colubrina asiatica*, *Morinda citrifolia*, *Piscidia piscipula*, *Sophora tomentosa* and *Hippomane mancinella*. *Thrinax parviflora* is sometimes a conspicuous element. The herb layer is frequently completely absent. Soil may have a litter layer on the surface, underneath which lies sand with organic matter mixed into the upper horizon. This may be underlain by limestone rock.

IIa2.* Palm woodland (adapted from Beard, 1944)

Disturbed woodlands in which the aspect is dominated by palms,

on soils with poor drainage. Dominant (palm) species may be *Roystonea princeps* or *Sabal jamaicensis*, or the palmetto, *Thrinax* spp. The ground layer is dominated by graminoids, and climbers may be abundant. Where there is a marked coastal influence, *Batis maritima* may dominate the ground layer.

IIa3.* Disturbed strand woodland

Weedy herb species are a noticeable component of the ground layer, e.g. *Spilanthes urens*, *Sida* spp.,*Wedelia* spp. The small trees *Crescentia cujete* and *Tecoma stans* are more frequent than in undisturbed areas, and *Cocos nucifera* is often planted.

IIa4.* Plantation woodlands

IIa4.1.* Citrus grove

Dominated by *Citrus* spp., with a grassy ground layer and, in older plantations, a rich epiphyte flora.

IIa4.2.* Coconut palm plantation

Dominated by *Cocos nucifera*, usually with a ground layer of grasses.

III. **SCRUBS** (Shrublands or thickets).

Mainly composed of caespitose woody phanerophytes 0.5-5m tall. In tropical areas, scrub may reach to 10m. In shrublands, most of the individual shrubs do not touch each other, in thickets they do.

IIIa. Dry semi-evergreen thicket

Scrub in which a significant proportion of the species lose their leaves in the dry season.

IIIa1. Dry limestone thicket (adapted from Beard, 1944; Loveless & Asprey, 1957; Asprey & Loveless, 1958; Kelly *et al.*, 1988)

This is a diminutive, coastal version of Type Id1, Dry limestone forest. As such it supports an arid element in the columnar cactus *Stenocereus hystrix*, some strand woodland trees growing in a stunted fashion (*Hippomane mancinella*, *Cordia sebestena*, *Capparis ferruginea*, *Pithecellobium unguis-cati*) as well as the characteristic species *Coccothrinax fragrans*, *Thrinax multiflora*, *Croton linearis*, *Phyllanthus angustifolius*, *Erithalis fruticosa*, and *Jacquinia arborea*.

Substratum is generally limestone karst, with some places where sand has blown over the rocks and formed a rudimentary soil.

IIIa2.* Disturbed dry limestone thicket (adapted from Stoffers, 1956)

This coastal variant of dry limestone forest is in some areas replaced by a low (to 1.5m) scrub, dominated by any combination of: *Croton*

linearis, *Borrichia arborescens*, *Morinda royoc*, *Jatropha gossypiifolia* and/or *Lantana* spp., with the climber *Jacquemontia pentantha* locally frequent.

IIIb. Partly deciduous thorn thicket

Thorny leguminous phanerophytes predominate from 3-10m tall. Leaves are mostly microphyll, and often show additional adaptations for decreasing transpiration. The phanerophyte flora is poor.

IIIb1. Thorn thicket (Beard, 1944; Asprey & Robbins, 1953).

Vegetation dominated by thorny leguminous phanerophytes 3-10m tall. Diversity is not high, with *Prosopis juliflora* often composing 75% of the cover. Most species show partial defoliation in the extreme dry period.

Common tree species are *Prosopis juliflora*, *Acacia tortuosa*, *A. macrantha*, *Haematoxylum campechianum*, *Caesalpinia vesicaria* and *Guaiacum officinale*. Shrubs include *Capparis ferruginea*, *Cassia emarginata*, and *Brya ebenus*, and the ground bromeliad *Bromelia pinguin* is locally frequent. There are many xerophytic epiphytes, and the climbing cacti *Selenicereus grandiflorus* and *Hylocereus triangularis*. Ground flora is sparse.

Soil is characteristically alluvial clay, and drainage may be poor, leading to ponding in certain areas in wet weather. This accounts for records of rare mud-loving plants in areas such as Harris Savanna (e.g. *Isoetes jamaicensis*, *Eleocharis oligantha*), in which the general character of the vegetation is xeromorphic thorn scrub.

IIIb2.* Disturbed thorn thicket

Many of the dominant leguminous thorny species regenerate easily from cut stumps. This renders this vegetation type resistant to change by cutting. However, a very distinct variant with impeded drainage dominated almost exclusively by *Mimosa pigra* was observed in the Negril morass. In the Upper Black River morass, the introduced *Callistemon* spp. forms thickets on the dikes, often associated with *Amaranthus australis*.

IIIc. Cactus thorn scrub (Asprey & Robbins ,1953; Beard, 1944)

This is an open community with a relatively simple structure. It consists of two layers, an upper layer of columnar cacti and thorny shrubs at about 3m, and a lower layer of undershrubs to about 1m, often with a few ephemerals.

IIIc1. Cactus thorn scrub (Asprey & Robbins, 1953; Beard, 1944; Loveless & Asprey, 1957)

Diagnostic species for this community in Jamaica are *Stenocereus hystrix*, *Cephalocereus swartzii*, *Acacia tortuosa* and *Opuntia tuna*. *Ayenia magna* may be dominant in the lower layer, with the barrel

cactus, *Melocactus communis*, occasional. Substratum is impoverished sand, gravel or rocks. Where there is a greater depth of soil, *Prosopis juliflora* occurs and the community is transitional to Type IIIb, partly deciduous thorn thicket.

IIId. Montane scrub (adapted from Grubb & Tanner, 1976; Beard, 1944)

Thickets developed in montane areas where the soil is impoverished, giving rise to some stunting of phanerophytes, as well as a sizeable representation of shrubs.

IIId1. Montane limestone thicket (Adapted from Grubb & Tanner, 1976; Asprey & Robbins, 1953)

Canopy 2-7m, composed of spindly shrubs and small trees which are rooted in fissures in the limestone. Some of these are *Clethra occidentalis*, *Clusia havetioides*, *Picramnia antidesma*, *Columnea hirsuta*, *Zanthoxylum* spp.

IIId1.1. Typical variant (as yet not described in detail, but a sketchy description given by Asprey & Robbins, 1953)

Occurs in areas of high rainfall at >1,000m in the John Crow Mts. Canopy 5-7m. May be dominated by *Clusia havetioides*. *Conostegia icosandra*, *Viburnum alpinum* and *Wallenia venosa* are also present, along with the herbs *Lobelia grandiflora*, *Pilea grandiflora* and *Psychotria discolor*.

IIId1.2. Blue Mountains variant (Grubb & Tanner, 1976)

Found on limestone outcrops in the Blue Mountains, best known example is on SE side of John Crow Peak, where isolation has given rise to the local endemics *Zanthoxylum hartii* and *Salvia jamaicensis*. Canopy 2-4m.

IIId2.* Disturbed mesic/dry scrub over shale

Phanerophyte height generally 1-4m, density is extremely variable, ground layer with graminoids. This impoverished vegetation is recognizable through the number of weedy introduced species which generally dominate. Common woody species are *Moghania strobilifera*, *Guazuma ulmifolia*, *Lantana* spp., *Conostegia* spp., *Datura suaveolens*, *Piper* spp., *Dunalia arborescens*, *Solanum torvum*, *Senecio discolor* and *Baccharis scoparia*. In the region of the Central Inlier, the transition from this vegetation to that over limestone is marked by the presence in the former of *Rondeletia amplexicaulis*, a local calcifuge endemic. Here and there clumps of bamboo (*Bambusa vulgaris*) occur. At medium to high altitudes, *Rubus* spp. form impenetrable thorny tangles in areas which have been burned, and the species *Hedychium gardneranum* and *Polygonum chinense* can form monospecific stands.

IIIe. Mangrove scrub (adapted from Beard, 1944; Tomlinson, 1988)

This is a diminished form of the Mangrove forest described above. Mangrove species with their physiognomic adaptations to brackish habitats dominate, but may not form a closed canopy.

IIIe1. Mangrove scrub (Asprey & Robbins, 1953; Chapman, 1944)

In Jamaica this scrub supports stunted or underdeveloped representatives of *Rhizophora mangle*, *Avicennia germinans* and *Laguncularia racemosa*. *Conocarpus erectus* may dominate in some places. The giant ferns *Acrostichum aureum* and *A. danaeifolium* are locally dominant. This is transitional to community Type IVb2, Herbaceous salt marsh. Some herbs occur, e.g. *Fimbristylis* spp., *Sporobolus virginicus*, *Spilanthes urens*, *Lippia nodiflora*.

IIIf.* Mixed subsistence agriculture with dwellings

This commonly has the physiognomy of a scrub formation, and is therefore included here. It often encompasses herb-dominated areas as well as scattered trees. Common non-farm trees are *Spathodea campanulata* and *Cecropia peltata*. Among the more common farmed trees are *Mangifera indica*, *Artocarpus altilis*, *A. heterophyllus*, *Citrus* spp., *Manilkara* spp., *Chrysophyllum cainito*, *Syzigium* spp., *Persea americana*, *Coffea arabica*, *Theobroma cacao*, *Bixa orellana* and *Blighia sapida*. Shrubs and herbs include *Capsicum* spp., *Dioscorea* spp., *Allium* spp. and *Thymus vulgaris*.

IIIg.* Commercial shrub plantations

IIIg1.* Coffee plantation

Coffea spp. dominant, sometimes intercropped with *Musa* spp. (banana), ground layer may or may not be present.

IIIg2.* Papaw plantation

Carica papaya dominant, with a graminoid ground layer.

IV. TERRESTRIAL HERBACEOUS COMMUNITIES

Grasses, graminoid and other herbaceous plants are predominant in the cover, but woody plants may be sparingly present (not covering more than 30%).

IVa. Tall-herb savanna (UNESCO, 1972)

Dominated by broad-leaved and tall graminoids. Hemicryptophytic caespitose forms most frequent.

IVa1. Tall-grass flood savanna (UNESCO, 1972; Beard, 1944)

Land is periodically inundated in various mosaic patterns, with palms and groups of other trees on raised positions.

IVa1.1. Sedge savanna (Proctor, 1986; Coke *et al.*, 1980)

Open wet savanna dominated mainly by the sedge *Cladium jamaicense*. This often forms pure stands, but in some places

is partly or wholly replaced by other sedges, of which various species of *Rhynchospora*, *Scirpus* and *Eleocharis* are conspicuous. The presence of scattered *Sabal jamaicensis* palms in some areas may denote a separate community of Palm sedge savanna.

IVa1.2. Riparian swale (Proctor, 1986)

Non-woody thickets along river margins. Diagnostic species *Phragmites australis* may form pure stands, or it may be partly or fully replaced by other tall graminoids such as *Typha angustifolia*, *Cladium jamaicense*, *Cyperus giganteus*, *Scirpus validus*, *S. olneyi*, and *Fuirena umbellata*. The introduced *Alpinia allughas* forms monospecific stands in some places, and *Thalis geniculata* is locally dominant. *Sagittaria lancifolia* is locally frequent, and climbers twine abundantly.

IVa2. Tall-grass montane savanna (Shreve, 1914; Asprey & Robbins, 1953)

Grassland dominated by caespitose high altitude grass *Danthonia domingensis*, which forms an almost monospecific stand at to about 1m. Confined to the N side of High Peak in the Blue Mountains.

IVa.3.* Guinea grass savanna

Sward dominated by *Panicum maximum*, with *Mangifera indica*, *Samanea saman*, *Delonix regia* and/or an occasional *Solanum torvum*, creating a parkland appearance.

IVa4.* Tall fern-dominated sward

Generally dominated by *Pteridium aqiulinum* or *Gleichenia* spp.; may be perpetuated by burning.

IVa5.* Tall herbaceous commercial crops

IVa5.1.* Sugar cane field

Dominated exclusively by *Saccharum officinarum*.

IVa5.2.* Rice padi

Dominated exclusively by *Oryza sativa*.

IVa5.3.* Banana plantation

Dominated exclusively by *Musa spp.*

IVb. Short-herb savanna (UNESCO, 1972)

Dominated by narrow-leaved and more or less short graminoids.

IVb1. Mud flat

Plants generally <30cm tall. Plants often widely spaced, with expanses of bare mud between. Annuals/ephemerals more frequent than in Type IVa, above.

IVb1.1. Estuarine mud flat

Small sedges dominate (e.g. *Fimbristylis cymosa*), accompanied by halophytic forbs, e.g. *Salicornia virginica*, *Batis maritima* (which can form swards) and *Sesuvium portulacastrum*.

IVb1.2. Freshwater mud flat

Generally ephemeral or hemicryptophytic herbs dominate, e.g. *Marsilea berteroi*, *M. polycarpa*, *Heteranthera limosa*, *Ludwigia peploides*, and some small sedges.

IVb2. Herbaceous salt marsh

Plants forming a dense mat of vegetation, graminoids mixed with forbs, often fleshy-leaved. Height about 30cm. Dominant species are sedges and the forbs *Sesuvium portulacastrum*, *Portulaca halimoides*, and *Lippia nodiflora*,

IVb3.* Molasses grass hillsides

Hillsides dominated by *Melinis minutiflora* in the east of Jamaica, with the occasional shrub and clump of bamboo (*Bambusa vulgaris*).

IVb4.* Short fern-dominated swards

Nephrolepis spp. dominant, particularly the recently naturalized *N. multiflora* (earliest collection apparently 1948); may in all cases be perpetuated by burning.

IVb5.* Pastures

Pastures are used for grazing cattle, goats and other animals, and are generally dominated by such pan-tropical grasses as *Cynodon dactylon*, *Chloris petraea*, *Setaria barbata*, *Digitaria ciliaris* and *Andropogon glomeratus*. Trees of secondary formations are often present, such as *Samanea saman*, *Cocos nucifera*, *Delonix regia*, *Casuarina equisetifolia* and *Mangifera indica*.

IVb6.* Pathside, bank and trail vegetation

Pathsides and trails are inhabited by low herbs, the species dictated by altitude and planimetric location. Many naturalized adventives occur in these widespread communities.

IVdb6.1.* Montane trail vegetation

IVb6.1.a.* Sunny montane trail vegetation

Characterized by the distinctive combination of temperate grassland species and some other very common introductions such as *Briza* spp. and *Trifolium* spp., many composites and some umbellifers such as *Taraxacum* spp., *Senecio vulgaris*, *Daucus carota*, *Pastinaca sativa*; *Trimezia vulgaris*, *Aristea*

gerrardii and *Calceolaria chelidonioides*. *Lycopodium clavatum* is locally dominant.

IVb6.1.b.* Shady montane trail vegetation

Shade-loving *Pilea* spp. such as *P. grandifolium* and *P. nigrescens* dominate the banks. *Sphagnum* spp. occur in this habitat in Jamaica, along with some orchids. Large sedges are frequent (*Rhynchospora* spp.).

IVb6.2.* Lowland to mid-altitude trail vegetation

Themeda arguens is locally dominant. Small chamaephytes (e.g. *Sida* spp., *Stylosanthes hamata*) are occasional to frequent among the herbs. Creeping species are often abundant, e.g. *Antigonon leptopus* (introduced), and *Desmodium* spp.

V. DESERTS AND OTHER SCARCELY VEGETATED FORMATIONS

Bare mineral soil determines the aspect more or less constantly. Plants are scattered or may be absent.

Va. Bare rock with or without sparse vegetation

Va1. Bare rock

Va2. Limestone pavement vegetation (adapted from Asprey & Loveless, 1958)

This is a low, usually well-spaced community over limestone rocks at the seashore. The plants are adapted to this habitat with leathery microphyllous leaves, or leaves which are tomentose and/or succulent. Characteristic chamaephytes are *Argusia* (formerly *Mallotonia*) *gnaphalodes*, *Borrichia arborescens*, *Ernodea littoralis*, *Jacquinia keyense*, *Morinda royoc*, *Rachicallis americana* and *Suriana maritima*. *Conocarpus erectus* and some other large phanerophytes grow in a very stunted fashion here. There are a few creeping herbs such as *Canavalia maritima* and *Sesuvium portulacastrum*.

Vb. Bare sand with or without sparse vegetation

Vb1. Bare sand

Vb2. Pioneer beach vegetation (Asprey & Robbins, 1953)

The beach sands of Jamaica are highly calcareous, containing high proportions of weathered and pulverized limestone and coral rock, together with sea shells and calcareous algae. In a few localities, the sand is composed primarily of *Halimeda* remains. Vegetation is composed primarily of hemicryptophytes which tolerate the shifting sand environment, as well as the salt influence. Succulence is often a feature.

This pioneer community begins above the tidal limits on initially, and potentially, mobile sand. The important plants are low herbaceous halophytes and psammophytes with quick vegetative propagation by runners. *Ipomoea pes-caprae* flourishes on the mobile sand front and, together with *Sporobolus virginicus*, is diagnostic of this community. Also usually present are *Cenchrus tribuloides*, *Paspalum vaginatum*, *Sesuvium portulacastrum*, *Cakile lanceolata*, *Scaevola plumieri*, *Euphorbia mesembranthemifolia* and *Portulaca halimoides*.

Vc. Cliffs and landslides

Rocks and large stones are the substratum in these communities. Where soil accumulates, vegetation becomes denser and tends towards the surrounding community type.

Vc1. Seed plants and ferns predominant

Perennial higher plants dominate, rooted in fissures of rocks. The species composition depends upon the location of the area, e.g. near to the sea *Coccoloba uvifera*, *Conocarpus erectus* and/or *Plumeria obtusa* may occur; in the Cockpit Country *Gesneria acaulis* may be the dominant plant; at higher altitudes over shale, bromeliads and *Pilea microphylla* form a particular type. In more disturbed areas, this vegetation tends to communities of trails, Type IVb6.*.

Vc2. Lichens and bryophytes predominant

On the shale/volcanic rocks at higher altitudes, lichens frequently form a community on bare rocks. Fruticose genera recorded are *Cladonia* and *Usnea*, the foliose *Sticta*, and crustose species are also present.

Vd.* Rock rubble and walls

Generally fern-dominated sparsely vegetated formations.

Vd1.* Rock rubble

This is most often seen as the rubble remains from road making exercises. Dominant fern is *Pteris longifolia*, other common plants are *Wedelia* spp, *Spilanthes urens*, *Portulaca oleracea* and *Cynanchum* spp.

Vd2.* Rocky wall vegetation

Polypodium spp. may dominate along with *Bryophyllum pinnatum*, and orchids are locally frequent on older walls. In places with older decorative gardens, *Ficus pumila* may dominate.

VI. AQUATIC PLANT FORMATIONS (except marine formations)

Composed of rooted and/or floating plants that endure or need water covering the soil constantly or at most times of the year. The following subdivisions often occur in an intermixed fashion. Rooted emergent vegetation such as reed beds are included under IV, TERRESTRIAL HERBACEOUS COMMUNITIES.

VIa. Free-floating non-rooted fresh water communities (UNESCO, 1972)

Mat-forming plants such as *Eichornia crassipes* dominate, others are *Nymphaea ampla* and *Nymphoides indica*, or the smaller plants *Pistia stratiotes* and/or *Lemna* spp.

VIb. Rooted floating-leaf communities (UNESCO, 1972)

Composed chiefly of aquatic plants that are rooted, with floating leaves, e.g. *Potamogeton fluitans*.

VIc. Rooted underwater communities (UNESCO, 1972)

Comprised of aquatic plants that are structurally supported by water, e.g. communities with *Ludwigia repens*.

VId. Non-rooted underwater communities (UNESCO, 1972)

Characterized by such plants as *Utricularia foliosa*, *Cabomba piauhiensis* and *Ceratophyllum demersum*.

VII. URBAN/INDUSTRIAL CLASSES

VIIa. Residential/Business

High to low density urban residential/business and linear development along roads and shorelines.

VIIb. Industrial

Includes mining and primary processing at extraction sites, raw materials stockpiles, chemical and petroleum industries, tank farms, industrial waste treatment facilities.

VIIc. Transportation/Communication

Includes highways, secondary roads, railways and parking lots and airports.

B. Classified Vegetation and Land Cover Map of Jamaica

Using the classes described above, a vegetation and land cover map was developed for Jamaica (see inserted map, Figure 4).

Discussion

REA Products and Applications

A primary objective of this project has been the collection of critical biological and conservation information across the Island of Jamaica, and the synthesis of this information into products that will improve conservation planning, training, and education. No matter how thorough the information collection and analysis phases of the project, the success of this project will depend upon the dissemination of information as useful products. The products from Phase 1 of the REA include the updated classification and characterization of the natural and modified communities, the digital and hardcopy Landsat TM image data, and the classified digital and hardcopy cover maps.

The updated classification produced 69 types under the headings: Forests [22], Woodlands [5], Scrubs [12], Terrestrial Herbaceous [17], Deserts and other scarcely vegetated communities [7], Aquatic [4] and Urban/Industrial [3]. This includes 38 natural and 31 modified cover types.

The actual data and their associated data management systems are:

Spatial Databases

1. Land Cover
2. Community Classification
3. Land Use

Textual Database: Biological and Conservation Data System (BCD)

1. Elements of Biological Diversity: Species and Communities
2. Site Information
3. Protected Area Information

The REA products support a vast array of applications. The cover maps can be analyzed manually or within a GIS for area calculations and to highlight classes of interest for further analysis. Both the raw and classified image data can support planning at the park level by providing a comprehensive description of prevailing land cover and use.

By definition, a Rapid Ecological Assessment is a process of consecutive steps of finer resolution that produce biological and conservation data as needed to guide conservation action. The results of this phase of the Jamaica REA are intended to be used as a framework for further research and applications in resource management. The classified maps are released as a first edition, and are intended to be updated as additional information and resources become available.

The investigators solicit comments and recommendations on both the product and process, so that this and future assessments might better meet the needs of the conservation community in Jamaica.

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