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HERBARIUM OF THE VIRGIN ISLANDS NATIONAL PARK: CONSOLIDATION AND CURATION OF A REFERENCE COLLECTION

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ABSTRACT

This report documents the establishment of a reference collection of vascular plants indigenous to or naturalized on St. John, based on collections made by Roy O. Woodbury and associates, largely in 1983 and 1984. Determinations were made almost exclusively by Woodbury. The collections were consolidated, curated and organized by the Virgin Islands Cooperative Extension Service (VICES) under contract to the Virgin Islands Resource Management Cooperative (VIRMC). The St. John reference collection (herbarium) is physically housed at the Virgin Islands Biosphere Reserve Center, Lind Point, St. John, with the voucher (and reference) collections of other organisms.

The Woodbury collection consists of at least 600 species distributed among 99 families, represented by some 1156 mounted specimens (List A of Reference Herbarium List). Sterile specimens in the collections are listed separately in List B. As a convenience and cross-reference, synoptic lists of the included families are provided in phylogenetic and alphabetical order (Lists C and D).

An additional 210 species are listed separately (Appendix I) as sight records, so that the total flora recorded stands at 810, including at least six new species and 12 rare, endangered species. The lists include numbers of specimens per species, and of specimens with inflorescence and/or fruit. Additional fern species noted by G. B. Proctor in 1984, but not in the reference collection, are noted in Appendix II. The VICES retained 185 species (186 sheets) of plants for which there were sufficient numbers of mounted specimens (Appendix III). The entire project served the important goal of enhancing the capability of the University of the V.I. in serving the public in plant-related information outreach through the VICES.

Finally, an overview is presented of floristic studies (published, unpublished, and in progress) on St. John and the Virgin Islands. Information is summarized on existing herbarium collections, floral revisions in progress, endangered species of plants, vegetational structure, and living plant collections in the Virgin Islands.

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INTRODUCTION

In connection with the establishment of the Virgin Islands Biosphere Reserve, a comprehensive series of coordinated research projects has been implemented to support environmentally acceptable management of terrestrial and marine resources (e.g., Putney 1986b, Rogers and Zullo 1985). Many of these studies generate, or should generate, voucher specimens in a biological reference collection. Such a collection has been developed for marine macrofauna and macroflora as part of the V.I. National Park Marine Specimen Collection (Beets and Lewand 1985).

Voucher specimens ensure that identification of organisms studied can be verified and corrected if necessary, even in cases where a study cannot be repeated (e.g., Lee et al., eds., 1982). Herbarium collections are an archetypal source of voucher specimens.

In 1982-83, comprehensive botanical field surveys and collections were undertaken by Roy O. Woodbury on St. John for the V.I. National Park. Several repeat visits at various times of the year were made until 1986, to obtain a phenologically more representative collection, i.e., so the number of specimens with inflorescences and other critical structures would be maximized. The objectives of that study were in part to (Weaver and Woodbury 1982a and b) Woodbury and Weaver 1984):

a. Collect and identify as complete a set of herbarium specimens as possible, including natural and naturalized species of herbs, shrubs and trees;

b. Develop a complete species list, indicating the relative abundances by vegetation type;

c. Find and characterize the status of rare and endangered species, and

d. Obtain appropriate collections of new species found.

By this means, it was expected that a consistent and reasonably exhaustive baseline record of the natural terrestrial vegetation of St. John would be established. Thus, a definitive reference and voucher collection would be available to future researchers and the interested public.

The collecting trips and processing of specimens were undertaken in collaboration with several other agencies: Institute of Tropical Forestry, New York Botanical Garden, the University of the Virgin Islands, the Virgin Islands National Park, and the Department of Natural Resources, Puerto Rico.

This is the final report on the contract to the V.I. Cooperative Extension Service for the project to evaluate, document and curate Woodbury's collections as a baseline reference herbarium for the V.I. Biosphere Reserve.

Consistent with the education and training objectives of the V.I. Biosphere Reserve (e.g., Putney 1986a), and as the informal education branch of the University of the Virgin Islands, the V.I. Cooperative Extension Service took the opportunity of processing the Woodbury collection to strengthen its herbarium and to enhance its plant-related educational activities provided as a community service.

OVERVIEW OF BOTANICAL ACTIVITY IN THE VIRGIN ISLANDS

Botanical exploration in the Virgin Islands has been unusually extensive, beginning in the 1700s. The number of studies conducted on all aspects of the terrestrial flora of the Virgin Islands exceeds 200 (Highfield et al. in prep.), and floristics studies involving St. John material number around 40. The most significant recent descriptive floras of the Virgin Islands include the Britton and Wilson (1923-30) "Flora of Porto Rico and Virgin Islands" series, with nomenclatural revisions by Liogier (1965, 1967) and Fosberg (1976); Little and Wadsworth (1964), Little, Woodbury and Wadsworth (1974, 1976); Woodbury and Little (1976). Many of the more important sources through 1970 are listed in Rundel's (1974) Annotated Bibliography of West Indian Plant Ecology.

A recent systematic synopsis of the flora of Puerto Rico and the Virgin Islands is provided by Liogier and Martorell (1982). Excellent reviews of the history of botany in these islands are available in Martorell et al. (1981) and Stevenson (1975). Among the most useful recent floras of the region are those of the Bahamas (Correll & Correll 1982), Hispaniola (Liogier 1982-83), Lesser Antilles (Howard 1974-79), and Jamaica (Adams 1972). The flora of Anguilla and other "limestone Caribbees" of the northwestern Leeward Islands was recently assessed by Howard and Kellogg (1987).

A few technically rigorous publications designed for more general audiences are also available. For example, a profusely illustrated paperback on trees for urban use in Puerto Rico and the Virgin Islands was published by Schubert (1979). "Avid natural history buffs" will find the field guide to the common trees and large shrubs of Puerto Rico by Ashton (1985) of interest.

An interesting treatment of about 130 St. John plants of economic significance was presented by Woodworth (1943); it deals mainly with indigenous species used for purposes such as fish bait, dye, soap, wood, fiber, or utensils, and plants with ornamental, weedy, or medicinal properties.

Information on vines of the region has been difficult to obtain until recently, when, in a very useful contribution, Acevedo-Rodriguez and Woodbury (1985) produced the first of a two volume series on the vines of Puerto Rico. This volume treats 150 of ca. 300 species, including a discussion of the ecological importance of vines in tropical forests.

Virgin Islands herbarium collections

Despite the comparatively active investigation of the Virgin Islands flora, no single comprehensive herbarium collection or flora of any of the individual islands has been available in the Virgin Islands. The most complete herbaria in the V.I., besides the St. John reference collection at the V.I. National Park (Biosphere Reserve Center), are to be found at the following V.I. institutions:

St. John: V.I. Ecological Research Station.

St. Thomas: Extension Diagnostic Lab., V.I. Cooperative Extension Service, University of the Virgin Islands. Includes portions of the Woodbury series of the St. John flora (Appendix III) and Bryophyta collected by W.R. Buck, N.Y. Botanical Garden.

St. Croix: (1) Extension Diagnostic Lab., V.I. Cooperative Extension Service, University of the Virgin Islands. Strength in grasses and weeds.

(2) Division of Fish & Wildlife, V.I. Department of Planning and Natural Resource Management, Frederiksted.

(3) West Indies Laboratory, Teague Bay.

Most if not all of these collections have been reviewed, identified or confirmed by one or more of the botanists F. R. Fosberg, R. O. Woodbury, G. R. Proctor (ferns) and H. A. Liogier.

Revisions and floras in progress

In 1983, George R. Proctor began field work for a revision of Maxon's (1926) volume on ferns for the Britton and Wilson series. He visited each of the U.S. and British Virgin Islands in March 1984. The resulting volume is presently in press. Dr. H. A. Liogier (1986) is engaged in producing a seven volume series on the flora of Puerto Rico and adjacent islands. Finally, the New York Botanical Garden is engaged in a project to produce a Flora of St. John, to serve as a field guide, based largely on Woodbury's checklist (J. Earhart, G. Prance, pers. comm.).

Some interest has been expressed by the L. H. Bailey Hortorium, Cornell University, in developing an Economic Botany of the Virgin Islands. The University of the Virgin Islands maintains a continuing interest in building local expertise in terrestrial botany and plant ecology (e.g., Matuszak and Stearman 1982). The Institute of Tropical Forestry (USDA, Southern Forest Experiment Station, Rio Piedras, P.R.) maintains an Experimental Forest of 149 acres on St. Croix at Estate Thomas (Little and Woodbury 1980).

Endangered and threatened plants

Endemic, rare, endangered and threatened tree species in the V.I. have been characterized by Little, Woodbury and Wadsworth (1974) and Little and Woodbury (1980). One V.I. plant so far, the prickly-ash *Zanthoxylum thomasianum* (family Rutaceae), has been Federally listed as endangered (U.S. Department of the Interior 1985, U.S. Fish & Wildlife Service 1985). If the proposal is made final, this plant will receive all of the protection authorized under the Endangered Species Act of 1973. A total of some 18 species of plants on St. John are considered rare and endangered, including perhaps six species new to science (Woodbury and Weaver 1984). An additional 38 species have been suggested as needing protection (Matuszak 1985). The status of endemic plants in the northwestern Leeward Islands, including the B.V.I., was reviewed by Howard and Kellogg (1987). Matuszak (1985) listed some 14 species which may be considered endemic in the V.I.

Vegetation distribution and structure

Several studies relating to structural and distributional characteristics of the flora of St. John and the northwestern Leeward Islands are available, most of them quite general in nature, dealing with community type (Ewel and Whitmore 1973, Lugo and Brown 1982, Harris 1963, Multer and Gerhard 1974, Teytaud 1983, Weaver and Woodbury 1982a and b); others give more or less detailed breakdown by species (Beard 1949, Forman 1974, Forman and Hahn 1980, Boergesen and Paulsen 1898, Velez 1957, Woodbury and Weaver 1984). An important long-term study of the dynamics and successional patterns of secondary forests on St. John has been initiated on three permanent plots by members of the V.I. Resource Management Cooperative, in conjunction with the N.Y. Botanical Garden (Earhart et al. 1987, Matuszak et al. 1987). The Tropical Resources Institute of the Yale School of Forestry and Environmental Studies has placed interns on the above study and in general is interested in promoting natural resource management studies in the Virgin Islands and Puerto Rico (e.g., Rasmussen 1984).

Research presently being conducted by the Institute of Tropical Forestry on St. John is assessing phytosociological distribution with respect to topography (Weaver and Chinea-Rivera 1987), and long-term forest growth patterns (Weaver 1987, pers. commun.). University of California Research Expeditions have, since 1984, been investigating physiological and photosynthetic aspects of drought and water-stress adaptations of epiphytes on St. John (Ting, et al. 1985).

Unpublished studies

Many unpublished or "in-house" reports and studies contain worthwhile information and often reflect considerable effort. St. John and surrounding cays and islands have been the subject of an apparently unusually large number of such studies, although investigations of terrestrial plants are included in only a minority of these. Because many of these studies are available in the files of the Virgin Islands National

Park (especially the Red Hook, Cruz Bay or Lind Pt. offices) and the Island Resources Foundation (IRF) at Red Hook, St. Thomas, we shall here refer to representative studies which include botanical data. Bibliographic reviews of such materials at the VINP and IRF, respectively, are available in part in Highfield et al. (1985) and Towle and Teytaud (1982).

A series of ecological surveys of offshore cays including classifications of plant life, were conducted by students as part of the Hackley-Masters Science Seminars (Tarrytown, NY), including Agardy et al. (1980[1], Saba Is.); Dickensen et al. (1975[1], Saba Is., Turtle Dove Is.); Herrmann and Schessel (1971[1], Steven Cay); and Herrmann et al. (1972[1], Henley Cay).

Several other sources of more-or-less-detailed student reports should be pointed out, because they are usually submitted by their supervisory professors for use by interested persons. Studies conducted by a series of students from Gustavus Adolphus College (Minnesota) at the V.I. Ecological Research Station (VIERS) are available in project report binders covering alternate years from 1972[1] through at least 1980[1]. Students at the West Indies Laboratory (WIL) of Fairleigh Dickensen Univ. on St. Croix also have left a substantial record of studies, which are deposited at the WIL library (e.g. Thomas 1969[1]). The majority of the above deal with marine ecology subjects.

Field ecology trips by a group from the University of Connecticut to Lameshur Bay resulted in a detailed list of vascular plants (A. H. Dammon 1972[1]). A 160 p. draft manuscript for a high school-level text entitled "Botany in the V.I." by B. Rodrigue (1977[1]) is in VINP files. Of particular note are two documents produced by VINP staff as preliminary assessments of the flora:

a. "A Preliminary Checklist of the Woody Plants of St. John, Virgin Islands" (11 p.), by Vincent J. Mrazek[1], Chief Park Naturalist (1956?); lists some 300 plants, mostly personally verified by Mrazek, with common names, approximate blooming dates, and growth habits.

b. "A Tentative Checklist of Plants of the Virgin Islands National Park, St. John" (224 p.), compiled by Charles F. Adams, Park Naturalist (about 1958?). An annotated list, based on literature reviews, of 1058 species, including lichens, mosses, liverworts and introduced food and ornamental plants. Notes include interpretation of the scientific names, common names, habitat and some ethnobotanical data. According to the introduction, a botanical card file representing the 132 families in this list was compiled and indexed as the basis of an herbarium which was to be established. A review of this list reveals some redundancies and synonymies, and suggests that native species are under-represented.

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[1] Unpublished work recorded in Highfield et al. (1985).

Robertson (1957) developed a report on the biology of the new park including vegetation assessments and general estimates of the biological values of the park. Numerous collections of photographs dating back to 1936 are on file and are available to evaluate vegetative changes over time (e.g., see entries "Photographs of ..." and "Aerial Views of ..." in Highfield et al. 1985).

Environmental Assessment Reports may also be useful sources of botanical survey data, in connection with First Tier Major Permit Applications to the Coastal Zone Management (CZM) Division of the V.I. Department of Planning and Natural Resources Management. These are on file for public review at the St. Croix and St. Thomas offices of the CZM Division. On St. Thomas, for example, lists of plants have been compiled for Long Point, Magens Bay (J.M. Matuszak) and Dorothea Bay (F. Grifo).

Plant introductions are continually taking place, particularly in light of the significant expansion of the tourism sector. For instance, a list of palm species cultivated at Caneel Bay Plantation includes some 70 species, of which only few are indigenous to the Antilles (Rockresorts 1987).

Living plant collections

It is apt to provide a brief synopsis of what may be loosely referred to as "living plant collections" in the V.I., including deliberately assembled, groups of living plants, usually labeled, more-or-less well-tended, and accessible to the general public as "botanical gardens".

St. Croix. The St. George Botanical Garden represents the largest such enterprise in the V.I., with about 150 labeled plants on some 30 acres. Estate Whim Plantation Museum has a small number of identified plants. At the St. Croix Campus of the University of the V.I., 60 plants are labeled; and at the adjacent V.I. Agricultural Experiment Station, nearly 40 tropical fruit species, plus about 25 citrus lines, from the V.I. Agricultural Experiment Station(VIAES) Fruit Orchard and Museum are labeled. In 1898, a "Botanical Experiment Station" was established at Estate Anna's Hope, and for about 15 years, many species of plants were introduced and propagated there. Several palms and other trees remain prominently standing, but the property is overgrown. The commercial nursery, Cruzan Gardens, is notable for the many native or Antillean species propagated there. At Estate Thomas, the Experimental Forest, planted by the U.S. Forest Service and the local Department of Agriculture, contains stands of about 16 species of trees (see bottom of p. 3 above).

St. John. Caneel Bay Plantation has a fairly rich selection of plants in the landscape of this resort hotel operated by Rockresorts, including some 75 species of palms (with nursery stock).

St. Thomas. The former St. Thomas Arboretum, planted in the early 1930's in the southeastern section of Magens Bay, by Arthur Fairchild with local horticulturist Alfonso Nelthropp, remains largely intact, though long neglected (Zegetosky, 1980). Some clearing and restoration work has been accomplished since 1979, and while the Arboretum has not been forgotten, resources to complete the restoration satisfactorily have not been assembled.

The Water Isle Botanical Garden, owned by Dr. Walter H. Philips on Water Island off St. Thomas, contains a diversity of labeled plants, some of which are succulent, drought-tolerant species. Dr. Philips "pioneered" hydroponics in the V.I., applying it to his botanical garden.

On the St. Thomas campus of U.V.I., over 200 plants are labeled, and a selection of some 80 regionally native ornamental plants and fruit tree species is planted at the New House of this campus.

REFERENCE HERBARIUM DEVELOPMENT AND CURATION PROJECT

The goals of the curation project by the V.I. Cooperative Extension Service were to:

a. Preserve, organize and curate the existing botanical collections (previously identified) made on St. John by Roy O. Woodbury and other investigators in connection with the U.S. National Park Service and the Man and the Biosphere projects;

b. Mount, label and incorporate additional plant specimens subsequently collected by Woodbury and associates;

c. Assemble and catalogue the collection as a reference herbarium, part of the V.I. Biosphere Reserve baseline collections; and

d. Submit duplicate specimens to the New York Botanical Garden to support the possible development of a Flora of St. John.

The reference collection and list

Our main authority for spellings, nomenclature, and organization of the reference collection is the list developed by Woodbury and Weaver (1984; see their Appendix 1), but Liogier and Martorell (1982) and Adams (1972) were used as important supplementary sources.

As of June 1987, the reference collection *per se* consisted of ca. 1156 specimens, representing 600 species among 99 families arranged phylogenetically. These species are all represented in the main list -- List A. In addition to the total number of specimens per species, notations were provided as to the numbers of sterile specimens, as well as specimens with fruits and/or inflorescences for each species. The more significant synonymies are provided in parentheses. List B lists the species in the main list which are represented only by sterile individuals, in the interest of facilitating future filling of gaps. To facilitate cross-comparisons and retrieval, Lists C and D provide synoptic lists of the phylogenetic and alphabetical order of families.

Plants identified by Woodbury as present on St. John, but not represented by specimens in the reference collection, are listed in Appendix I. This list consists of 210 species.

All told, therefore, these lists document the presence of 810 species and 115 families of indigenous and naturalized herbs, shrubs and trees on St. John. This is 18 more species than presented by Woodbury and Weaver (1984) because of subsequent collections. The latter authors also reported 116 families, but in the present lists, the Cuscutaceae are subsumed under Convolvulaceae, which accounts for the discrepancy.

According to Howard and Kellogg (1987), existing floristic studies of the small northern Lesser Antilles are not comparable, so significant comparisons are difficult to make. However, St. John appears to have a considerably greater number of indigenous species than any of the eight islands compared by Howard and Kellogg. The highest number of species on the islands compared is for Tortola (equivalent to St. John in size and altitude), where 484 indigenous dicots are recorded, as opposed to possibly 600 on St. John. While this undoubtedly is influenced by interpretation of which plants are indigenous as opposed to introduced, it is likely also that the St. John total reflects a relatively more extensive collection effort.

New and rare species

Of the 12 rare and endangered species found during Woodbury and Weaver's (1984) survey (listed in their Table 4), all but two are in the reference collection: *Galactia eggersii* and *Solanum mucronatum* are not included at present. Of the six taxa listed as new in their table, all but the apocynaceous vine are in the collection. An additional one (*Justicia* sp.) is included in the present collection by Woodbury, but is not in the Woodbury and Weaver (1987) checklist. The new or unidentified species in this collection are:

Acanthaceae
  Justicia n. sp.

Malpighiaceae
  Byrsonima n. sp.
  Malpighia n. sp.

Myrtaceae
  Eugenia n. sp.
  Psidium n. sp.

Rubiaceae
  Machaonia n. sp.

It is understood that additional collecting will inevitably turn up more records. As an example, the 1984 collecting trip by G. R. Proctor in connection with his revision of the fern flora of Puerto Rico and the V.I. (referred to earlier), resulted in an additional six species/subspecies of ferns recorded for St. John (Appendix II).

Similarly, subsequent collections in the long-term forest monitoring plots on St. John (Earhart et al. 1987, Matuszak et al. 1987) have turned up additional species, including G. eggersii, one of the two mentioned above as not being in the reference herbarium.

Finally, in the interest of augmenting the diagnostic herbarium of the V.I. Cooperative Extension Service (the contracted agency), the V.I. National Park agreed to the retention by the VICES of surplus specimens from the Woodbury series. As a result, 184 plant species (185 specimens) were added to the VICES collection. This list of species is presented in Appendix III.

SUMMARY AND RECOMMENDATIONS

With the establishment of the V. I. Biosphere Reserve Center came the consolidation of existing natural history specimens, such as the Randall fish collection, with more recent assemblages such as the Marine Specimens Collection(e.g., Beets and Lewand 1985). The present botanical reference collection of some 600 species of plants constitutes the single most complete herbarium in the Virgin Islands. It is to be expected that these collections will be continually added to in the future. They serve as the key to all past and future reference to data derived from studies done in the V.I. Biosphere Reserve. As such, they are a vital national resource.

The importance of proper care and maintenance of these collections cannot be overemphasized. Good guidelines are available, including methods appropriate to curation of small collections (e.g., Faber 1983), and pest control (e.g., Edwards et al. 1981). A voucher specimen concept should be developed and promulgated as part of the required documentation for any research project conducted within the V.I. National Park (e.g., Lee et al. 1982). Indeed, comprehensive standards should be developed for specimen documentation, preservation and storage, in coordination with national initiatives by the Association of Systematics Collections. Likewise, deposition costs ought to be included in research proposal budgets.

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REFERENCE HERBARIUM PLANT LISTS

FOR

VIRGIN ISLANDS NATIONAL PARK

VIRGIN ISLANDS BIOSPHERE RESERVE

ST. JOHN

compiled by
John M. Matuszak and Toni Ackerman Thomas

Current as of June 1987

List A. Main Checklist of Species in Virgin Islands National Park Reference Herbarium

Herbarium Specimens collected by Roy O. Woodbury on St. John,
U.S. Virgin Islands, for the National Park Service

# of Specimens
Family Number (phylogenetic)
Genus Species (#<u>st</u>-sterile; #<u>fr</u>-fruit; #<u>infl</u>-inflorescence)
(Synonym)

	1	Psilotaceae
	2	Ophioglossaceae
	3	Polypodiaceae
3		Adiantum fragile Sw. 1 st 2 infl
1		Adiantum tenerum Sw. 1 infl
1		Asplenium pumilum Sw. 1 infl
1		Blechnum occidentale L. 1 infl
1		Doryopteris pedata (L.) Fee 1 infl
1		Nephrolepis exaltata (L.) Schott 1 infl
1		Odontosoria aculeata (L.) J. Sm. 1 st
2		Pityrogramma calomelanos (L.) Link 1 st 1 infl
5		Polypodium astrolepis Liebm. 1 st 4 infl
1		Polypodium aureum L. 1 infl
1		Polypodium heterophyllum L. 1 infl
1		Polypodium latum Moore 1 infl
1		Polypodium phyllitidis L. 1 infl
1		Pteris biaurita L. 1 st
1		Pteris longifolia L. 1 infl
1		Thelypteris poiteana (Bory) Proctor 1 infl
4		Thelypteris subtetragona 2 st 2 infl
2		Thelypteris tetragona (Sw.) Small 1 st 1 infl
	4	Lycopodiaceae
1		Lycopodium cernuum L. 1 st
Dicotyledons		
	5	Casuarinaceae
2		Casuarina equisetifolia J.R.&G. Forst 2 infl
	6	Piperaceae
2		Peperomia glabella (Sw.) Dietr. 2 st
1		Peperomia humilis (Vahl) Dietr. 1 st
1		Peperomia magnoliifolia (Jacq.) A, Dietr. 1 infl
2		Peperomia myrtifolia (Vahl) Dietr. 2 infl
1		Piper amalago L. 1 infl
	7	Ulmaceae
2		Celtis iguanaea (Jacq.) Sarg. 2 st
6		Celtis trinervia Lam. 4 fr 2 st
2		Trema micranthum L. Blume 2 infl
	8	Moraceae
3		Cecropia peltata L. 2 st 1 infl
1		Ficus citrifolia Mill. 1 infl
2		Ficus trigonata L. 2 st

9 Urticaceae
1 Pilea microphylla (L.) Liebm. 1 st
6 Pilea nummulariifolia (Sw.) Wedd. 6 st
4 Pilea sanctae-crucis Liebm. 2 st 2 infl
3 Pilea tenerrima Miq. 3 st
2 Vitis tiliifolia Humb. & Bonpl. ex Willd. 2 st
10 Olacaceae
2 Schoepfia obovata Wright ex Sauv. 2 st
5 Schoepfia schreberi Gmel. 2 st 3 fr
1 Ximenia americana L. 1 st
11 Loranthaceae
4 Dendropemon caribaeus Krug & Urb. 4 fr
12 Aristolochiaceae
2 Aristolochia trilobata L. 2 st
13 Polygonaceae
1 Antigonon leptopus Hook. & Arn. 1 inflk
3 Coccoloba krugii Lindau 3 fr
3 Coccoloba microstachya Willd. 1 st 2 infl
1 Coccoloba swartzii Meissn. in DC. 1 infl
1 Coccoloba uvifera (L.) L. 1 infl
3 Coccoloba uvifera & krugii 2 st 1 infl
6 Coccoloba venosa L. 5 st 1 infl
14 Chenopodiaceae
1 Atriplex pentandra (Jacq.) Standl. 1 infl
1 Chenopodium ambrosioides L. 1 infl
15 Amaranthaceae
1 Achyranthes aspera L. var. aspera 1 infl
1 Alternanthera ficoidea (L.) R.&S. 1 infl
(Alternanthera tenella Colla)
2 Alternanthera peploides (HBK) Urban 2 infl
(Alternanthera caracasana HBK.)
1 Amaranthus gracilis Dest. 1 infl
1 Celosia nitida Vahl 1 infl
1 Iresine angustifolia Euph. 1 infl
2 Philoxerus vermicularium (L.) R. Br. 2 infl
(Blutaparon vermiculare (L.) Mears)
16 Nyctaginaceae
3 Boerhavia diffusa L. 3 infl
3 Boerhavia erecta L. 3 infl
1 Guapira fragrans (Dum.-Cours.) Little 1 infl
2 Neea buxifolia (Hook.) Heirmel 2 st
1 Pisonia aculeata L. 1 fr
1 Pisonia subcordata Sw. 1 infl
17 Bataceae
1 Batis maritima L. 1 infl
18 Phytolaccaceae
3 Petiveria alliacea L. 3 infl
1 Rivina humilis L. 1 infl
1 Trichostigma octandrum (L.) Walt. 1 fr
19 Aizoaceae
3 Cypselea humifusa Turp. 3 st
1 Mollugo nudicaulis Lam. 1 infl
1 Trianthema portulacastrum (L.) L. 1 infl
20 Portulacaceae
1 Portulaca oleracea L. 1 infl

1		Portulaca quadrifida L. 1 st
3		Portulaca teretifolia HBK. 3 infl
1		Talinum paniculatum (Jacq.) Gaertn. 1 fr
1		Talinum triangulare (Jacq.) Willd. 1 infl
	21 Basellaceae	
1		Anredera leptostachys (Moq.) V.Steenis 1 infl
	22 Menispermaceae	
2		Cissampelos pareira L. 1 st 1 infl
1		Hyperbaena domingensis (DC.) Benth. 1 st
	23 Annonaceae	
2		Annona glabra L. 1 st 1 infl
1		Annona muricata L. 1 st
1		Annona squamosa L. 1 infl
	24 Lauraceae	
1		Cassytha filiformis L. 1 infl
1		Licaria salicifolia (Sw.) Kostern. 1 st
2		Licaria triandra (Sw.) Kostern. 2 st
3		Ocotea coriacea (Sw.) Britt. 2 infl 4 fr (Nectandra coriacea (Sw.) Griseb.)
2		Ocotea globosa (Aubl.) Schlecht. & Cham. 2 infl (Nectandra antillana Meisn.)
2		Ocotea leucoxylon (Sw.) Mez. 1 fr 1 st
1		Phoebe elongatum (Vahl) Nees 1 infl (Cinnamomum elongatum (Nees) Kostermans)
	25 Papaveraceae	
2		Argemone mexicana L. 2 infl
	26 Brassicaceae syn. Cruciferae	
1		Cakile lanceolata (Willd.) Schulz. 1 infl
5		Lepidium virginicum L. 5 infl & fr
	27 Capparaceae	
2		Capparis amplissima Lam. 1 infl 1 fr
2		Capparis cynophallophora L. 2 fr
1		Capparis flexuosa (L.) L. 1 infl
1		Capparis frondosa Jacq. 1 infl
2		Capparis hastata Jacq. 2 infl
1		Capparis indica (L.) Fawc. & Rendle 1 infl
1		Cleome spinosa Jacq. 1 infl
1		Cleome viscosa L. 1 infl (Cleome icosandra L.)
3		Morisonia americana L. 1 st 2 infl
	28 Moringaceae	
1		Moringa oleifera (L.) Lam. 1 infl
	29 Crassulaceae	
		Kalanchoe pinnata (Lam.) Pers. 1 infl (Bryophyllum pinnatum (Lam.) Oken)
	30 Chrysobalanaceae	
	31 Fabaceae-Mimosoideae	
2		Acacia macracantha Humbl & Bonpl. 1 infl 1 infl & fr
1		Acacia muricata (L.) Willd. 1 infl
2		Acacia tortuosa (L.) Willd. 1 fr & infl
3		Acacia westiana DC. 1 st 2 infl (Acacia riparia HBK.)
2		Adenanthera pavonina L. 2 st
2		Albizia lebbeck (L.) Benth. 2 infl
2		Calliandra portoricensis (Jacq.) Benth. 1 st 1 infl & fr

(Calliandra carasacana (Jacq.) Benth.)
1 Demanthus virgatus (L.) Willd. 1 fr & infl
2 Inga fagifolia (L.) Willd. 2 infl
1 Leucaena leucocephala (Lam.) Dewitt. 1 infl
1 Mimosa ceratonia L. 1 infl
1 Mimosa pudica L. 1 infl
2 Pithecellobium saman (Willd.) Benth. 1 st 1 infl
(Samanea saman (Jacq.) Merrill)
2 Pithecellobium unguis-cati (L.) Benth. 2 infl
32 Fabaceae-Caesalpinioideae
2 Bauhinia monandra Kurz 2 infl
1 Caesalpinia bonduc (L.) Roxb. 1 infl
1 Caesalpinia divergens Urb. 1 infl
1 Caesalpinia pulcherrima (L.) Sw. 1 infl & fr
2 Cassia alata Raf. 2 st
2 Cassia bicapsularis L. 2 infl
2 Cassia glandulosa L. var. swartzii (Wicker) Macbr. 2 infl
1 Cassia grammica Spreng. 1 infl
(Cassia lineata Swartz)
1 Cassia occidentalis L. 1 st
2 Cassia siamea Lam. 1 st 1 fr & infl
2 Delonix regia (Boj.) Raf. 1 st 1 infl
1 Hymenaea courbaril L. 1 st
1 Parkinsonia aculeata L. 1 infl
1 Tamarindus indica L. 1 infl
33 Fabaceae-Faboideae
3 Abrus precatorius L. 2 st 1 infl
1 Aeschynomene americana L. 1 fr & infl
1 Alysicarpus vaginalis (L.) DC. 1 st
1 Andira inermis HBK. 2 infl
2 Canavalia maritima (Aubl.) Thouars. 1 st 1 infl & fr
2 Centrosema virginianum (L.) Benth. 2 infl
1 Clitoria ternatea L. 1 fr
3 Cracca caribaea (Jacq.) Benth. 3 st
2 Crotalaria falcata Vahl ex DC. 2 infl
1 Crotalaria incana L. 1 infl.
1 Crotalaria lotifolia L. 1 fr
1 Crotalaria retusa L. 1 infl
1 Crotalaria verrucosa L. 1 fr & infl
1 Dalbergia ecastaphylla (L.) Taub. 1 st
1 Desmodium incanum DC. 1 infl
(Desmodium canum (Gmel.) Thelling & Schinz)
1 Desmodium mollis (Vahl) DC. 1 infl
2 Desmodium procumbens (Mill.) Hitch. 2 infl
1 Erythrina corallodendrum L. 1 st
4 Erythrina eggersii Kruk. & Mold. 4 st
1 Galactia dubia DC. 1 fr & infl
2 Galactia striata (Jacq.) Urb. 1 infl 1 infl & fr
1 Indigofera suffruticosa Mill. 1 infl & fr
1 Indigofera tinctoria L. 1 infl & fr
1 Lablab purpureus (L.) Sweet 1 infl
1 Machaerium lunatum (L.f.) Ducke 1 st
1 Macroptilium lathyroides (L.) Urb. 1 infl
2 Pictetia aculeata (Vahl) Urb. 2 infl
2 Piscidia carthagenensis Jacq. 1 st 1 infl & fr

1 Pueraria phaseoloides (Roxb.) Benth. 1 infl
2 Rhynchosia minima (L.) DC. 1 fr 1 infl
2 Rhynchosia reticulata (Sw.) DC. 1 infl 1 infl & fr
2 Sesbania sericea (Willd.) Link 1 st 1 fr
1 Sophora tomentosa L. 1 fr
1 Stylosanthes hamata (L.) Taub. 1 infl
1 Tephrosia cinerea (L.) Pers. 1 infl & fr
1 Tephrosia senna HBK. 1 infl & fr
2 Teramnus labialis (L.f.) Spreng. 2 fr
34 Oxalidaceae
1 Oxalis corniculata L. 1 infl & fr
35 Zygophyllaceae
1 Guaiacum officinale L. 1 fr
3 Kallstroemia pubescens (G. Don.) Dandy 3 infl
36 Malpighiaceae
2 Bunchosia glandulosa (Cav.) L.C. Rich. 2 st
5 Brysonima lucida (Miller) L.C. Rich 2 st 1 infl 2 infl & fr
2 Brysonima sp. (New) 2 st
3 Brysonima spicata (Cav.) HBK. 3 infl
(Brysonima horneana Britt. & Small)
(Brysonima coriacea (Sw.) DC.)
2 Heteropteris purpurea (L.) Kunth 1 infl 1 infl & fr
5 Malpighia sp. (poss. new sp.) 4 st 2 fr
3 Malpighia linearis Jacq. 3 st
4 Malpighia woodburyana Vivaldi 4 st
1 Stigmaphyllon periplocifolium (Poir.) Juss. 1 infl
4 Stigmaphyllon tomentosum Desf. 4 st
(Stigmaphyllon ledifolium (HBK.) Small)
37 Erythroxylaceae
2 Erythroxylum brevipes DC. 2 fr
38 Rutaceae
1 Murraya paniculata (L.) Jacq. 1 st
1 Pilocarpus racemosus Vahl 1 st
1 Triphasia trifolia (Burm.f.) P.Wilson 1 st
2 Zanthoxylum monophyllum (Lam.) P.Wilson 2 infl
8 Zanthoxylum thomasianum (Krug & Urban) Krug & Urban 4 infl 4 st
39 Simaroubiaceae
2 Picrasma excelsa (Sw.) Planch. 1 st 1 infl
1 Suriana maritima L. 2 infl
40 Burseraceae
1 Bursera simaruba (L.) Sarg. 1 fr
41 Meliaceae
2 Azadirachta indica (L.) Juss 2 st
42 Polygalaceae
43 Euphorbiaceae
1 Acalypha chamaedrifolia (Lam.) Muell. 1 infl
1 Acalypha indica Juss. 1 infl
1 Adelia ricinella L. 1 infl
1 Argythamnia candicans Sw. 1 infl
1 Argythamnia fasciculata (Vahl) Muell. 1 infl & fr
1 Argythamnia stahlii Urban 1 infl
1 Ateramnus lucidus (Sw.) Roth 1 fr
1 Chamaesyce articulata (Aubl.) Britton 1 infl
2 Chamaesyce glomerifera Millsp. 2 infl
(Chamaesyce hypericifolia (L.) Millsp.)

1 Chamaesyce hirta (L.) Millsp. 1 infl
2 Chamaesyce mesembryanthemifolia (Jacq.) Dugand 2 st
(Chamaesyce buxifolia (Lam.) Small)
1 Chamaesyce prostrata (Ait.) Small 1 infl
3 Chamaesyce serpens (HBK.) Small 3 infl
1 Chamaesyce thymifolia (L.) Millsp. 1 infl
2 Croton betulinus Vahl 1 infl & fr
1 Croton lobatus L. 1 infl
1 Croton ovalifolius Vahl 1 infl
2 Croton rigidus (Muell. Arg.) Britton 2 infl
2 Dalechampia scandens L. 1 st 1 infl
3 Drypetes alba Poit. 3 st
1 Euphorbia cyathophora J. Murray 1 fr
1 Euphorbia heterophylla L. 1 infl
(Euphorbia geniculata Ort.)
1 Euphorbia oerstediana (Klotzsch & Garcke) Boiss. 1 infl
1 Euphorbia petiolaris Sims 1 infl
1 Hippomane mancinella L. 1 infl
1 Hura crepitans L. 1 infl
1 Jatropha gossypifolia L. 1 infl
4 Margaritaria nobilis L. f. 2 st 1 infl 1 fr
1 Pedilanthus tithymaloides ssp. angustifolius (Poit.) Dressler 1 fr
1 Phyllanthus acidus (L.) Skeels 1 st
3 Phyllanthus amarus Schumach 3 infl
1 Phyllanthus stipulatus (Raf.) Webster 1 infl
1 Ricinus communis L. 1 infl
1 Sapium laurocerasus Desf. 1 st
2 Savia sessiliflora (Sw.) Willd. 1 st 1 infl
1 Securinega acidoton (L.) Fawc. & Rendle 1 st
1 Tragia volublis L. 1 infl

44 Anacardiaceae
1 Anacardium occidentale L. 1 infl
1 Schinus terebinthifolius Raddi 1 infl
1 Spondias mombin L. 1 fr

45 Celastraceae
1 Cassine xylocarpa Vent. 1 infl
1 Crossopetalum rhacoma Crantz 1 fr
12 Maytenus elliptica (Lam.) Krug & Urban 5 infl 7 fr
(Maytenus laevigata (Vahl) Griseb. ex Eggers)
2 Schaefferia frutescens Jacq 1 st 1 fr

46 Sapindaceae
2 Allophyllus racemosus Sw. 2 infl
1 Cupania triquetra A. Rich in Sagra 1 st
1 Exothea paniculata (Juss.) Radlk. 1 st
2 Melicoccus bijugatus Jacq. 2 infl
3 Serjania polyphylla (L.) Radlk. 1 st 2 infl & fr

47 Aquifoliaceae
6 Ilex urbaniana Loes. 3 st 2 infl 1 fr

48 Rhamnaceae
1 Colubrina arborescens (Miller) Sarg. 1 infl
4 Colubrina elliptica (Sw.) Briz. & Stern 4 st
3 Gouania lupuloides (L.) Urban 1 infl 2 fr
3 Krugiodendron ferreum (Vahl.) Urban 3 st
2 Reynosia guama Urban 2 infl

49 Vitaceae
1 Cissus caustica Tussac. 1 st
4 Cissus sicyoides L. 4 infl
3 Cissus trifoliata L. 3 infl
2 Vitis tiliifolia Humb. & Bonpl. ex Willd. 2 st
50 Tiliaceae
1 Corchorus aestuans L. 1 infl
2 Corchorus hirsutus L. 2 infl
1 Triumfetta lappula L. 1 infl
1 Triumfetta semitriloba Jacq. 1 infl
51 Malvaceae
6 Abutilon umbellatum (L.) Sweet 6 infl
2 Bastardia viscosa (L.) HBK. 2 fr
2 Gossypium barbadense L. var. acuminatum (Roxb.) Mast. in Hook.
2 infl & fr
1 Herrisantia crispa (L.) 1 fr
1 Malachra alceifolia Jacq. 1 infl & fr
1 Malvastrum americanum (L.) Torr. 1 infl & fr
(Malvastrum spicatum (L.) A. Gray)
1 Malvastrum corchorifolium (Desr.) Britt. 1 fr
2 Pavonia spinifex (L.) Cav. 2 infl
4 Sida alba L. 4 infl
(Sida spinosa L.)
1 Sida acuta Burm. f. 1 infl
5 Sida aggregata Presl 5 infl
1 Sida ciliaris L. 1 infl
1 Sida cordifolia L. 1 infl
3 Sida glabra Mill. 3 infl
1 Sida glomerata Cav. 1 infl
3 Sida glutinosa L. 3 infl
1 Sida jamaicensis L. 1 infl
1 Sida rhombifolia L. 1 infl
1 Sida urens L. 1 infl
1 Thespesia populnea (L.) Soland. ex Correa 1 infl & fr
1 Urena lobata L. ssp. lobata 1 infl & fr
(Urena trilobata Vell.)
1 Wissadula amplissima (L.) Fries 1 infl & 1 fr
2 Wissadula periplocifolia (L.) Presl 1 infl & fr
52 Bombacaceae
2 Quararibea turbinata (Sw.) Poir. 1 st 1 infl
53 Sterculiaceae
2 Ayenia insulicola Cristobal 2 fr
4 Guazuma ulmifolia Lam. 4 infl
1 Helicteres jamaicensis Jacq. 1 infl
3 Melochia pyramidata L. 3 infl & fr
2 Waltheria indica L. 2 infl
54 Ochnaceae
1 Ouratea littoralis Urban 1 st
55 Theaceae
6 Ternstroemia peduncularis DC. 3 st 3 infl
56 Clusiaceae syn. Guttiferae
2 Clusia rosea Jacq. 1 st 1 infl
1 Mammea americana L. 1 st
57 Canellaceae
4 Canella winterana (L.) Gaertn. 1 st 3 fr

	58 Flacourtiaceae
1	Casearia decandra Jacq. 1 infl
3	Casearia guianensis (Aubl.) Urban 1 st 2 infl
4	Casearia sylvestris Sw. 3 infl 1 st
2	Prockia crucis L. 2 infl
1	Samyda dodecandra Jacq. 1 st 2 infl 1 fr
1	Xylosma buxifolium A. Gray 1 st
	59 Turneraceae
1	Turnera diffusa Willd. 1 inflk
3	Turnera ulmifolia L. 3 infl
	60 Passifloraceae
2	Passiflora foetida L. 1 infl & fr
3	Passiflora multiflora L. 1 st 2 fr
2	Passiflora rubra L. 2 infl & fr
1	Passiflora suberosa L. 1 infl
	61 Caricaceae
	62 Cactaceae
1	Opuntia dillenii (Ker-Gawl.) Haw. 1 infl
2	Pilosocereus royenii (L.) Byles & Rowley 2 infl
	63 Thymeleaceae
3	Daphnopsis americana(Mill.)J.R.Johnst. ssp. Caribaea (Griseb.) Nevil. 2 infl 1 infl & fr
	64 Punicaceae
	65 Rhizophoraceae
1	Rhizophora mangle L. 1 infl
	66 Lythraceae
1	Ammanniua coccinea Rottb. 1 infl
1	Ginoria rohrii (Vahl) Koehne 1 infl
	67 Combretaceae
4	Bucida buceras L. 4 infl
2	Conocarpus erectus L. 1 infl 1 infl & fr
1	Laguncularia racemosa (L.) Gaertn.f. 1 infl
1	Quisqualis indica L. 1 infl
2	Terminalia cataplpa L. 2 st
	68 Myrtaceae
9	Calyptranthes thomasiana Berg. 6 st 3 infl
3	Eugenia axillaris (Sw.) DC. 3 st
2	Eugenia biflora (L.) DC. 2 fr
6	Eugenia confusa DC. 1 st 4 infl 1 fr & infl
3	Eugenia cordata (Sw.)DC. 1 st 2 fr
2	Eugenia lingustrina (Sw.) Willd. 2 fr
6	Eugenia monticola (Sw.)DC. 6 infl
3	Eugenia procera (Sw.) Poir. 1 st 1 infl 1 fr
2	Eugenia pseudopsidium Jacq. 2 fr
2	Eugenia rhombea (Berg) Krug & Urb. 2 fr
5	Eugenia sessiliflora Vahl 4 st 1 infl
5	Eugenia sp. (new species) 5 infl
1	Myrcia citrifolia (Aubl.) Urb. 4 infl
5	Myrcianthes fragrans (Sw.) McVaugh 2 st 3 fr
2	Myrciaria floribunda (West ex Willd.) Berg. 2 st
2	Pimenta racemosa (Mill.) Moore 2 infl
2	Psidium amplexicaule Pers. 2 fr
1	Psidium guajava L. 1 st
5	Psidium sp. (new species) 5 st
	69 Melastomaceae

4 Miconia laevigata (L.) DC. 1 infl 3 fr
2 Tetrazygia angustifolia (Sw.) DC. 2 infl
2 Tetrazygia elaeagnoides (Sw.) DC. 2 infl
70 Onagraceae
1 Ludwigia octovalvis (Jacq.) Raven 1 infl
71 Araliaceae
2 Didymopanax morototoni (Aubl.) Decne. & Planch. 2 st
72 Apiaceae syn. Umbelliferae
1 Apium leptophyllum(Pers.)F. Muell. 1 infl & fr
73 Theophrastaceae
1 Jacquinia arborea Vahl. 1 infl & fr
2 Jacquinia berterii Spreng. 2 fr
74 Myrsinaceae
4 Ardisia obovata Hamilt. 4 infl
75 Plumbaginaceae
4 Plumbago scandens L. 4 infl
76 Sapotaceae
2 Bumelia obovata (Lam.) A. DC. 2 infl
4 Bumelia salicifolia (L.) Sw. 1 st 3 infl
4 Chrysophyllum eggersii Pierre in Urban 1 s t 3 infl
2 Chrysophyllum pauciflorum Lam. 2 infl
5 Manilkara bidentata (A. DC.) A. Chev. 1 st 4 infl
1 Mastichodendrom foetidissimum (Jacq.)H.J. Lam. 1 st
77 Symplocaceae
1 Symplocos martinicensis Jacq. 1 st
78 Oleaceae
5 Forestiera eggersiana Krug & Urban 1 st 5 infl
1 Jasminum fluminense Vell. 1 st
(Jasminum azoricum L.)
1 Jasminum multiflorum (Burm.f.)Andr. 1 infl
2 Linociera caribaea (Jacq.) KInobl. 2 infl
(Chionanthus compactus Sw.)
79 Loganiaceae
3 Spigelia anthelmia L. 3 infl & fr
80 Apocynaceae
1 Catharanthus roseus (L.) G. Don 1 infl
2 Nerium oleander L. 2 infl
3 Plumeria alba L. 1 infl
3 Prestonia agglutinata (Jacq.) Woods 2 st 1 fr
3 Rauvolfia nitida Jacq. 1 st 1 infl 1 fr
1 Rauvolfia viridis Willd. ex Roem & Schult. 1 infl
1 Urechites Lutea (L.) Britton 1 infl & fr
81 Asclepiadaceae
1 Asclepias curassavica L. 1 infl
1 Cryptostegia grandiflora R. Br. 1 infl
1 Cynanchum cheesmanii Woods. 1 infl
2 Matelea maritima (Jacq.) Woods. 2 st
82 Convolvulaceae (incl. Cuscutaceae)
2 Convolvulus nodiflorus Desr. 2 infl
1 Cuscuta americana L. 1 infl
1 Cuscuta indecora Choisy 1 infl & fr
2 Evolvulus linifolius L. 2 infl
1 Evolvulus nummularius (L.)L. 1 st
1 Ipomoea acuminata (Vahl) R & S 1 infl
(Ipomoea indica(Burm.f.) Merrill var. acuminata(Vahl) Fosb.)

1 Ipomoea fistulosa Mart. Ex choicy 1 infl
1 Ipomoea macrantha Roem. & Schult. 1 infl
1 Ipomoea nil (L.) Roth 1 infl
1 Ipomoea pes-caprae (L.) R. Br. 1 infl
1 Ipomoea repanda Jacq. 1 infl
1 Ipomoea solanifolia L. 1 infl & fr
(Jacquemontia solanifolia (L.) Hall. f.)
3 Ipomoea steudelii Millsp. 1 st 2 infl
1 Ipomoea tiliaceae (Willd.) Choisy 1 infl
1 Ipomoea tricolor Cav. 1 infl
4 Jacquemontia pentantha (Jacq.) G. Don 4 infl
1 Merremia aegyptia (L.) Urban 1 infl & fr
1 Merremia dissecta (Jacq.) Hall. f. 1 fr & infl
2 Merremia quinquefolia (L.) Hall f. 2 infl
2 Merremia umbellata (L.) Hall f. 2 infl & fr
1 Stictocardia tiliifolia (Desr.) Hall f. 1 st

83 Boraginaceae

1 Bourreria succulenta Jacq. 1 fr
2 Cordia alba (Jacq.) R. & S. 2 infl
2 Cordia alliodora (R & P.) Oken 1 st 1 infl
2 Cordia collococca L. 1 st 1 infl
2 Cordia laevigata Lam. 2 infl
(Cordia nitida Vahl)
Cordia polycephala (Lam.) I. M. Johnst. 1 infl
1 Cordia rickseckeri Millsp. 1 infl
1 Cordia sebestena L. 1 infl
2 Cordia sulcata DC. 1 st 1 infl
2 Heliotropium angiospermum Murray 2 infl
1 Heliotropium curassavicum L. 1 infl
1 Heliotropium indicum L. 1 infl
2 Heliotropium procumbens Miller 2 infl
1 Heliotropium ternatum Vahl 1 infl
2 Rochefortia acanthophora (DC.)Griesb. 2 infl
1 Tournefortia bicolor Sw. 1 infl
1 Tournefortia filiflora Griseb. 1 infl
1 Tournefortia gnaphalodes (L.)R. Br. 1 infl
1 Tournefortia hirsutissima L. 1 infl
1 Tournefortia microphylla Bert. 1 infl & fr
(Tournefortia volubilis L.)

84 Verbenaceae

1 Bouchea prismatica (L.) Kuntze 1 fr
3 Citharexylum fruticosum L. 2 st 1 infl
2 Citharexylum spinosum L. 2 fr
1 Clerodendrum aculeatum (L.) Schlecht. 1 infl
1 Duranta repens L. 1 fr
1 Lantana camara L. 1 infl
2 Lantana involucrata L. 2 infl
1 Lantana urticifolia Miller 1 infl
1 Priva lappulaceae (L.) Pers. 1 infl
1 Stachytarpheta jamaicensis (L.) Vahl 1 infl
2 Stachytarpheta strigosa Vahl 2 infl
2 Vitex divaricata Sw. 2 st

85 Lamiaceae syn. Labiatae

1 Hyptis capitata Jacq. 1 infl
1 Hyptis pectinata (L.) Poit. 1 infl

1 Leonotis nepetifolia (L.) Ait.f. in Ait. 1 infl
1 Leonorus sibiricus L. 1 infl
1 Ocimum micranthum Willd. 1 infl & fr
3 Salvia occidentalis Sw. 3 infl
2 Salvia serotina L. 2 infl & fr
86 Solanaceae
2 Brunsfelsia americana L. 2 infl
1 Capsicum baccatum L. 1 fr
1 Cestrum laurifolium L. Her. 1 infl
1 Datura innoxia Mill. 1 infl
2 Physalis cordata Miller 2 infl & fr
3 Solanum americanum var. nodiflorium (Jacq.) Edm. 3 infl & fr
1 Solanum erianthum D. Don 1 infl
1 Solanum lanceifolium Jacq. 1 fr & infl
1 Solanum persicifolium Dunal 1 fr & infl
5 Solanum polygamum Vahl 4 infl 1 fr
5 Solanum racemosum Jacq. 5 infl
1 Solanum torvum Sw. 2 infl
87 Scrophulariaceae
4 Bacopa monnieri (L.) Pennel 4 infl
1 Capraria biflora L. 1 infl
2 Scoparia dulcis L. 2 infl & fr
88 Bignoniaceae
1 Arrabidaea chica (H. & B.) Verlot 1 infl
1 Crescentia cujete L. 1 st
2 Crescentia linearifolia Miers 1 infl 1 fr
2 Cydista aequinoctialis (L.) Miers 2 infl
1 Enallagma latifolia (Mill.) Standl. 1 fr
(Amphitecna latifolia (Mill.) A. Gentry)
2 Macfadyena unguis-cati (L.) Gentry 1 st 1 fr
1 Tabebuia heterophylla (DC.) Britt. 1 infl
1 Tecoma stans (L.) HBK. 1 infl
89 Acanthaceae
1 Blechum brownei Juss. 1 infl
2 Justicia mirabiloides Lam. 2 infl
1 Justicia periplocifolia Jacq. 1 infl
1 Justicia sessilis Jacq. 1 infl
(Siphonoglossa sessilis (Jacq.) Gibson)
2 Justicia sp. 2 infl
3 Oplonia microphylla (Lam.) Stearn 2 st 1 infl
1 Ruellia coccinea (L.) Vahl 1 infl
4 Ruellia tuberosa L. 4 infl
1 Ruellia tweediana Griseb. 1 infl
2 Stenandrium tuberosum (L.) Urban 1 st 1 infl
90 Myoporaceae
91 Plantaginaceae
1 Plantago major L. 1 fr
92 Rubiaceae
4 Borreria laevis (Lam.) Griseb. 4 infl
1 Borreria ocymoides (Burm.f.) DC. 1 infl
4 Chiococca alba (L.) A.S.Hitchc. 5 infl
2 Chione venosa (Sw.) Urban 2 st
3 Erithalis fruticosa L. 3 infl
3 Exostema caribaeum (Jacq.) R & S 2 infl & fr 1 fr
1 Faramea occidentalis (L.) A.Rich 1 infl

4 Gonzalagunia spicata (Lam.) Gomez Maza 4 infl
6 Guettarda parviflora Vahl 1 st 4 infl 1 fr
4 Guettarda scabra (L.) Lam 1 infl 3 fr
2 Ixora ferrea (Jacq.) Benth. 2 infl
4 Machaonia sp 4 infl
3 Palicouria domingensis (Jacq.) DC. 3 infl
3 Palicouria riparia Benth. 2 infl 1 fr
(Palicouria crocea var. riparia (Benth.) Griseb.)
7 Psychotria brownei Spreng. 1 st 3 infl 3 fr
7 Psychotria microdon (DC.) Urban 5 infl 2 fr
5 Psychotria nervosa Sw. 5 infl
1 Randia aculeata L. 1 st
3 Rondeletia pilosa Sw. 1 infl & fr 2 fr
5 Scolosanthes versicolor Vahl 5 st
93 Cucurbitaceae
2 Cayaponia americana (Lam.) Cogn. 1 st 1 infl & fr
1 Corallacarpus emetoicatharticus (Gros.) Cogn. 1 fr
(Doyerea emetocatharticus (Grosourdy)
1 Momordica charantia L. 1 infl
94 Lobeliaceae
1 Hippobroma longiflora (L.) G. Don 1 infl
95 Goodeniaceae
96 Asteraceae syn. Compositae
1 Acanthospermum hispidum DC. 1 fr
1 Ageratum conyzoides L. 1 infl
1 Bidens pilosa L. 1 infl
(Bidens alba (L.)DC. var. radiata (Sch.-Bip.) Ballard)
1 Chaptalia nutans (L.) Polak. 1 infl
1 Conyza bonariensis (L.) Cron. 1 infl
1 Conyza canadensis (L.) Cron. var. pusilla (Nutt.) Cron. 1 infl
2 Eclipta alba (L.) Hassk. 2 infl
(Eclipta prostrata (L.) L.)
1 Elephantopus mollis Kunth 1 infl
2 Emelia fosbergii Nicols. 2 infl
(Emelia coccinea) sagittata Vahl DC.)
2 Emelia sonchifolia (L.) DC. 2 infl
1 Erigeron cuneifolius DC. 1 infl
5 Eupatorium corymbosum Aubl. 5 infl
1 Eupatorium odoratum L. 1 infl
3 Eupatorium sinuatum Lam. 3 infl
1 Galinsoga ciliata (Raf.) Blake 1 infl
(Galinsoga parviflora Cav.)
1 Launaea intybacea (Jacq.) Beauverd 1 infl
1 Neurolaena lobata (L.) Cass. 1 infl
1 Parthenium hysterophorus L. 1 infl
4 Pectis humifusa Sw. 4 infl
1 Pectis linifolia L. 1 infl
1 Piptocoma antillana Urban 1 infl
1 Pluchea carolinensis (Jacq.) G. Don 1 infl
(Pluchea symphytifolia (Miller) Gillis)
1 Pterocaulon virgatum (L.) DC. 1 infl
2 Sonchus oleraceus L. 1 st 1 infl
2 Synedrella nodiflora (L.) Gaertn. 2 st
3 Vernonia albicaulis Pers. 1 st 2 infl
2 Vernonia sericea L. C. Rich. 2 infl

1 Wedelia parviflora L.C.Rich. 1 infl
(Wedelia calycina var. parviflora (L.C.Rich.)Alain)
1 Wedelia trilobata (L.) A.S.Hitchc. 1 infl

Monocotyledons
97 Typhaceae
98 Ruppiaceae
99 Zannichelliaceae
100 Hydrocharitaceae
101 Poaceae syn. Gramineae
1 Andropogon pertusus (L.) Willd. 1 infl
(Bothriochloa pertusa (L.) A.Camus)
1 Andropogon semiberbis (Nees) Kunth 1 infl
(Schizachyrium sanguineum (Retz.) Alston var.sanguineum)
1 Anthephora hermaphrodita (L.) Kuntze 1 infl
4 Aristidia adscensionis L. 4 infl
2 Aristidia cognata Trin.&Rupr. 2 infl
2 Arthrostylidium capillifolium Griseb. 2 infl
3 Axonopus compressus (Sw.) Beauv. 3 infl
3 Cenchrus brownii R. & S. 3 infl
2 Chloris barbata Sw. 2 infl
(Chloris inflata Link)
2 Cynodon dactylon (L.) Pers. 2 infl
6 Dactyloctenium aegyptium (L.) Beauv. 6 infl
3 Digitaria ciliaris (Retz.) Koeler 3 infl
2 Echinochloa colona (L.) Link 2 infl
1 Eleusine indica (L.) Gaertn. 1 infl
3 Eragrostic ciliaris (L.) R.Br. 3 infl
4 Eragrostic tenella (L.) Beauv. ex R. & S. 4 infl
1 Eragrostic tephrosanthos Schult. 1 infl
2 Eriochloa punctata (L.) Desv. 2 infl
1 Heteropogon contortus (L.) Beauv. ex Roem. & Schult. 1 infl
7 Lasiacis divaricata (L.) Hitchc. 7 infl
1 Lasiacis maculata (Aubl) Urban 1 st
1 Lasiacis rucifolia (HBK.) Hitchc. 1 infl
4 Lasiacis sorghoidea (Desv.) Hitchc. & Chase 4 infl
2 Leptochloa virgata (L.) Beauv. 2 infl
3 Leptochloopsis virgata (Poir.) Yates 3 infl
(Uniola virgata (Poir.) Griseb.)
1 Olyra latifolia L. 1 infl
2 Oplismenus hirtellus (L.) Beauv. 2 infl
1 Panicum adspersum Trin. 1 infl
(Brachiaria adspersa (Trin.) Parodi)
2 Panicum fasciculatum Sw. 2 infl
(Brachiaria fassciculatum (Sw.) S.T.Blake)
1 Panicum geminatum (Forssk.) Stapf)
3 Panicum maximum Jacq. 3 infl
1 Paspalum conjugatum Berg. 1 infl
3 Paspalum fimbriatum HBK. 3 infl
8 Paspalum laxum Lam. 8 infl
2 Paspalum molle Poir. 2 infl
1 Paspalum notatum Flugge 1 infl
1 Paspalum vaginatum Sw. 1 infl
1 Pharus glaber HBK. 2 infl
1 Tricholaena repens (Willd.) Hitchc. 1 infl

(Rhynchelytrum repens (Willd.) C.E. Hubb)
1 Setaria leiophylla (Nees) Kunth 1 infl
5 Setaria setosa (Sw.) Beauv. 5 infl
1 Setaria utowanaea (Schribn.) Pilger 1 infl
2 Spartina patens (Ait.) Muhl. 2 st
2 Sporobolus indicus (L.) R.Br. 2 infl
2 Sporobolus virginicus (L.) Kunth 2 infl
1 Stenotaphrum secundatum (Walt.) Kuntze 1 infl
3 Syntherisma digitata (Sw.) Hitchc. 3 infl
(Digitaria horizontalis Willd.)
1 Tragus berteronianus Schhult. 1 infl
3 Trichachne insularis (L.) Nees 3 infl
102 Cyperaceae
2 Abildgaardia monostachya (L.) Vahl 2 infl
(Fimbristylis ovata (Burm.f) Kern)
2 Bulbostylis pauciflora (Liebm.) Clarke 2 infl
2 Cyperus compressus L. 2 infl
1 Cyperus elegans L. 1 infl
1 Cyperus ligularis L. 1 infl
(Mariscus ligularis L.)
1 Cyperus nanus Boeckl. 1 infl
(Mariscus capillaris (Sw.) Vahl)
1 Cyperus planifolius L.C.Rich. 1 infl
2 Cyperus rotundus L. 2 infl
1 Cyperus surinamensis Rottb. 1 infl
1 Cyperus vahlii (Nees) Steud. 1 infl
(Cyperus flexuosus Vahl)
1 Dichromena radicans Schl. & Cham. 1 infl
6 Eleocharis geniculata (L.) R.& S.) 6 infl
(Rhynchospora radicans (S. & C.) Pfeiff.)
2 Fimbristylis dichotoma (L.) Vahl. 2 infl
1 Scleria lithosperma (L.) Sw. 1 infl
2 Scleria pterota Presl 2 infl
(Scleria melaleuca Cham. & Schlt.)
103 Arecaceae syn. Palme
104 Araceae
1 Anthurium acaule Britton & Wilson 1 infl
(Anthurium crenatum (L.) Kunth)
1 Anthurium cordatum (Willd.) G.Don 1 st
2 Anthurium selloum C. Koch 2 infl (1 specimen on 2 sheets)
1 Dieffenbachia seguine (Jacq.) Schott 1 st
1 Philodendron giganteum Schott 1 st
1 Philodendron scandens Koch & Sello 1 st
1 Pistia stratiotes L. 1 st
105 Lemnaceae
106 Bromeliaceae
1 Aechmea lingulata (L.) Baker 1 infl
2 Bromelia pinguin L. 2 infl (1 specimen on 2 sheets
1 Catopsis floribunda (Sw.) Griseb. 1 infl
2 Pitcairnia angustifolia Aiton 2 infl (1 specimen on 2 sheets)
1 Tillandsia fasciculata Sw. 1 infl
4 Tillandsia lineatispica Mez 4 infl
2 Tillandsia recurvata L. 2 infl
4 Tillandsia utriculata L. 3 infl 1 st
107 Commelinaceae

1		Callisia repens (Jacq.) L. 1 st
1		Commelina elegans HBK. 1 infl
1		Rhoeo spathacea (Sw.) Stearn 1 st
1		Spironema fragrans Lindl. 1 infl (?)
		(Callisia fragrans (Lindl.) Woods.)
	108 Liliaceae	
1		Sansevieria trifasciata Prain 1 infl
	109 Smilaceae	
	110 Hypoxidaceae	
1		Hypoxis decumbens L. 1 infl
	111 Amaryllidaceae	
1		Pancratium declinatum Jacq. 1 infl
		(Hymenocallis caribaea (L. emend. Gawl.) Herb.)
	112 Agavaceae	
	113 Dioscoreaceae	
1		Dioscorea alata L. 1 st
	114 Iridaceae	
	115 Orchidaceae	
1		Epidendrum ciliare L. 1 infl
1		Oncidium variegatum (Sw.) Sw. 1 infl
3		Tetramicra canaliculata (Aubl.) Urban 1 st 2 infl
		(Tetramicra elegans (Hamilt.) Cogn.)
1		Vanilla barbellata Rchb.f. 1 st

List B. Sterile Specimens

Species only represented by sterile specimens in VINP Collection:

Family No. & Family

- 3 Polypodiaceae
  - Odontosoria aculeata
  - Pteris biaurita
- 4 Lycopodiaceae
  - Lycopodium cernuum
- 6 Piperaceae
  - Peperomia glabella
  - Peperomia humilis
- 7 Ulmaceae
  - Celtis iguanaea
- 8 Moraceae
  - Ficus trigonata
- 9 Urticaceae
  - Pilea microphylla
  - Pilea nummulariifolia
  - Pilea tenerrima
  - Vitis tiliifolia
- 12 Aristolochiaceae
  - Aristolochia trilobata
- 16 Nyctaginaceae
  - Neea buxifolia
- 19 Aizoaceae
  - Cypselea humifusa
- 20 Portulacaceae
  - Portulaca quadrifida
- 22 Menispermaceae
  - Hyperbaena domingensis
- 23 Annonaceae
  - Annona muricata
- 24 Lauraceae
  - Licaria salicifolia
  - Licaria triandra
- 31 Fabaceae-Mimosoideae
  - Adenanthera pavonia
- 32 Fabaceae-Caesalpinioideae
  - Cassia alata
  - Cassia occidentalis
  - Hymenaea courbaril
- 33 Fabaceae-Faboideae
  - Alysicarpus vaginalis
  - Cracca caribaea
  - Dalbergia ecastaphylla
  - Erythrina corallodendron
  - Erythrina eggersii
  - Machaerium lunatum
- 36 Malpighiaceae
  - Bunchosia glandulosa

  - Brysonima sp.
  - Malpighia linearis
  - Malpighia woodburyana
  - Stigmaphyllon tomentosum
- 38 Rutaceae
  - Murraya paniculata
  - Pilocarpus racemosus
  - Triphasia trifolia
- 41 Meliaceae
  - Azadirachta indica
- 43 Euphorbiaceae
  - Chanaesyce mesembryanthemifolia
  - Drypetes alba
  - Phyllanthus acidus
  - Sapium laurocerasus
  - Securinega acidoton
- 46 Sapindaceae
  - Cupania triquetra
  - Exothea paniculata
- 48 Rhamnaceae
  - Colubrina elliptica
  - Krugiodendron ferreum
- 49 Vitaceae
  - Cissus caustica
- 54 Ochnaceae
  - Ouratea littoralis
- 56 Clusiaceae syn. Guttiferae
  - Mammea americana
- 58 Flacourtiaceae
  - Casearia guianensis
  - Xylosma buxifolium
- 67 Combretaceae
  - Terminalia catappa
- 68 Myrtaceae
  - Eugenia axillaris
  - Myrciaria floribunda
  - Psidium sp.
- 71 Araliaceae
  - Didymopanax morototoni
- 76 Sapotaceae
  - Mastichodendron foetidissimum
- 77 Symplocaceae
  - Symplocos martinicensis
- 78 Oleaceae
  - Jasminum fluminense Vell.
    (Jasminum azoricum L.)
- 81 Asclepiadaceae
  - Matelea maritima
- 82 Convolvulaceae
  - Evolvulus nummularius
- 84 Verbenaceae
  - Vitex divaricata
- 88 Bignoniaceae
  - Crescentia cujete
- 92 Rubiaceae

Chione venosa
Randia aculeata
Scolosanthes veriscolor

96 Asteraceae syn. Compositae
Synedrella nodiflora

101 Poaceae syn. Gramineae
Spartina patens

104 Araceae
Anthurium cordatum
Dieffenbachia seguine
Philodendron giganteum
Pistia stratiotes

107 Commelinaceae
Callisia repens
Rhoeo spathacea

113 Dioscoreaceae
Dioscorea alata

115 Orchidaceae
Vanilla barbellata

List C. Phylogenetic Order of Plant Families

This is a synoptic listing of the phylogenetic order of plant families which is used in this document. The authority for this order is Woodbury and Weaver (1984) with minor exceptions.

Family no.	Family
1	Psilotaceae
2	Ophioglossaceae
3A	Cyatheaceae
41	Meliaceae
3B	Polypodiaceae
4	Lycopodiaceae
Dicotyledons	
5	Casuarinaceae
6	Piperaceae
7	Ulmaceae
8	Moraceae
9	Urticaceae
10	Olacaceae
11	Loranthaceae
12	Aristolochiaceae
13	Polygonaceae
14	Chenopodiaceae
15	Amaranthaceae
16	Nyctaginaceae
17	Bataceae
18	Phytolaccaceae
19	Aizoaceae
20	Portulacaceae
21	Basellaceae
22	Menispermaceae
23	Annonaceae
24	Lauraceae
25	Papaveraceae
26	Brassicaceae syn. Cruciferae
27	Capparaceae
28	Moringaceae
29	Crassulaceae
30	Chrysobalanaceae
31	Fabaceae-Mimosoideae
32	Fabaceae-Caesalpinioideae
33	Fabaceae-Faboideae
34	Oxalidaceae
35	Zygophyllaceae
36	Malpighiaceae
37	Erythroxylaceae
38	Rutaceae
39	Simaroubiaceae
40	Burseraceae
42	Polygalaceae
43	Euphorbiaceae
44	Anacardiaceae
45	Celastraceae
46	Sapindaceae
47	Aquifoliaceae
48	Rhamnaceae
49	Vitaceae
50	Tiliaceae
51	Malvaceae
52	Bombacaceae
53	Sterculiaceae
54	Ochnaceae
55	Theaceae
56	Clusiaceae syn. Guttiferae
57	Canellaceae
58	Flacourtiaceae
59	Turneraceae
60	Passifloraceae
61	Caricaceae
62	Cactaceae
63	Thymeleaceae
64	Punicaceae
65	Rhizophoraceae
66	Lythraceae
67	Combretaceae
68	Myrtaceae
69	Melastomaceae
70	Onagraceae
71	Araliaceae
72	Apiaceae syn. Umbelliferae
73	Theophrastaceae
74	Myrsinaceae
75	Plumbaginaceae
76	Sapotaceae
77	Symplocaceae
78	Oleaceae
79	Loganiaceae
80	Apocynaceae
81	Asclepiadaceae

82 Convolvulaceae
83 Boraginaceae
84 Verbenaceae
85 Lamiaceae syn. Labiatae
86 Solanaceae
87 Scrophulariaceae
88 Bignoniaceae
89 Acanthaceae
90 Myoporaceae
91 Plantaginaceae
92 Rubiaceae
93 Cucurbitaceae
94 Lobeliaceae
95 Goodeniaceae
96 Asteraceae syn. Compositae

Monocotyledons
97 Typhaceae
98 Ruppiaceae
99 Zannichelliaceae
100 Hydrocharitaceae
101 Poaceae syn. Gramineae
102 Cyperaceae
103 Arecaceae syn. Palmae
104 Araceae
105 Lemnaceae
106 Bromeliaceae
107 Commelinaceae
108 Liliaceae
109 Smilaceae
110 Hypoxidaceae
111 Amaryllidaceae
112 Agavaceae
113 Dioscoreaceae
114 Iridaceae
115 Orchidaceae

List D. Alphabetical Listing of Families:

Family no.	Family
89	Acanthaceae
112	Agavaceae
19	Aizoaceae
15	Amaranthaceae
111	Amaryllidaceae
44	Anacardiaceae
23	Annonaceae
80	Apocynaceae
47	Aquifoliaceae
72	Apiaceae syn. Umbelliferae
104	Araceae
71	Araliaceae
103	Arecaceae syn. Palmae
12	Aristolochiaceae
81	Asclepiadaceae
96	Asteraceae syn. Compositae
21	Basellaceae
17	Bataceae
88	Bignoniaceae
52	Bombacaceae
83	Boraginaceae
26	Brassicaceae syn. Cruciferae
106	Bromeliaceae
40	Burseraceae
62	Cactaceae
57	Canellaceae
27	Capparaceae
61	Caricaceae
5	Casuarinaceae
45	Celastraceae
30	Chrysobalanaceae
67	Combretaceae
107	Commelinaceae
82	Convolvulaceae
29	Crassulaceae
26	Cruciferae syn. Asteraceae
93	Cucuribitaceae
3A	Cyatheaceae
102	Cyperaceae
113	Dioscoreaceae
37	Erythroxylaceae
43	Euphorbiaceae
32	Fabaceae-Caesalpinioideae
31	Fabaceae-Faboideae
33	Fabaceae-Mimosoideae
58	Flacourtiaceae
95	Goodeniaceae
101	Gramineae syn. Poaceae
56	Guttiferae syn. Clusiaceae
100	Hydrocharitaceae
110	Hypoxidaceae
114	Iridaceae
85	Labiatae syn. Lamiaceae
24	Lauraceae
105	Lemnaceae
108	Liliaceae
94	Lobeliaceae
79	Loganiaceae
11	Loranthaeae
4	Lycopodiaceae
66	Lythraceae
36	Malpighiaceae
51	Malvaceae
69	Melastomataceae
41	Meliaceae
22	Menispermaceae
8	Moraceae
28	Moringaceae
90	Myoporaceae
74	Myrsinaceae
68	Myrtaceae
16	Nyctaginaceae
54	Ochnaceae
10	Olacaceae
78	Oleaceae
70	Onagraceae
22	Ophioglossaceae
115	Orchidaceae
34	Oxalidaceae
103	Palmae syn. Arecaceae
25	Papaveraceae
60	Passifloraceae
18	Phytolaccaceae
6	Piperaceae
91	Plantaginaceae
75	Plumbaginaceae
101	Poaceae syn. Gramineae
42	Polygalaceae
13	Polygonaceae
3B	Polypodiaceae
20	Portulacaceae
1	Psilotaceae

64	Punicaceae
48	Rhamnaceae
65	Rhizophoraceae
92	Rubiaceae
98	Ruppiaceae
38	Rutaceae
46	Sapindaceae
76	Sapotaceae
87	Scrophulariaceae
39	Simaroubaceae
109	Smilacaceae
86	Solanaceae
53	Sterculiaceae
77	Symplocaceae
55	Theaceae
73	Theophrastaceae
63	Thymeleaceae
97	Typhaceae
50	Tiliaceae
59	Turneraceae
7	Ulmaceae
72	Umbelliferae syn. Apiaceae
9	Urticaceae
84	Verbenaceae
49	Vitaceae
99	Zannichelliaceae
35	Zygophyllaceae

Appendix I. Plants of St. John Not in the Main Collection

Plant Species listed as occuring on St. John,as compiled in the checklist by R.O. Woodbury and P. Weaver (1984. 1987), but not represented in the collection made by R.O. Woodbury (List A above). Other sources undoubtedly will add more records. For example, G.P. Proctor in a 1984 survey of the V.I., found an additional 6 species/subspecies of ferns on St. John (see Appendix II.).

Family no. Family

1 Psilotaceae
    Psilotum nudum (L.) Griseb.
2 Ophioglossaceae
    Ophioglossum reticulatun L.
3 Polypodiaceae
    Hemionitis palmata L.
    Thelypteris dentata (Forssk.) E. St. John
4 Lycopodiaceae

Dicotyledons
5 Casuarinaceae
6 Piperaceae
    Peperomia pellucida (L.) HBK.
7 Ulmaceae
8 Moraceae
Artocarpus altilis (S.Park.) Fosb.
Chlorophora tinctoria (L.) Gaud.
9 Urticaceae
    Fleurya aestuans (L.) Gaud.
     (Laportea aestuans (L.). Chew)
10 Olacaceae
11 Loranthaceae
12 Aristolochiaceae
    Aristolochia odoratissima L.
13 Polygonaceae
    Coccoloba diversifolia Jacq.
14 Chenopodiaceae
15 Amaranthaceae
    Alternanthera crucis (Moq.) Boldingh
    Amaranthus crassipes Schlecht.
    Amaranthus dubius Mart.
    Amaranthus viridis L.
16 Nyctaginaceae
    Boerhavia scandens (L.) Standl.
17 Bataceae
18 Phytolaccaceae
19 Azioaceae
    Sesuvium portulacastrum (L.) L.
20 Portulacaceae
    Portulaca halimoides L.
    Portulaca pilosa L.
21 Basellaceae

Portulaca pilosa L.
21 Basellaceae
22 Menispermaceae
23 Annonaceae
  Annona reticulata L.
  Guatteria caribaea Urban
24 Lauraceae
  Ocotea floribunda (Sw.) Mez
  Ocotea sintenisii (Mez) Alain
   (Nectandra sintenisii Mez)
25 Papaveraceae
26 Brassicaceae syn. Cruciferae
  Brassica willdenovii Boiss.
   (Brassica integrifolia (Willd.) Rupr.)
27 Capparaceae
  Cleome gynandra L.
28 Moringaceae
29 Crassulaceae
30 Chrysobalanaceae
  Chrysobalanus icaco L. var. icaco
31 Fabaceae-Mimosoideae
  Acacia farnesiana (L.) Willd.
  Prosopis pallida (H.& B. ex Willd.) HBK.
32 Fabaceae-Caesalpiniodeae
  Cassia chamaecrista L.
  Cassia obtusifolia L.
  Haematoxylum campechianum L.
33 Fabaceae-Faboideae
  Cajanus cajan (L.) Millsp.
  Desmodium scopiurus (Sw.) Desv.
  Desmodium triflorum (L.) DC.
  Galactia eggersii Urban
  Gliricidia sepium (Jacq.) Kunth ex Walp.
  Sabinea florida (Vahl) DC.
  Sesbania grandiflora (L.) Pers.
  Vigna luteola (Jacq.) Benth.
34 Oxalidaceae
35 Zygophyllaceae
  Kallstroemia maxima (L.) Torr. & A.Gray
36 Malphighiaceae
  Galphimia glauca Cav.
   (Galphimia gracilis Bartl.)
  Heteropteris laurifolia (L.) A. Juss.
  Malpighia emarginata Sesse & Moc. ex DC.
37 Erythroxylaceae
38 Rutaceae
  Amyris elemifera L.
  Citrus aurantifolia (Christm.) Swingle
  Zanthoxylum martinicense (Lam.) DC.
39 Simaroubaceae
  Picrasma antillana (Eggers) Urban (?)
  Quassia amara L.
40 Burseraceae

- 41 Meliaceae
  - Melia azedarach L.
  - Swietenia mahogani (L.) Jacq.
  - Trichilia hirta L.
- 42 Polygalaceae
  - Polygala hecatantha Urban
- 43 Euphorbiaceae
  - Croton astroites Dryand
  - Euphorbia tirucalli L.
  - Jatropha curcas L.
  - Phyllanthus niruri L.
  - Sapium caribaeum Urban
- 44 Anacardiaceae
  - Comocladia dentata Jacq.
  - Mangifera indica L.
  - Spondias dulcis Parkinson
  - Spondias purpurea L.
- 45 Celastraceae
  - Gyminda latifolia (Sw.) Urban
- 46 Sapindaceae
  - Cardiospermum microcarpum HBK.
  - Sapindus saponaria L.
- 47 Aquifoliaceae
  - Ilex sideroxyloides (Sw.) Griseb.
- 48 Rhamnaceae
  - Ziziphus rignonii Delp.
- 49 Vitaceae
- 50 Tiliaceae
  - Corchorus siliquosus L.
- 51 Malvaceae
  - Abutilon hirtum (Lam.) Sweet
  - Malvastrum coromandelianum (L.) Gracke
  - Sida acuminata DC.
    - (Sida multiflorum (Jacq.) Fryxell)
  - Sida javensis Cav. ssp. expilosa Borss. Waalkes
  - Sida procumbens Sw.
    - (Sida abutilifolia Mill.)
  - Sida salviifolia C. Presl.
  - Urena lobata L.
- 52 Bombacaceae
  - Ceiba pentandra (L.) Gaertn.
- 53 Sterculiaceae
  - Melochia nodiflora Sw.
  - Melochia tomentosa L.
- 54 Ochnaceae
- 55 Theaceae
- 56 Clusiaceae syn. Guttiferae
- 57 Canellaceae
- 58 Flacourtiaceae
- 59 Turneraceae
- 60 Passifloraceae
  - Passiflora edulis Sims
  - Passiflora laurifolia L.

- 61 Caricaceae
  - Carica papaya L.
- 62 Cactaceae
  - Consolea rubescens (Salm. Dyck.) Lem.
  - Hylocereus trigonus (Haw.) Stafford
  - Hylocereus undatus (Haw.) Britton
  - Lemaireocereus hystrix (Haw.) Britton & Rose
  - Lemaireocereus littoralis (K.Brandeg.) H. E. Gates
  - Mammillaria nivosa Link
  - Melocactus intortus (Miller) Urban
  - Nopalea cochenillifera (L.) Salm-Dyck
  - Opuntia antillana Britton & Rose
  - Opuntia repens Bello
  - Selenicereus grandiflorus (L.) Britton & Rose
- 63 Thymeleaceae
- 64 Punicaceae
  - Punica granatum L.
- 65 Rhizophoraceae
- 66 Lythraceae
- 67 Combretaceae
  - Buchenavia capitata (Vahl) Eichl.
- 68 Myrtaceae
  - Eugenia foetida Poir.
  - Eugenia sintenisii Kiaersk.
  - Myrcia citrifolia (Aubl.) Urban
  - Syzygium jambos (L.) Alst.
- 69 Melastomataceae
- 70 Onagraceae
- 71 Araliaceae
- 72 Apiaceae syn. Umbelliferae
- 73 Theophrastaceae
- 74 Myrsinaceae
- 75 Plumbaginaceae
- 76 Sapotaceae
  - Chrysophyllum cainito L.
  - Manilkara zapota (L.)R. v. Royen
  - Pouteria multiflora (A. DC.) Eyma
- 77 Symplocaceae
- 78 Oleaceae
- 79 Loganiaceae
- 80 Apocynaceae
  - Thevetia peruviana (Pers.) K. Schum.
- 81 Asclepiadaceae
  - Calotropis procera (Aiton) Aiton f.
  - Cynanchum grisebachianum (Schlecht.) Alain
- 82 Convolvulaceae
  - Evolvulus glaber Spreng.
    - (Evolvulus convolvuloides (Willd. ex Schult.) Stearn)
  - Ipomoea alba L.
  - Ipomoea macrantha Roem. & Schult.
  - Ipomoea hederifolia L.
  - Ipomoea trilobata L.
  - Jacquemontia cumanensis (HBK.) O. Kuntze

Jacquemontia tamnifolia (L.) Griseb.
83 Boraginaceae
84 Verbenaceae
  Avicennia germinans (L.) L.
  Lantana aculeata L.
   (Lantana camara var aculeata (L.) Mold.)
85 Lamiaceae syn. Labiatae
  Coleus amboinicus Lour.
   (Plectranthus amboinicus (Lour.) Launert)
  Hyptis suaveolens (L.) Poit.
  Salvia coccinea Buc'hoz ex Etlinger
86 Solanaceae
  Capsicum frutescens L.
  Cestrum nocturnum L.
  Cestrum diurnum L.
  Datura metel L.
  Physalis angulata L.
  Physalis pubescens L.
  Physalis turbinata Medic.
  Solanum conocarpum Dunal
  Solanum mucronatum O.E. Schulz.
  Solanum seaforthianum Andr.
87 Scrophulariaceae
88 Bignoniaceae
  Spathodea campanulata Beauv.
89 Acanthaceae
  Barleria lupulina Lindl.
  Dicliptera assurgens (L.) Juss.
  Justicia carthaginensis Jacq.
  Justicia pectoralis Jacq.
  Oplonia spinosa (Jacq.) Raf.
  Thunbergia alata Bojer
  Thunbergia fragrans Roxb.
90 Myoporaceae
  Bontia daphnoides L.
91 Plantaginaceae
92 Rubiaceae
  Coffee arabica L.
  Ernodea littoralis Sw.
  Genipa americana L.
  Geophila repens (L.) Johnst.
  Morinda citrifolia L.
  Spermacoce confusa Rendle & Gillis
93 Cucurbitaceae
  Cucumis anguria L.
  Melothria pendula L.
94 Lobeliaceae
95 Goodeniaceae
  Scaevola plumieri (L.) Vahl
96 Asteraceae
  Bidens cynapiifolia HBK.
   (Bidens bipinnata L. var. cynapiifolia (HBK.) Gomez Maza)
  Conyza apurensis HBK.

- Cosmos caudatus hbk.
- Gundlachia corymbosa (Urban) Britton
- Milkiana cordifolia (L.f.) Willd.
- Pseudelephantopus spicatus (Juss.) Baker
- Tridax procumbens L.
- Vernonia cinerea (L.) Less.
- Wedelia calycina L.C. Rich.
- Zinnia peruviana (L.) L.

Monocotyledons

- 97 Typhaceae
  - Typha domingensis Pers.
- 98 Ruppiaceae
  - Ruppia maritima L.
- 99 Zannichelliaceae
  - Syringodium filiforme Kutz
- 100 Hydrocharitaceae
  - Thalassia testudinum Banks & Solander
- 101 Poaceae syn. Gramineae
  - Andropogon bicornis L.
  - Andropogon ischaemum L.
    - (Bothriochoa ischaemum (L.) Keng)
  - Bambusa vulgaris Schrod. ex Wendl.
  - Bouteloua americana (L.f.) Scribn.
  - Cenchrus echinatus L.
  - Cenchrus tribuloides L.
  - Chloris radiata (L.) Sw.
  - Cymbopogon citratus (DC.) Stapf
  - Digitaria sanguinalis (L.) Scop.
  - Eragrostis urbaniana Hitchc.
  - Lithachne pauciflora (Sw.) Beauv.
  - Panicum diffusum Sw.
  - Panicum reptans L.
    - (Brachiaria reptans (L.) Gardn. & C.E. Hubb.)
  - Paspalum virgatum L.
  - Setaria geniculata (Lam.) Beauv.
  - Sporobolus tenuissimus (Schrank) Kuntze
- 102 Cyperaceae
  - Cyperus alternifolius L.
  - Cyperus brevifolius (Rottb.) Endl. ex Hassk.
  - Cyperus odoratus L.
    - (Torulinium odoratum (L.) Hooper)
  - Eleocharis mutata (L.) R. & S.
  - Frimbristylis ferruginea (L.) Vahl
- 103 Arecaceae syn. Palmae
  - Coccothrinax alta (O.F. Cook) Becc
  - Cocos nucifera L.
  - Phoenix dactylifera L.
  - Roystonea borinquena O.F. Cook
  - Sabal causiarum (O.F.Cook) Becc
- 104 Araceae
- 105 Lemnaceae
  - Lemna perpusilla Torrey

106 Bromeliaceae
    Tillandsia usneoides (L.) L.
107 Commelinaceae
    Commelina diffusa Burm.f.
108 Liliaceae
    Aloe vera (L.) Burm.f.
    Yucca guatemalensus Baker
109 Smilacaceae
    Smilax coriacea Spreng.
     (Smilax havanensis Jacq.)
    Smilax domingensis Willd.
110 Hypoxidaceae
111 Amaryllidaceae
    Hippeastrum puniceum (Lam.) Kuntze
    Zephyranthes grandiflora Lindl.
112 Agavaceae
    Agave americana L.
    Agave missionum Trel.
    Agave sisalana Perrine
113 Dioscoreaceae
    Dioscorea pilosiuscula Bertero ex Spreng.
114 Iridaceae
    Galatea bulbosa (Miller) Britton
     (Eleutherine bulbosa (Miller) Urban)
115 Orchidaceae
    Epidendrum bifidum Aubl.
    Oncidium prionochilum Kraenzlin
    Ponthieva racemosa (Walt.) Mohr.
    Prescottia oligantha (Sw.) Lindl.
    Prescottia stachyodes (Sw.) Lindl.
    Spiranthes elata (Sw.) L.C. Rich.
    Vanilla planifolia G.Jackson in Andr.

Appendix II. Additional Fern Species

Additional species of ferns found on St. John, as listed by G.P. Proctor (1984, 1987), and not found in the R.O. Woodbury mounted collection or the R.O. Woodbury & P. Weaver (1984) checklist of plant species occuring on St. John:

3A Cyatheaceae
- Cyathea arborea

3B Polypodiaceae
- Adiantum fragile var. rigidulum
- Nephrolepis multiflora
- Pityrogramma chrysophylla var. gabrielae
- Pteris vittata
- Thelypteris hispidula var. inconstans

Appendix III. Duplicate Specimens Retained by V.I. Cooperative Extension Service, University of the Virgin Islands, St. Thomas.

Duplicate specimens of the following species were retained by the University of the Virgin Islands from the St. John collection for educational and research purposes. These specimens are in addition to the total collection by R.O. Woodbury, List A. One specimen was retained in all cases except two of Maytenus elliptica (Celastraceae--#45).

Family no. & Family

- 3 Polypodiaceae
  - Adiantum tenerum
  - Asplenium pumilum
  - Polypodium astrolepis
  - Pteris biaurita
  - Thelypteris subtetragona
- 6 Piperaceae
  - Peperomia glabella
  - Peperomia humilis
- 7 Ulmaceae
  - Celtis iguanaea
  - Celtis trinervia
- 9 Urticaceae
  - Pilea nummulariifolia
  - Pilea sanctae-crucis
  - Pilea tennerrima
  - Vitex tiliifolia
- 10 Olacaceae
  - Schoepfia obovata
  - Schoepfia schreberi
  - Ximenia americana
- 11 Loranthaceae
  - Dendropemon caribaeus
- 13 Polygonaceae
  - Coccoloba uvifera & krugii
- 14 Chenopodiaceae
  - Atriplex pentandra
  - Chenopodium ambrosioides
- 15 Amaranthaceae
  - Alternanthera ficoidea (L.) R.&S.
    (Alternanthera tenella Colla)
  - Alternanthera peploides (HBK) Urban
    (Alternanthera caracasana HBK.)
  - Iresine angustifolia
  - Philorexus vermicularium
- 16 Nyctaginaceae
  - Boerhavia diffusa
  - Boerhavia erecta
  - Guapira fragrans

- Neea buxifolia

- 19 Aizoaceae
  - Cypselea humifusa
  - Mollugo nudicaulis
- 20 Portulacaceae
  - Portulaca quadrifida
  - Portulaca teretifolia
- 23 Annonaceae
  - Annona glabra
- 24 Lauraceae
  - Licaria triandra
  - Ocotea globosa Meisn.
    - (Nectandra coriacea (Sw.) Britt.)
  - Phoebe elongatum (Vahl) Nees
    - (Cinnamomum elongatum (Nees) Kostern.)
- 33 Fabaceae-Faboideae
  - Aeschynomene americana
  - Alysicarpus vaginalis
  - Crotalaria falcata
  - Desmodium procumbens
  - Erythrina eggersii
- 34 Oxalidaceae
  - Oxalis corniculata
- 36 Malpighiaceae
  - Brysonima lucida
  - Brysonima sp.
  - Malpighia linearis
  - Malpighia woodburyana
  - Stigmaphyllon tomentosum Desf.
    - (Stigmaphyllon ledifolium (HBK.) Small
- 37 Erythroxylaceae
  - Erythroxylum brevipes
- 38 Rutaceae
  - Zanthoxylum thomasianum
- 39 Simaroubiaceae
  - Picrasma excelsa
  - Suriana maritima
- 43 Euphorbiaceae
  - Acalpha chamaedrifolia
  - Acalpha indica
  - Adelia ricinella
  - Argythamnia stahlil
  - Chamaesyce glomerifera Millsp.
    - (Chamaesyce hypericifolia (L.) Millsp.)
  - Chamaesyce mesembryanthemifolia
  - Chamaesyce prostrata
  - Chamaesyce thymifolia
  - Croton betulinus
  - Dalechampia scandens
  - Drypetes alba
  - Euphorbia cyathophora
  - Euphorbia oerstediana
  - Pedilanthus tithymaloides spp. angustifolius

Phyllanthus acidus
Phyllanthus amarus
Securinega acidoton

44 Anacariaceae
Schinus terebinthifolius

45 Celastraceae
Maytenus elliptica

48 Rhamnaceae
Colubrina arborescens
Krugiodendron ferreum

49 Vitaceae
Cissus sicyoides
Cissus trifoliata

50 Tiliaceae
Corchorus aestuans
Triumfetta lappula
Triumfetta semitriloba

51 Malvaceae
Abutilon umbellatum
Herrisantia crispa
Malvastrum americanum
Sida aggregata
Sida glabra
Sida glutinosa
Wissadula amplissima

52 Bombacaceae
Quararibea turbinata

53 Sterculiaceae
Guazuma ulmifolia
Melochia pyramidata
Waltheria indica

54 Ochnaceae
Ouratea littoralis

58 Flacourtiaceae
Casearia sylvestris
Prokia crucis
Samyda dodecandra
Xylosma buxifolium

60 Passifloraceae
Passiflora multiflora

62 Cactaceae
Pilosocereus royenii

67 Combretaceae
Bucida buceras
Quisqualis indica

68 Myrtaceae
Eugenia confusa
Eugenia cordata
Eugenia sessiliflora
Eugenia sp.
Myrcianthes fragrans
Pimenta racemosa
Psidium sp.

- 71 Araliaceae
  - Didymopanax morototoni
- 73 Theophrastaceae
  - Jacquinia berterii
- 78 Oleaceae
  - Forestiera eggersiana
  - Jasminum multiflorum
- 79 Loganiaceae
  - Spigelia anthelmia
- 82 Convolvulaceae
  - Cuscuta indecora
  - Evolvulus linifolius
  - Ipomoea acuminata
  - Ipomoea fistulosa
  - Ipomoea steudelii
  - Ipomoea tiliaceae
  - Ipomoea tricolor
  - Merremia aegyptia
- 83 Boraginaceae
  - Cordia laevigata
  - Heliotropium procumbens
- 84 Verbenaceae
  - Duranta repens
  - Priva lappulaceae
  - Vitex divaricata
- 85 Lamiaceae syn. Labiatae
  - Hyptis pectinata
  - Leonorus sibiricus
  - Salvia occidentalis
- 86 Solanaceae
  - Capsicum baccatum
  - Physalis cordata
- 88 Bignoniaceae
  - Arrabidaea chica
  - Crescentia linearifolia
  - Enallagma latifolfia (Mill.) Standl.
    (Amphitecna latifolia (Mill.) A. Gentry)
  - Macfadyena unguis-cati
- 89 Acanthaceae
  - Justicia mirabiloides
  - Justicia sp.
  - Stenandrium tuberosum
- 92 Rubiaceae
  - Borreria laevis
  - Exostema caribaeum
  - Guettarda parviflora
  - Machaonia sp.
  - Palicourea riparia Benth.
    (Palicourea crocea var. riparia (Benth.) Griseb.)
  - Psychotria brownei
- 96 Asteraceae
  - Ageratum conyzoides
  - Bidens pilosa

  - Conyza bonariensis
  - Eclipta alba (L.) Hassk.
    - (Eclipta prostrata (L.) L.)
  - Erigeron cuneifolius
  - Eupatorium corymbosum
  - Eupatorium sinuatum
  - Galinsoga ciliata (Raf.) Blake
    - (Galinsoga parviflora Cav.)
  - Launeae intybacea
  - Pectis humifusa
  - Pterocaulon virgatum
  - Synedrella nodiflora
- 101 Poaceae syn. Gramineae
  - Andropogon semiberbis
  - Anthephora hermaphrodita
  - Aristida adscensionis
  - Chloris barbata Sw.
    - (Chloris inflata Link)
  - Digitaria ciliaris
  - Eragrostis ciliaris
  - Eriochloa punctata
  - Heteropogon contortus
  - Leptochloa virgata
  - Leptochloopis virgata (Poir.) Yates
    - (Uniola virgata (Poir.) Griseb.)
  - Olyra latifolia
  - Panicum fasciculatum
  - Panicum geminatum Forssk.
    - (Paspalidium geminatum (Forssk.) Stapf
  - Panicum maximum
  - Paspalum conjugatum
  - Paspalum molle
  - Paspalum vaginatum
  - Rhynchelytrum repens (Willd.) C.E. Hubb
    - (Tricholaena repens (Willd.) C.E. Hubb)
  - Setaria leiophylla
  - Setaria setosa
  - Setaria utowanaea
  - Spartina patens
  - Stenotaphrum secundatum
  - Trichachne insularis
- 102 Cyperaceae
  - Abildgaardia monostachya (L.) Vahl
    - (Fimbristyilis ovata (Burm. f.) Kern)
  - Bulbostylis pauciflora
  - Cyperus namus
  - Dichromena radicans
  - Fimbristylis dichotoma
- 106 Bromeliaceae
  - Pitcairnia angustifolia
- 107 Commelinaceae
  - Callisia repens
  - Commelina elegans

115 Orchidaceae
    Vanilla barbellata

VIRGIN ISLANDS
RESOURCE MANAGEMENT
COOPERATIVE

BIOSPHERE RESERVE
RESEARCH REPORT NO.18B

ESTABLISHMENT AND SOIL CHARACTERIZATION OF LONG-TERM FOREST MONITORING PLOTS IN THE VIRGIN ISLANDS BIOSPHERE RESERVE

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and Walter I. Knausenberger
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U.S. MAN AND THE BIOSPHERE PROGRAM

Virgin Islands National Park

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ABSTRACT

Three permanent study plots have been identified and established on St. John, with the overall long-term objective of monitoring representative components of secondary forest development on a small, steep-sloped, dry-to-moist tropical island. The plots are in representative ecological zones -- upland moist forest (Bordeaux), gallery moist forest (L'Esperance) and dry evergreen woodland (Hawksnest), and are 1.0, 0.5 and 0.5 ha in size, resp. They are situated on watersheds of critical importance to the V.I. National Park: Reef Bay, Fish Bay, and Hawksnest Bay, respectively. The bays are the subject of several long-term marine studies by V.I. Resource Management Cooperative and other research groups. The implementation of vegetation and soil studies on these watersheds will allow specific aspects of the association of land and marine systems on this island to be evaluated for the first time.

Pertinent background on events leading to this study are given, as is the rationale for selection of the study areas. Topographic and geological characteristics, and past land-use, of these sites are briefly reviewed.

The regenerating forest is an intriguing mixture of native and introduced species. Comparative study of the relative development of these two groups is likely to be most instructive, and of high relevance to other islands, especially in the Neotropics. Of the twelve species of trees most abundant in one or more of the three plots, eight are discussed briefly in their biological, historical and cultural contexts: Acacia muricata, Andira inermis, Ardisia obovata, Byrsonima coriacea, Guapira fragrans, Inga fagifolia, Pimenta racemosa, and Tabebuia heterophylla.

Soil was sampled at three depths from 33 sites immediately outside the perimeter of the three study plots. The samples were analyzed for pH, soluble salts, organic matter, sodium content, texture, five macronutrients (exchangeable P, K, Ca, Mg, S), and four micronutrients (exchangeable Zn, Fe, Cu, Mn). Nitrogen was not analyzed. The average pH ranged from 5.71 at Bordeaux, to 7.12 at Hawksnest. Percent organic matter was rather high, normal in a forest environment, but the Hawksnest plot was consistently lowest. Most of the nutrients were in the low-to-medium range, with the exception of iron, which was high to very high at the Bordeaux plot. The latter is consistent with the results of a geochemical survey of St. John by Tucker et al. (1985). Some differential in nutrient levels is apparent within and among the study areas, and these could have an effect on plant distribution and growth, but detailed analysis of this is beyond the scope of the present report.

Representative specific recommendations arising from this study are offered, concerning terrestrial plant development, soils and nutrient relationships, as they relate to management considerations and information and education needs in the Virgin Islands.

ACKNOWLEDGMENTS

We gladly recognize the significant role played in this project by Mr. John E. Earhart, who contributed to the initiation of the long-term forest monitoring concept on St. John; who stimulated the interest and salutary collaboration of Drs. Ghillean T. Prance, Scott A. Mori, as well as other scientists of the New York Botanical Garden; and who participated in various aspects of the plot location, layout, and installation, as well as data acquisition and processing. In connection with his continuation project (VIRMC III.10), taking up where the one reported here (VIRMC II.4) left off, Earhart arranged for the assistance of Ms. Anne E. Reilly and Mr. Matt Davis (at the time, interns with the Yale School of Forestry and Environmental Science) to complete the layout of the Hawksnest plot, tag the trees at Hawksnest, help re-tag the Bordeaux plot and take diameter measurements from the latter two plots, in addition to other data acquisition as part of their continuation project (e.g., height measurements and tree x,y coordinates).

Involved in the extensive discussions and deliberations concerning permanent plot location were, with Matuszak and Earhart, Drs. G. T. Prance, Caroline S. Rogers (V.I. National Park Research Biologist), and Prof. Roy O. Woodbury (New York Botanical Garden). Mr. Rafe Boulon (V.I. Division of Fish and Wildlife) added a useful perspective.

For their indispensable assistance in plot installation, layout, and record-taking, we acknowledge -- in addition to the above-mentioned Davis, Earhart and Reilly -- the following: Albion George, Francesca Grifo, C. Gibbons, Caroline Rogers, Herman Smith, Miriam Sorhaindo, and A. Wesselhoft. Dr. Peter L. Weaver (Institute of Tropical Forestry) offered useful technical advice.

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Any remaining errors of commission or omission are the responsibility of the authors. The actual forest plot work was carried out and coordinated by John M. Matuszak and he provided an early draft of the first section and many of the recommendations; Ellen Craft oversaw the soil analysis aspect and provided a draft of that section, including the appendix material; Walter I. Knausenberger was administratively involved in this project from the outset, prepared the review and final drafts of the manuscript, tables and figures, and added most of the material related to the literature cited.

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LONG-TERM FOREST MONITORING

Introduction

The Virgin Islands National Park on St. John has long been viewed as primarily a marine park. Most research attention there has been directed towards marine resources. While the island's land-based natural resources have received a fairly wide range of attention (U.S. Dept. Interior 1982; Highfield et al. 1985; Rogers 1987), much of this attention relates directly to the immediate management needs of the park, such as the study of burro feeding habits (Swanbeck 1985, Nellis et al. 1987 in prep.). Although of high relevance to interdisciplinary research and long-range planning, limited systematic work on vegetation structure and growth has been available to managers, researchers, or the public. As yet, no appropriate botanical framework is available with which to integrate other knowledge. The lack of detailed baseline and interpretative data on plants has hampered park managers and researchers making decisions about activities and resources influenced by, or influencing, vegetation.

The modern ecosystems on St. John reflect the long, continuous and dynamic interaction between man and nature. Those seeking to understand or manage the ecosystems must incorporate a historical and cultural dimension into their analytical framework. Within the Virgin Islands National Park (VINP), the terrestrial flora is in a state of recovery from the severe impacts of wood harvests and agriculture in the 18th, 19th and early 20th century (e.g., Oldendorp 1777; Tyson 1984). Little is known of the original forest on St. John (but see Beard 1949, in Earhart et al. 1987, and in Teytaud 1986). Until the recent work by Woodbury and Weaver (1987), large components of the current vegetation had gone unassessed. The status of botanical work to date is summarized by Earhart et al. (1987) and Knausenberger et al. (1987). A valuable annotated and indexed bibliography of forestry in Puerto Rico and the U.S. Virgin Islands is available (Mosquera and Feheley 1984).

While it is clear that terrestrial and marine ecosystems are in close harmony, little specific information exists as to the impact of major vegetative alteration on coral reefs or marine fisheries. Privately-owned lands on St. John are presently undergoing rapid development, and the extent of the impact on nearshore marine ecosystems has been under investigation. Currently, Coastal Zone Management permits require assessments of vegetation; preliminary recommendations have been made by Matuszak (1985) as to which plants should be accorded special protection in the V.I. by virtue of their being endemic, rare, threatened or endangered.

The Man and Biosphere Program has stimulated the VINP and V.I. scientists to look at the total St. John environment in a coordinated series of projects. As an example, in a study of the impact of terrigenous sediment on coral growth as related to historical development of the island, Hubbard et al. 1986 found that growth rates had decreased during the post-cultivation fallow period (1910-1950), contrary to their initial hypothesis. They suggest that insights into why this may be so would come from a study of forest succession, such as the relative development of understory as opposed to overstory. Another possibility raised by the

Hubbard study to explain the apparent relative lack of soil retention by a recovering forest cover, is that the water flow-restraining terraces have degraded steadily over the years.

The intent of the present study is to document the initiation of a long-term study of plant succession and forest stand development through the establishment of several permanent plots on the island of St. John. This report is presented in two sections. The first deals with the initiation and installation work undertaken before and during the first year of the project, and is chronologically an antecedent companion study to the work reported in Earhart et al. (1987). The second part describes basic soil chemical characters of the immediate study areas.

The long-term forest monitoring project on St. John is one of very few of its sort on small island ecosystems. It is probably unique in the tropical region, situated as it is on an island nearly 70% protected under biosphere reserve and national park status. The steep terrain of these islands -- 80 % of the slopes exceed 30 degrees (Rivera et al. 1970) -- and the fact that the plots are located on protected national park land, lend this study increased significance.

Background to the Present Study. In 1982, the National Park Service (NPS) contracted with Prof. Roy O. Woodbury (then with the Puerto Rico Department of Natural Resources) and Dr. Peter L. Weaver (Institute of Tropical Forestry -- ITF) to survey the plants of St. John and rework the vegetation classification. The Principal Investigator (P.I.) (JMM) of the project which this report reflects, seized this opportunity to work with these individuals whenever possible. Woodbury is recognized to be the authority on the identification and ecology of the vegetation of the northeast Caribbean. His experience bore fruit in the identification of six species potentially new to science, and in the reporting of dozens of species not previously reported from St. John (Woodbury and Weaver 1987). This project formed the basis of the subsequent development of a reference herbarium, assembled from Woodbury's accessions by the College of the Virgin Islands' Cooperative Extension Service (CVI-CES) in connection with a VIRMC Cycle II (1984-85) project (Knausenberger et al. 1987).

In 1983, the P.I. of the eventual 1985-86 VIRMC III Forest Dynamics Project, J. E. Earhart, joined these investigators in studying the St. John vegetation. During these meetings, discussions ensued about the opportunity that the National Park offered for the study of secondary forest development and recovery.

The VINP was interested in formalizing such a study through VIRMC. Simultaneously, Earhart, then at the Yale School of Forestry and Environmental Studies, contacted the New York Botanical Garden (NYBG) and ascertained their genuine interest in participating in such a study. A meeting was held in July 1984 among Prof. Woodbury and representatives of the National Park, NYBG, the College of the Virgin Islands, and V.I. Division of Fish and Wildlife. An agreement was reached to undertake the current study, and a research proposal was submitted to VIRMC through the CVI-Cooperative Extension Service of the University of the Virgin Islands (UVI; the College of the Virgin Islands was formally renamed University of the V.I. in March 1987).

Objectives. A long-term forest dynamics/vegetation monitoring project was therefore undertaken with the following objectives:

1. To establish baseline information on forest composition and structure, and to evaluate its current status in relation to historical land use patterns, as well as topographic and climatic factors. It is hoped that methods developed, and information and insight gained, will facilitate management decisions in protected areas in the V.I. and the eastern Caribbean;

2. To develop initial basic pedological data for the study areas, concentrating on available macro- and micronutrients; and

3. To provide information for community training and educational programs regarding the ecological role of vegetation, its dynamics, and the effects of management decisions on the total island ecosystem, thus to provide a basis of interaction and appreciation between the park and the community as is envisioned in the biosphere reserve concept;

As an important benefit of this long-term project, which is expected to continue for decades, we look forward to strengthened linkages between island institutions, e.g., UVI and VINP, and centers of excellence in botany and vegetation management, e.g., the NYBG, Institute of Tropical Forestry (ITF), and Yale School of Forestry and Environmental Studies, among others.

The present report deals with aspects of the first two objectives. We emphasize again that Earhart et al. (1987) deal with the same three long-term monitoring plots (Bordeaux, Hawksnest, L'Esperance) treated herein. In the future, other plots may well be added, and at least the L'Esperance plot is expected to be enlarged.

A beginning has been made by the UVI-Cooperative Extension Service on the training and educational objective. Several public seminars, workshops and exhibits relating to herbarium techniques, plant identification, native plant use and ethnobotany have been conducted which have directly or indirectly related to information deriving from the plots. Community education programs of the VICES on radio and television have repeatedly referred to the long-term forest monitoring plots. Also, several native residents were employed during the installation process. Indeed, the process of installation itself was an excellent learning experience.

Study Area Selection

Three sites were chosen for study (Figure 1, Table 1) representing a small portion of the number initially envisioned for the project (up to 12), which were to have included most vegetative zones throughout the island.

Current site selection criteria were determined within the context of critical watersheds designated by VIRMC. Practical considerations such as ease of access and sufficient size for placement, and minimizing edge effects, were major determinants. The three sites were all chosen in areas

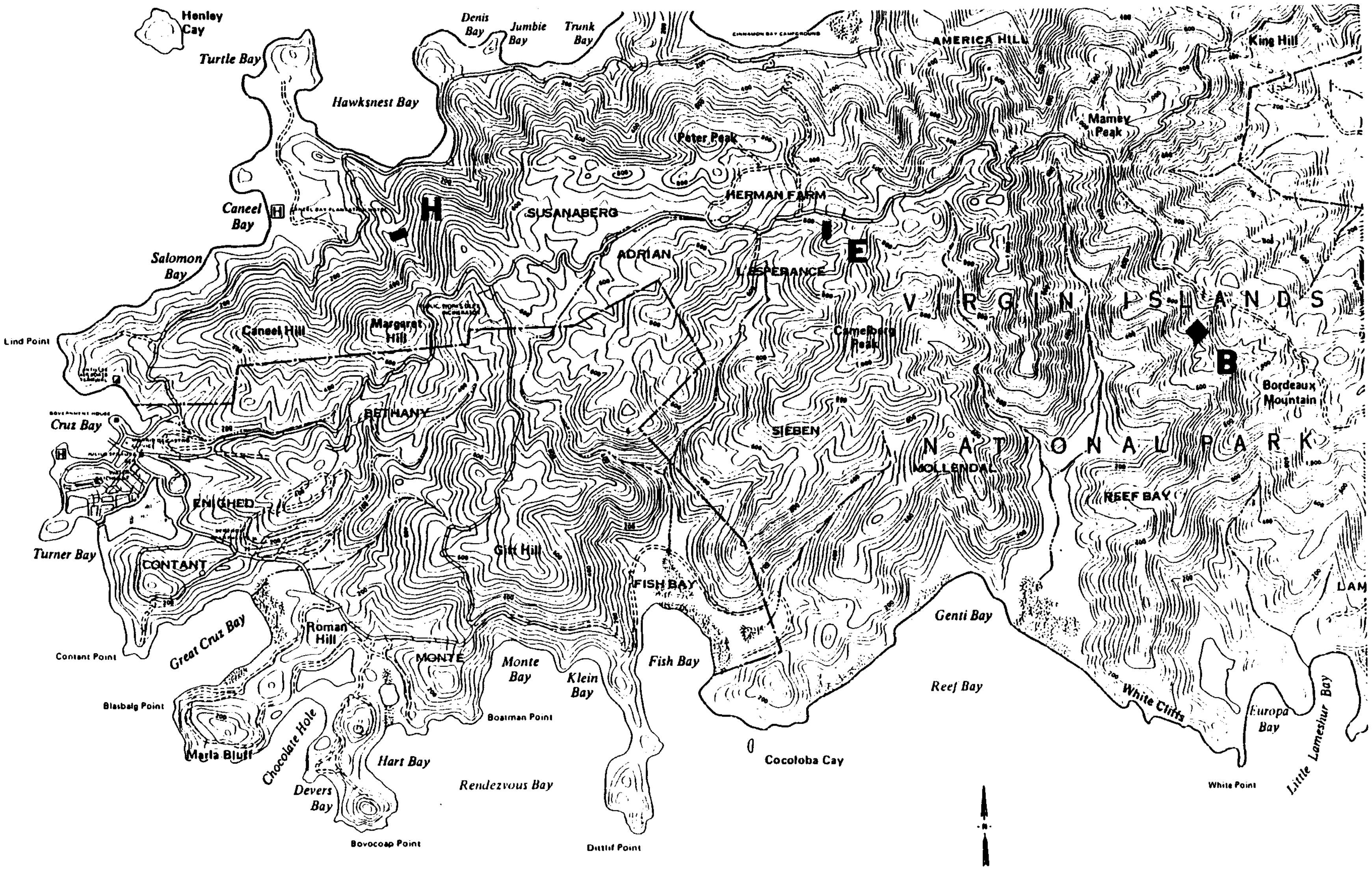

Figure 1. Map of the Location of the Bordeaux, Hawksnest and L'Esperance Long-term Forest Monitoring Plots on St. John. Plots are approximately to scale. (Original base map from Sediment Reduction Map (No. 20) prepared by Black, Crow and Eidsness.)

Table 1. Descriptive summary of the long-term forest monitoring plots on St. John.

Characteristics	Plot (Estate)		
	Bordeaux 100x100m	Hawksnest 50x100m	L'Esperance 50x100m
Watershed	Eastern Reef Bay	Western Hawksnest Bay	Eastern Fish Bay
Soil Series [1]	Cramer (CrF)	Cramer (CrE)? [1]	CrF ? [1]
Soil Origin [2]	N/A	N/A	N/A
Soil Classification [3]	N/A	N/A	N/A
Ecological Life Zone [4]	Subtropical Moist Forest	Smf	Smf
Holdridge Life Zone [5]	Moist Forest	Moist Forest/ Dry Transition	Moist Forest/ Dry Transition
Vegetation Type [6]	Upland Moist Forest	Dry Evergreen Woodland with narrow strip of Gallery Moist Forest in gut	Gallery Moist Forest
Average Slope [7]	19 %	37 %	18 %
Elevation Range (approx.)[8]	800-850 ft.	240-280 ft.	650-700 ft.
Mean Annual Rainfall	over 1270 mm	1140-1270 mm	1140-1270 mm
Drought Months	4-6	5-8	5-8

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[1] Extreme stoniness, lithologic discontinuities, and color, suggest that soil series identifcations need to be reassessed.

[2] Weathered, inclined, metamorphic, sedimentary and volcaniclastic rock with metallized intrusives (Tucker et al. 1985). Detailed site assessments for stratigraphic associations are needed.

[3] Detailed physical, chemical and mineralogical analyses are needed.

[4] Ewel and Whitmore (1973)

[5] Teytaud (1986)

[6] Woodbury & Weaver (1987)

[7] Hubbard et al. (1985). Refers to several transects for entire watershed.

[8] Respectively 246-260 m; 74-86 m; 200-215 m.

with secondary forests already well-established, so as to yield more immediate data on recovery patterns and to represent the current status of the majority of forests on St. John. Future plot establishment may be desirable on sites with less well-established forest cover.

Extensive discussions were held on the size of the plots. Initially the Bordeaux plot was 0.5 hectare (ha). In discussions with S. Mori of the NYBG, it was determined that at least one of the plots should be a full hectare for comparison with other similar studies of terrestrial vegetation under way in the Neotropics (e.g. Ewel 1980). It was decided that for the Bordeaux plot, a 1.0 ha plot would be best, based on the calculation of a species area curve. The Hawksnest plot was adequately sampled by a 0.5 ha plot. While the species-area curve for the L'Esperance plot indicated that a 1.0 ha plot would be ideal, time constraints led to the establishment of a 0.5 ha plot, with the hope that the plot can be enlarged in the near future. See Earhart _et al_. 1987 for details of plot location.

Bordeaux -- _Eastern Reef Bay Watershed_. The first site to be selected was the Bordeaux mountain site. It is situated in an Upland Moist Forest area within one of the VIRMC critical watersheds. It is in the lee of the highest peak on St. John at ca. 250 m elevation. This area, the Bordeaux peak, has some of the richest and most unique vegetation on the island (Woodbury pers. commun. 1984). It has a well-established secondary forest and evidence of earlier agricultural activity: terraces, a nearby coal pit and ruins remain.

There is evidence of arboreal manipulation, with an abundance of bay rum trees (_P. racemosa_ var. _racemosa_) long used in the small industry which flourished on St. John, and Bordeaux Mt. had one of the more important stands. Little and Wadsworth (1964) consider _P. racemosa racemosa_ as native to Puerto Rico and the Virgin Islands, and Landrum (1986) considers it "probably" to be native in Cuba, Puerto Rico and the Lesser Antilles. However, Woodbury, in personal conversations, argues that this particular variety is not found wild in the British Virgin Islands, and therefore must be introduced (see discussion under this species below). Amarat, _Acacia muricata_, is also found there in abundance, and this was a favored tree for charcoal production -- also a major industry on St. John during the last century. Historically, Bordeaux Mt. was known for its specialized coffee, cocoa, and citrus production (Oldendorp 1777), in addition to sugar.

This plot contains most major landscape features of the upland terrestrial ecosystems of St. John, including ridges, slopes with opposite-facing aspects and convergent drainage guts. There are areas of major boulder outcroppings at ridge ends in subplots E&F 2&3; A 8&9; B 8.

The plot was near a major area of intensive metallization which is evidenced by geochemical anomalies, Pb, Cu, Ba, Ag, & Au as reported by Tucker _et al_. (1985, Site Nos. 66, 68 & 85). Their study reports locally very high levels of a number of different heavy metals. Baseline data on the chemical profiles of the associated soil would allow some insight into the importance of these heavy metal elements as a determining factor in vegetation composition.

L'Esperance -- West Fish Bay Watershed. The second study area, in Estate L'Esperance, was chosen as a comparative site to the Bordeaux plot. It is found in the lee of the ridge which continues to Camelberg peak -- the second highest peak on St. John. This peak and ridge area differ from Bordeaux in forest species composition. The forest is not as well developed as in the Bordeaux plot and, although it does not contain an abundance of exotic species or signs of past cultivation (but some remnants of terraces are detectable), there are trees swollen with old barbed wire attachments (subplot C5) and evidence of human manipulation of the vegetation, both to the immediate east and west of the plot. There are sizable patches of Bromelias pinguin bordering subplots A1-C1, and a high density of sweetlime (Triphasia trifolia) and sandbox (Hura crepitans) bordering E5-J5. The plot is close to an old road and a major plantation ruin for which there are fairly good historical tax records, the so-called matricules (Tyson pers. commun., 1985).

This smaller plot has a single drainage gut which traverses it from east to west. It contains north and south facing slopes extending on the south to a ridge (J1) which drops off to an area of large boulders adjacent to the southern limit of the plot (J 2-4). The species composition is rather different from Bordeaux, providing the potential to test hypotheses relating to seed source, age, moisture or nutrient status effects on vegetation. It would also be possible to compare developmental patterns in future generations to determine if the island as a whole would move toward an equilibrium. Fairly good rainfall records are available for this area, as there is a nearby weather station which has been maintained for many years at the park biologist's house (171 Centerline Road).

This is also a site of considerable metallization with high levels of metals -- Pb, Cu, Ba, Ag, Bi, and Si found in the drainage gut (Tucker et al. 1985; Test site #54). As evidenced by the data included in this report, the nutrient status of the site is considerably different from Bordeaux.

Hawksnest Bay -- Western Watershed. The third study area, at Hawksnest, was chosen as the only site in this watershed on VINP land extensive enough for a plot. A watershed immediately to the east drains a larger area, but is on private land. It is that eastern sub-watershed which drains the area impacted by the clinic development, and any sedimentation or erosion studies should focus on that area. The western watershed in which the plot is located represents a lower elevation area heavily impacted by erosion and dominated by an exotic species, i.e., Melicoccus bijugatus, genip.

Limited information on historic land use is available for this specific area; it was an annex to the fertile Caneel estate to the west. The current status of the site indicates a heavy impact and slow recovery, which suggests possible exploitation for fuelwood and/or possibly for grazing, as is suggested by data in Tyson (1984).

The drainage gut runs south to north with an extremely steep slope on the west and a gentler slope on the east. The plot contains no ridge areas, but the westward rows (1-3) are bordered by a steep wall of boulders. There are numerous rock outcroppings in the eastern half of the plot.

The site also includes an area of metallization -- mainly Cu & Pb -- relatively extensive for the size of the watershed (Tucker et al. 1985, Site #3). The extremely steep aspect of the western slope and the high degree of erosion and percentage rock cover, make nutrient availability a major constraint for any vegetation. Insight which is gained on how an area like this recovers naturally, may offer valuable lessons for use elsewhere in similar situations.

Plot Installation

The choice of plot sites was a joint effort: the Bordeaux site initially was identified by J. E. Earhart, L'Esperance identified by Matuszak and Woodbury, and Hawksnest identified by a team of the aforementioned three and P. Acevedo and G. Prance of N.Y.B.G. In each case the other principals, Matuszak, Earhart and Woodbury, made the final decision jointly in consultation with the park biologist C. Rogers. The methodology of plot installation proved to require many adjustments during the course of the work, particularly in the Bordeaux and Hawksnest plots.

Initial hurdles arose when the plots were established, measuring the periphery of the Bordeaux plot. The corner posts were installed as "Permanent PVC" pipe set in concrete. Concrete, water and the pipe were all carried in ca. 1000 m via steep terrain. Heavy duty twine was strung between the corner posts; treated 2 x 2 inch wooden stakes were installed every 10 meters, and twine was then strung between the stakes to delineate 10 x 10 m subplots.

The placement of the stakes and the crosslines required at least three persons at one time. Tagging of the trees was begun prior to completion of the installation of all subplots. Measurements were recorded on a subplot-by-subplot basis. Tree tags on the first few subplots were nailed in at 135 cm from the ground, where diameter was measured. Upon the recommendation of P. L. Weaver (while on island examining ITF plots at Cinnamon Bay), the tags were subsequently installed (and reinstalled) either 10 cm above or below the diameter at breast height (dbh) measurement to avoid an abnormal swelling resulting from the nail. Aluminum tags and nails were utilized in this process. All trees with the trunk splitting below or at dbh were tagged on each trunk $>$ 5 cm dbh, and each was recorded separately, as were the root-trunks of epiphytic trees $>$ 5 cm in diameter. Earhart et al. (1987) report all these measurements for each stem individually.

The epiphyte Clusia rosea (Guttiferae) presented a particular challenge. This species usually had only its woody roots present at breast height. Many of these were of sufficient size to be included in the study. A single tag was assigned to a given epiphyte specimen, and its individual roots were labeled with a letter and measured individually in a clockwise direction.

Determining where to measure actual dbh was complicated by the fact that many of the trees are growing at considerable angles away from perpendicular. To the extent possible, therefore, the length of the trunk was measured directly, the measurement being taken at the specified distance from where the trunk emerged from the ground, as distinct from an actual height. This measurement was always taken at the high point (i.e., on the uphill side) of the trunk/soil intersection, as this point varied substantially around the trunk on steep slopes. The dbh level was marked with fluorescent spray paint or tree crayons so the same spot would be measured in the future. The permanence of these markings, however, is limited, so that annual, or at least biennial, maintenance is needed. In the two-year period that the plots were visited after installation, much of the original marking was gone from many trees, especially those like Pimenta, with exfoliating bark.

Because of the extreme variation in topography, it was not possible to lay out the grid with high accuracy. The Bordeaux plot, on the basis of peripheral measurements, was discovered to have a bottom boundary 5 m too long and a side boundary which was off by a few meters. A tentative decision was reached that this was not a significant problem, because the individual 10 x 10 m subplots were considered to take precedence. Tagging, measuring and identification therefore proceeded to near completion. Matuszak was responsible for the bulk of the identifications. Unknown species were collected or recorded for later identification by Woodbury.

A few months later, in November 1985, Woodbury and S. Mori visited the site. The plot dimensions were judged to be too inaccurate after all. Mori also argued convincingly that for the studies to be useful in comparison to other studies of a similar nature being done elsewhere (e.g., Briscoe and Wadsworth 1970; Soriano-Ressy et al. 1970), plots would have to be at least 1.0 ha. A compromise was reached such that one plot, Bordeaux, would be 1.0 ha, while the other two plots would be 0.5 ha each. This allowed for comparisons between the plots using only a half hectare of the Bordeaux data and also an evaluation regarding the size necessary to accurately assess the ecological processes. As noted earlier, it is expected that the L'Esperance study area will be enlarged to 1.0 ha in the immediate future.

This re-evaluation led to the reinstallation of the entire grid system, and caused many specimens to be reassigned from one plot to another. With the addition of the second half hectare at Bordeaux, it was decided to re-tag the entire plot, thus providing for consistent stem location and coordinate data. The decision to reinstall was made during a visit by Earhart, Woodbury, Prance, and Acevedo. At that time, Acevedo also took specimens of undetermined species which were flowering in the canopy.

Also in November 1985, installation began for the L'Esperance plot. The Hawksnest plot was established in March 1986 and completed that summer. Complete tagging and retagging of the latter two plots was not accomplished until the summer of 1986, during the taking of coordinates by a joint team of personnel from the VIRMC cycles II & III involved in the long-term forest monitoring project (Matuszak et al. 1987; and Earhart et al. 1987, resp.).

Observations On Major Tree Species' Occurrence and Distribution

Although the basic inventory and mensuration data of the plots is available (Earhart et al. 1987), much verification and interpretation of species occurrence is still required. Many questions on identification remain to be addressed via the collecting of specimens and comparison with type specimens. This is especially true of the rare and endemic species, Calyptranthes thomasiana Berg. in Hawksnest, and Chrysophyllum eggersii Pierre, in L'Esperance. Flowering and fruiting specimens of these species are needed from the plots, though these species do possess several other fairly distinctive structural features. Additional individuals of C. thomasiana and C. eggersii have been found on land adjacent to the study areas, which are being monitored for fertile parts (Earhart, pers. commun.). Closely related genera represented by more than one species, e.g., Guettarda, Cordia, and Licaria, also need to have specimens collected of each species. The currently available data regarding distribution within and between plots also need to be examined in much greater detail.

These and related matters are presently under investigation by scientists from the ITF, NYBG, UVI and Yale University, and others. A series of publications interpreting the distributional data in relation to topographic, synecological and other considerations is in preparation by J. E. Earhart, G. T. Prance, A. Reilly et alia. A related phytosociological study is in progress by the ITF in the Cinnamon Bay watershed, St. John (Weaver and Chinea-Rivera 1987). The latter study demonstrates a clear relationship between plant distribution and topography.

The spatial distribution of the most abundant trees in the Bordeaux and L'Esperance plots, by subplot, is represented in rough synoptic fashion in Figures 2 and 3, using the codes interpreted in Table 2. This table presents only those species which are among the five most common on one or more of the three plots (Earhart et al. 1987). A discussion of certain distributional and ethnobotanical correlates for some of the prominent species follows.

Acacia muricata (L.) Willd. -- Amarat; Spineless Acacia. This deciduous tree has a hard, heavy wood considered excellent for charcoal; it has also been used for rough construction, fence posts and fish pot braces (Woodworth 1943). In the plots it is extremely localized, not occurring in L'Esperance, and there is only one specimen in Hawksnest. In Bordeaux it occurs primarily in the northwest corner, along the west ridge and along the northeast below the ruin (A1-A8; B1-B7; C1-C4; D1-D2; E1-E2; I4-I5; J3-J5). Elsewhere on Bordeaux mountain it does appear to be locally common.

This distribution may be related to previous land use. Other questions of relevance to distribution arise, such as the role nutrient availability plays; whether there are rhizobial associations and, if so, does innoculum or molybdenum availability play a role?

This species may be in the process of being supplanted during the course of succession. Thus, in the one subplot with smaller trees measured (6A), the total stem number > 5 cm was very high (n=41), and amarat was a high percentage of the total, 16 stems; however, in the 23 stems measured between 3-5 cm, none were amarat. This may indicate a trend toward the eventual elimination of this species. Amarat is normally found in considerable abundance in lower dryer areas, such as in the White Cliffs area on St. John; its presence may be an artifact of clearing. This may represent a trend in which species more typically from dryer areas colonize uplands after clearing. Such a trend might be applicable in the development of management strategies elsewhere for reclaiming degraded watershed with forestry or agroforestry projects, or expediting recovery of natural forests. The possible reduction of this species could indicate a trend toward a change from a deciduous to an evergreen canopy/subcanopy. A moisture/transpiration parameter could be associated with this trend (e.g., Teytaud 1986).

Andira inermis (W. Wright) H.B.K. -- Pigturd, Bastard mahogany (Woodworth (1943) cites "Hunklut" as an old Creole name on St. John). This deciduous tree is found in all plots in relatively high numbers, although it is a dominant tree only in L'Esperance. It is not known to reach great heights and its ability to survive in mature evergreen forests is questionable. This species is less common in the Bordeaux plot than in the other two, especially L'Esperance. Thus it is possible that Bordeaux is in a later stage of development, and that the *A. inermis* remaining there will soon die out. In Costa Rican lowlands, *A. inermis* is an occasional member of the subcanopy and understory, flowers regularly, and fruits once in two years (Hartshorn, Ch. 7 in Janzen 1983).

In the V.I. the wood is traditionally regarded as good for furniture making (Woodworth 1943) and construction, especially for boat building. It has occasionally been used for coffee shade and this, along with its copious fruit production, attractiveness to animals, and ability to colonize open areas, may all lend to its wide distribution.

Ardisia obovata Desv. -- Whitewood, Breakbill. This small evergreen tree, which is the most abundant tree in the L'Esperance plot, is also found in Hawksnest and in high numbers in Bordeaux. It challenges *Foramea* as the dominant understory tree, in some places becoming much larger and playing a role in the subcanopy. Its effect on microclimate -- light intensity, moisture, and nutrient cycling -- play an important but undefined role in the ecology of areas where it is a dominant species. Whitewood appears to be rather shade tolerant and may not be an early gap species (Earhart, 1987 pers. commun.).

The hardwood is used primarily for charcoal and posts in St. John, but the latter last only about two years (Woodworth 1943, as *A. guadalupenis*).

Byrsonima coriacea (Sw.) DC -- Hogberry. This large evergreen tree with moderately hard wood is found only in the Bordeaux plots and is locally abundant there. It is found especially in the southeast corner (J 7-J 10; I 7-I 10) and along the eastern gut, extending to the western half of the plots in a few concentrations (C9-E9; C8-D8; C5-E5). The seeds of this species are in a small fleshy yellow fruit which is edible, though mealy and sometimes tart. The fruit may play an as yet undetermined role in distribution (e.g., seed dispersal through frugivory).

Why the limited distribution? Is it related to high levels of Fe and Cu (soil sample sites B12-B13 -- see Appendix III), or is it strictly due to seed source? The importance of seed source, seed availability, and dispersal mechanism, may play an important role in any kind of restoration ecology for watersheds. This also is true of other species of limited distribution found in this study, e.g., Pimenta, Pouteria, Acacia muricata, Ilex, Picrasmia, etc. Rather than being randomly distributed or hyperdispersed, many upper canopy tropical forest trees tend to be found in clumps (e.g., Hartshorn 1983 in Janzen 1983).

The wood is recommended for furniture, flooring and all kinds of carpentry uses (Little and Wadsworth 1964) and may have played a historic role in plantation construction.

Guapira fragrans (DC) Little -- Black mampoo; Loblolly. This softwood, fast-growing evergreen tree is found throughout the three plots and is one of the dominant species in each. It is especially abundant in areas around ridges and those with an abundance of boulders. The importance of this species needs to be analyzed more thoroughly. In Bordeaux, nearly all of the specimens appear to be affected by a disorder which manifests itself as swellings in the trunk. These symptoms are also found in the other plots. The causal agent should be isolated and identified, and the extent and importance of this phenomenon be determined. Is this species declining in numbers, and what are the reasons if it is?

The wood of this species is so soft that it is not even considered useful as a fuel. It is regularly employed by local gardeners as a soil amendment, especially in containers, due to its water holding capacity after rapid decay. In the forest, fallen limbs and trunks provide an excellent microenvironment for natural seedling establishment in areas with limited organic matter or moisture availability.

Inga fagifolia (L.) Willd. [syn. Inga laurina (Sw.) Willd.] -- Sweetpea. This medium-sized evergreen tree is a major component of the two upland plots, Bordeaux and L'Esperance, but is not found in Hawksnest. Although found throughout the plots, it is regularly abundant in the areas adjacent to the guts. Is this because of moisture requirements, tolerance of occasional flooding, or simply because the large seeds are carried to low spots during heavy rains? What role do animals play in its distribution?

The moderately hard wood is considered excellent for fish pot frames (Woodworth 1943) and charcoal, but is of limited use in construction because it is susceptible to dry wood termites. Sweetpea is regularly used for coffee shade (Little and Wadsworth 1964). Its abundance in the upland areas may be in part due to this historic use. St. John was historically known for its coffee production (Oldendorp 1777) and coffee can still be found on Bordeaux to the west of the plot.

Pimenta racemosa (Mill.) Moore var. racemosa -- bay rum. This evergreen tree with very hard wood is found throughout Bordeaux, but is not found in the other plots. In Bordeaux there are heavy concentrations in the areas around C1; G1-H1; J3-10; and E9-F9. It has been suggested that these trees were planted and that this variety was introduced to St. John

(Woodbury pers. commun. 1984). In a recent monograph on seven Myrtaceae genera, Landrum (1986) considers *P. racemosa racemosa* to be native to the Virgin Islands and the Lesser Antilles.

The grove around subplot C1 includes many trees which have similarly split trunks, all at approximately breast height. This also applies to the stand at the old bay rum distillery at America Hill in the Cinnamon Bay area, St. John. Such uniformity suggests that the trees may have been pruned for greater leaf production. The uneven spatial distribution indicates that the trees were probably not planted but may have been "saved". This is a common practice of enlightened workers throughout the West Indies, described from Jamaica in its current context by Rashford (1987), in which volunteer seedlings and saplings of desirable species are identified and encouraged. The leaves of this variety are used in the production of bay oil and bay rum. St. John was historically known for this production, with the Bordeaux Mountain area recognized as a major production spot.

It is interesting that this variety thus far has not been found in the wild in Tortola -- where the common variety is *P. r. grisea* (Kiaerskou) Fosberg -- though *P. r. racemosa* is recorded from Virgin Gorda (Landrum 1986). The *grisea* variety has a lemon scent and produces an inferior oil, reducing the value by as much as 90%, even with only minor contamination. *Pimenta racemosa* var. *grisea* is not known from St. John or St. Thomas. Conceivably, this may be due to the historical industrial importance of the essential oils of bay rum, thus a strict requirement of distillers, and vigilance and advice of agricultural advisors, calling for selective rogueing of this variety.

The hard wood of this species and most members of the family Myrtaceae is excellent for charcoal, posts and fish pot construction.

Tabebuia heterophylla (DC.) Britt. -- Cedar, Pink cedar. This deciduous tree with moderately hard, heavy wood is found throughout the three plots in moderate to high numbers, reflecting its wide distribution throughout the V.I. It is to be found in nearly all vegetation types/ecological zones in these islands. The wood of this tree is considered valuable by islanders for boat building (Woodworth 1943), home construction, and especially for landscaping. Its role in the forest and ability to persist need to be more thoroughly investigated.

Although it is one of the larger trees found, it is the most frequently colonized by the epiphyte *Clusia rosea* (Guttiferae) and as such is susceptible to windthrow, perhaps because of the unusual weight distribution, e.g., Bordeaux G1; L'Esperance J1. Is this relationship with *Clusia* due to an interaction with birds, as Woodbury (pers. commun. 1985) suggests? If so, what species of birds?

Will cedar persist in mature evergreen forests, or is it a primary colonizer of cleared sites which will be eliminated? A seedling study of this and other deciduous species needs to be undertaken in areas with closed canopies, to determine their ability to persist in the evolving forest. It is significant to note also that recent tropical storms have caused considerable windthrows of cedar. In general, the role of windthrow is likely to be comparatively more important in the succession of insular forest stands than it is in forests of continental areas.

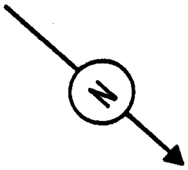
Other Species. Four additional species (Bs, Kf, Mb and Oc in Table 2), all among the most common species in the Hawksnest plot, but uncommon or absent in the other plots, are consistently associated with dry woodlands and thickets, generally at low and mid-elevations from northern South America, through the Caribbean islands, Central America, and, in part, far southern North America. *Melicoccus bijugatus*, which thrives in the dry transitional/moist forest context, is by far the dominant tree in Hawksnest (see Earhart et al. 1987). It is an aggressive and successful colonizer, thanks in good part to its large seed and popular fruit. Indeed, it can be characterized as a "weed" species.

Table 2. The Most Abundant Species of Trees in the Three Long-Term Monitoring Forest Plots on St. John[1].

Code	Species	Family	Common Names[2]	Plots[1]
Am	Acacia muricata	Fabaceae-Mimosoideae	Amarat, Spineless Acacia	B
Ai	Andira inermis	Fabaceae-Papilionoideae	Pigturd, "Hunklut", Bastard Mahogany	E
Ao	Ardisia obovata	Myrsinaceae	Whitewood, Bádula, Breakbill	E
Bs	Bursera simaruba	Buseraceae	Turpentine tree, W.I. birch, Gum tree	H
Bc	Byrsonima coriacea	Malpighiaceae	Hogberry	B
Gf	Guapira fragrans	Nyctaginaceae	Black mampoo, loblolly	B,H,E
If	Inga fagifolia	Fabaceae-Mimosoideae	Sweet peas, Sweetpea	B,E
Kf	Krugiodendron ferreum	Rhamnaceae	Black ironwood, Ebony	H
Mb	Melicoccus bijugatus	Sapindaceae	Genip, K'nip, Spanish Lime	H
Oc	Ocotea coriacea	Lauraceae	Laurel	H
Pr	Pimenta racemosa	Myrtaceae	Bay rum, Bay tree	B
Th	Tabebuia heterophylla	Bignoniaceae	Cedar, Pink cedar	E

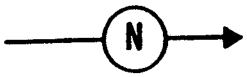
[1] B — Bordeaux (Plot 1); E — L'Esperance (Plot 2); H — Hawksnest (Plot 3). Includes only those species among the 5 most abundant in the plots indicated, based on the analysis presented in Earhart et al. (1987).

[2] Drawn from local oral sources and appropriate literature (e.g., Liogier and Martorell 1982, Martorell et al. 1981; Little and Wadsworth 1964, Little et al. 1974, Woodworth 1943).



Pr 12 Bc 5 If 5 Gf 4 Am 1	Bc 6 If 2 Gf 2 Pr 1	Bc 5 If 4 Gf 1	Bc 2 If 2 Pr 1	If 5 Pr 1 Bc 1 Gf 1	Pr 3 If 2 Bc 1	If 5 Pr 2 Bc 1	Bc 6 If 6 Pr 2 Am 1	If 3 Pr 2 Bc 1	If 3 Gf 2	10
Bc 7 If 7 Pr 5	If 3 Pr 3 Bc 3 Gf 1	Bc 3 If 1	If 7 Pr 1 Bc 1 Gf 1	Pr 7	Pr 13 If 4 Bc 3 Gf 1	If 7 Bc 4 Pr 1 Gf 1	If 8 Bc 7 Pr 2 Gf 1	If 9 Pr 2 Gf 2	Gf 11 Pr 2	9
Bc 12 Pr 8 If 4 Bc 2	Pr 5 Gf 5 Bc 4 If 2	If 3 Pr 3 Gf 2 Bc 1	If 6 Bc 2 Pr 1 Gf 1	If 3 Bc 3 Pr 1 Gf 1	If 5 Pr 2 Bc 1 Gf 1	If 7 Bc 3 Pr 3 Gf 1	If 9 Bc 3	Gf 5 If 1	Gf 3 Am 1	8
Pr 12 Bc 11 If 4 Gf 1	Bc 8 Pr 6 If 2 Gf 1	Pr 3 If 2 Gf 2	If 1	Pr 2 If 2 Bc 1	Gf 5 If 1 Pr 1	If 4 Gf 4 Pr 1	If 4 Pr 3 Gf 2 Bc 1	Gf 3 Am 1 Pr 1	Am 5 Pr 3 Gf 3	7
Pr 11 If 1	Pr 6 Gf 2 If 2	Bc 2 If 1	If 4 Gf 1 Bc 1	If 3 Bc 2	Gf 4 If 1 Pr 1	Gf 6 If 3 Pr 1	If 4 Gf 3 Am 2 Pr 1	Am 4 Gf 2 Pr 2	Am 16 Gf 6 Pr 3	6
Pr 7 Am 5	If 2 Gf 1 Am 1	If 6 Gf 2	If 3 Gf 2 Bc 1	Gf 4 If 1 Pr 1	Gf 5 If 2 Pr 2 Bc 1	Gf 7 If 3 Bc 2 Pr 1	Gf 6 Bc 1 If 1	Am 6 Gf 4 Pr 2 If 1	Am 17 Pr 5 Gf 1	5
Pr 11 Am 7 If 1 Bc 1	Am 3 Pr 2 Gf 1 If 1	If 5 Bc 3 Pr 1 Gf 1	Pr 3 If 2	If 3 Gf 1	If 1 Bc 1	Gf 9	Gf 8 Am 6 Pr 1	Am 2 Pr 2 Gf 1	Am 14 Gf 8 Pr 1	4
Pr 12 Am 4 If 1	If 9 Pr 4 Gf 3	If 3 Gf 3 Bc 1	If 2 Gf 1	Gf 4 If 1	Gf 9 If 1 Am 1	Gf 10 Bc 1 Pr 1	Am 6 Bc 6 Gf 5 If 2 Pr 1	Am 10 Pr 4 Gf 3	Am 11 Gf 6 Fr 3	3
If 7 Bc 5 Pr 3 Gf 2	If 4 Bc 3 Pr 1	If 3 Gf 1	If 3 Gf 3	Pr 3 Gf 3 If 1	Gf 16 If 1 Am 1	Gf 6 Am 5 Pr 4	Am 11 Pr 6 Gf 1	Am 9 Pr 3	Am 7 Gf 5 Pr 2	2
If 5 Bc 2 Gf 2	Pr 2 If 2	Pr 6 If 4 Gf 1	Pr 8 Gf 5 If 1	Gf 4 Pr 3 If 1	Am 5 Pr 3 Gf 2	Am 20 Gf 7 Pr 3	Pr 16 Am 6 Gf 2 If 1	Am 17 Pr 5 If 1	Am 14 Gf 5 Pr 4	1
J	I	H	G	F	E	D	C	B	A	

Figure 2. Synopsis of the Spatial Distribution by Subplot of the Five Most Important Species of Trees in the Bordeaux Plot. Subplots are 10x10m.



Ao 12 Gf 1	Ao 12 Gf 4 If 1	Ao 8 Gf 2 If 1	Ao 23 If 2	Ao 7 If 2 Ai 1	Ao 6 If 4 Ai 1	Th 7 Ao 6 Ai 2 If 1	Ao 4 Th 3 Ai 2 Gf 1	Ao 8 Ai 3 Gf 2	Gf 4 Ao 3 Ai 1 If 1	5
Ao 21	Ao 10 Gf 1	Ao 9 Gf 2	Ao 16 Ai 1	Ao 9 Ai 4 If 1	Ao 5 Gf 1 Ai 1	Ao 3 Gf 1 Ai 1	Ao 5 If 3 Ai 2 Th 1 Ai 1	Ao 9 Ai 6 Gf 2	Ao 6 Gf 1	4
Ao 18 If 1	Ao 15 Th 2 If 2	Ao 22 Gf 2 If 1 Ai 1	Ao 14 Ai 2 If 1 Gf 1	Ao 9 Ai 2 Gf 2	Ai 4 Ao 3 Gf 1	Ao 3 Ai 1	Ao 10 Gf 5 Th 2 Ai 1 If 1	Gf 4 Ao 3 Ai 3 If 1	Ao 4 Th 1 Ai 1 If 1	3
Ao 20 Th 2	Ao 11 If 2 Ai 1 Th 1 Gf 1	Ao 18 If 1 Ai 1 Gf 1	Ao 13 If 1 Gf 1 Th 1	Ao 14 Ai 3 Gf 1 If 1 Th 1	Ao 9 If 2 Gf 1	Ao 3 If 1 Ai 1	Ao 13 If 3 Ai 3 Gf 1	Ao 8 Ai 3 If 1 Gf 1	Ao 8 Gf 4 Th 2 Ai 1	2
Ao 2 Th 2 Gf 1	Ao 7 Th 4	Ao 11 Th 7 If 1 Ai 1 Gf 1	Ao 8 If 4 Th 3 Ai 2	Ao 9 If 2 Ai 2 Th 1	Ao 8 Gf 3 If 1 Ai 1	Ao 7 If 3 Ai 3 Gf 2	Ao 8 If 6 Ai 2	Ao 12 If 2 Gf 1	Ao 2 Ai 2 If 1	1
J	I	H	G	F	E	D	C	B	A	

Figure 3. Synopsis of the Spatial Distribution by Subplot of the Five Most Important Species of Trees in the L'Esperance Plot. Subplots are 10x10m.

SOIL CHEMISTRY ANALYSIS

Introduction

Limited information is available on soil-forest interactions, particularly within the Caribbean (Lugo et al., 1981). However, the fact that soil physical, chemical and biological properties interact in a complex way with forest composition is well established (e.g., Cole et al., 1977; Cole and Johnson 1978; Lugo and Brown, 1982; Odum and Pigeon 1970). This complex relationship makes generalizations about nutrient cycling in forested areas difficult. Therefore, it is necessary to evaluate each area individually.

Within the U.S. Virgin Islands, soil physical, chemical, and mineralogical characteristics have not been assessed in detail. Of some 25 entries for the U.S. Virgin Islands in Orvedal's (1978) bibliography of soils of the tropics, only 5 deal specifically with soils, the remainder deal with geology (9), geography (6), water resources (3) or other subjects. The Soil Conservation Service (1967) has completed characterizations and data sets for only eight Virgin Islands pedons (soils), none from St. John. Sixteen pedons have recently been analyzed from the three main Virgin Islands, of which three are from St. John (Collins and Craft, unpubl. data). Six of the total are addressed in Collins and Craft (1988), including one from St. John. Rivera et al. (1966, 1970) mapped and classified the soils of the U.S.V.I. based on extensive air photos, including commendable interpretations for a wide range of uses related to agriculture and construction. However, subsequent experience suggests that the classifications need to be revised and adjusted in the light of changing concepts of soil series applicable to local tropical insular conditions with a complex geological history, particularly for St. John and parts of St. Croix (Collins and Craft 1988).

An insightful attempt at synthesis is made by Teytaud (1986), in which he seeks to place the hierarchical soil taxonomy of the USDA into the context of the zonal system of soil classification and the FAO Soil Map of the World, and to integrate this into Holdridge associations of environmental factors. His designation and mapping of such associations for St. John has considerable merit, but is compromised by the very incomplete characterization of St. John soils to date. Thus, the information on soils gathered in this study can contribute to the strengthening of a vital information base for future understanding of soil development on St. John.

Materials and Methods

Soil samples were taken from each plot within a several weeks' period during May and June, 1986. Samples were taken at about 20 meter intervals 3 m outside the perimeter along the three up-slope sides of the Bordeaux and L'Esperance plots. Sampling was performed outside the plots so as to avoid disturbing the integrity of the soil cover and the plants' root spheres within the plots. Due to the extreme rockiness of the Hawksnest plot, and equipment and time constraints, only three samples were taken there, on the exterior of the plot in the same fashion as at the other two plots. All told, 33 sites were sampled, for a total of about 100 usable samples.

At each site, samples were taken over three depths, symbolized as A = 0 - 3 inches, B = 3 - 8 inches, C = 8 - 12 inches. Because of the shallow depth of most of the soils and the abundance of rocks in many of them, the precision of the depth separations undoubtedly varied somewhat from site to site. Sampling maps for each site are given in Figure 4 (Appendix I), showing the relative location of the sample sites. The sites' distance from the perimeter, not to scale in Figure 4, was maintained as close to three meters as possible. Each sample consisted of ca. 1000 cc in actual volume. No special attempt was made to remove surface organic detritus (leaf litter, etc.) before sampling. Field notes were made for the soil sampling sites, including observations on surface features, understory and canopy.

The samples were submitted to the VICES Diagnostic Laboratory for soil analysis. The samples were dried for 24 hours at 105° F. They were then ground to 10-mesh size using a Dynacrush grinder. The samples were analyzed for pH; soluble salts, organic matter and sodium content; texture; and ten elements: sodium, five macronutrients (P, K, Ca, Mg, S) and four micronutrients (Zn, Fe, Cu, Mn). Nitrogen could not be analyzed due to equipment unavailability when the samples were being processed. Aliquots of all soil samples from the three St. John plots have been retained in case of a need for future reference or verification.

The lab utilized a 1:2.5 water pH and soluble salt test (McLean, 1982; Rhoades, 1982). Organic matter was determined by acid dichromate digestion and read on a Bausch & Lomb Spectronic 20 (Hunter, 1983). Sulfate was analyzed with a calcium phosphate extraction colorimetric method (Hunter, 1983) and read on the Spectronic 20. Phosphorus, potassium, copper, iron, manganese and zinc were extracted using a sodium bicarbonate EDTA ammonium fluoride solution (Hunter, 1983). Phosphorus was then complexed with an antimony trioxide ammonium molybdate solution in a colorimetric reaction and measured on the Spectronic 20. The latter elements were read directly on an Instrumentation Laboratory (now Fisher Scientific) Model 457 atomic absorption spectrophotometer (AA). Calcium, magnesium and sodium were measured by potassium chloride extraction (Hunter, 1983) and read directly on the AA. A summary of the chemical analysis procedures is given in Table 3. Texture was assessed by hydrometer particle size analysis (Gee and Bauder, 1986).

A guide to interpretation of the soil test values in relation to plant nutrient availability to agronomic crops is outlined in Table 4. This interpretation may be different for the vegetation found within the research plots.

Results

Average results for the sampling sites over sampling depths for each plot are outlined in Table 5 and summarized below. Tables 6 through 8 (Appendix II) list the results of each test for each sampling site and depth for each plot. Test results in relation to sampling site for

Bordeaux, Hawksnest and L'Esperance plots are found in Appendices III, IV and V, respectively.

Soil pH. The average pH varies between plots, with the Hawksnest plot being highest at 7.12, and Bordeaux lowest, at 5.71. This variation in average pH between plots could influence the natural selection of plant species growing in those areas.

For both the Bordeaux and L'Esperance plots, the pH decreased with depth, which is consistent with principles of soil formation. However, the Hawksnest plot increased in pH with increasing depth. At this time, no reason for this is apparent.

Organic Matter. The surface horizons on all three plots have high organic matter contents, which is to be expected within a forested area. The significant and consistent decrease in organic matter content with depth is consistent with soil development.

There is only a slight change with depth in the percent organic matter content of the Hawksnest plot. This may be caused by several possible factors. There may be less deposition of vegetative material due to a difference in vegetative species. It also may indicate faster movement of water through this area due to the rocky soils and less underbrush to slow water movement. Any vegetative material deposited could easily be washed through the gut area and deposited below.

Soluble Salt Content. The soluble salt content is low and consistent over the area within each plot. Relative differences with depth are non-significant.

Available Phosphorus. The phosphorus level at all sites is low, with no significant change between plots. It also does not change significantly with depth in any of the plots.

Available Potassium. The potassium level of the surface is moderate to high, declining to low-moderate with depth for the Bordeaux and L'Esperance plots. There is no significant difference between these plots. The Hawksnest plot has a high potassium content in the surface, declining to medium over depth. This difference could be attributed to either mineralogy or nutrient cycling related to vegetative cover.

Available Calcium. In all of the plots there was a moderate amount of available calcium. The calcium content in both the Bordeaux and L'Esperance plots decreased with depth. The calcium content is slightly higher in the Hawksnest plot but not significantly different from the other plots. Within the Hawksnest plot there is also essentially no change over depth in the availability of calcium.

Available Magnesium. Low-medium levels of magnesium were available in each of the plots. The L'Esperance plot does have a slightly higher level of available magnesium than the other two plots. However, there is no significant difference between plots or over the depth of the plots.

Table 3. Outline of Soil Analysis Procedures, as Summarized from Agro Services International, Inc. procedures manual (Hunter 1983).

	SAMPLE	EXTRACTION		STIRRING		FILTRATE	COMPLEX REAGENT			INST.
ELEMENT	SIZE	VOLUME	REAGENT	TIME	SPEED	VOLUME	VOLUME	REAGENT	TIME	
pH	10 ml	25 ml	DEIZ.H_2O	10 min.	400 rpm		NONE			pH METER
SOLUBLE SALTS	10 ml	25 ml	DEIZ.H_2O	10 min.	400 rpm		NONE			CONDUCT. BRIDGE
P	2.5 ml	25 ml	0.25 $\underline{N}$ $NaHCO_3$ 0.01 $\bar{M}$ EDTA 0.01 $\underline{N}$ NH_4F	10 min.	400 rpm	1 ml	10 ml 9 ml	ANTIMONY-TRIOXIDE AMMONIUM-MOLYBDATE DIEZ. H_2O	40 min.	SPEC 20 680 nm
K	2.5 ml	25 ml	0.25 $\underline{N}$ $NaHCO_3$ 0.01 $\bar{M}$ EDTA 0.01 $\underline{N}$ NH_4F	10 min.	400 rpm	1 ml	19 ml	DEIZ. H_2O		AA 766.5
Cu	2.5 ml	25 ml	0.25 $\underline{N}$ $NaHCO_3$ 0.01 $\bar{M}$ EDTA 0.01 $\underline{N}$ NH_4F	10 min.	400 rpm			NONE		AA 324.7
Fe	2.5 ml	25 ml	0.25 $\underline{N}$ $NaHCO_3$ 0.01 $\bar{M}$ EDTA 0.01 $\underline{N}$ NH_4F	10 min.	400 rpm			NONE		AA 248.3
Mn	2.5 ml	25 ml	0.25 $\underline{N}$ $NaHCO_3$ 0.01 $\bar{M}$ EDTA 0.01 $\underline{N}$ NH_4F	10 min.	400 rpm			NONE		AA 279.3
Zn	2.5 ml	25 ml	0.25 $\underline{N}$ $NaHCO_3$ 0.01 $\bar{M}$ EDTA 0.01 $\underline{N}$ NH_4F	10 min.	400 rpm			NONE		AA 213.9
Ca	2.5 ml	25 ml	1 $\underline{N}$ KCl	10 min.	400 rpm	1 ml	9 ml 10 ml	DEIZ.H_2O 1% La_2O_3		AA 422.7
Mg	2.5 ml	25 ml	1 $\underline{N}$ KCl	10 min.	400 rpm	1 ml	9 ml 10 ml	DEIZ.H_2O 1% La_2O_3		AA 285.2
Na	2.5 ml	25 ml	1 $\underline{N}$ KCl	10 min.	400 rpm	1 ml	9 ml 10 ml	DEIZ.H_2O 1% La_2O_3		AA 589.0
SO_4	5 ml	25 ml	$CaH_4(PO_4)_2$	10 min.	400 rpm	7 ml	9 ml 4 ml	HNO_3-GLAC. ACETIC ACID $BaCl_2$-PVP	20 min.	SPEC 20 535 nm
ORGANIC MATTER	1 ml	10 ml	$Na_2Cr_2O_7$-H_2SO_4	DIGEST 300 F		2 ml	25 ml 10 ml	DEIZ. H_2O DEIZ. H_2O		SPEC 20 650 nm

Table 4. Guide to interpretation of soil analysis value ranges (in ppm), as applicable to agronomic crops.

Test Variables	Low	Medium	High
Soluble Salts	1000	1000-4000	4000+
Phosphorus	25	75	150
Potassium	90	150	300
Calcium	1600	7200	14,400
Magnesium	480	2160	7200
Sulfate	25	75	150
Zinc	4	18	35
Iron	40	200	400
Copper	3	10	20
Manganese	10	50	100
Sodium	as low as possible for optimum conditions		

Table 5. Summary of average analysis values for each plot by depth.

Analysis	Depth[1]	Bordeaux	L'Esperance	Hawksnest
pH	A	5.93	7.13	6.87
	B	5.65	6.39	7.09
	C	5.55	6.16	7.16
	Total	5.71	6.49	7.12
			%	
Organic Matter	A	7.35	6.24	4.83
	B	5.92	4.39	4.30
	C	4.28	3.55	4.60
	Total	5.82	4.80	4.58
			ppm	
Soluble Salts	A	144	185	167
	B	101	75	83
	C	47	20	100
	Total	97	98	119
<u>Macronutrients</u>				
Phosphorus	A	11.4	9.30	7.70
	B	6.7	5.70	8.00
	C	16.4	4.58	3.50
	Total	11.5	6.74	6.75
Potassium	A	214	238	303
	B	154	168	292
	C	110	115	187
	Total	159	181	270
Calcium	A	1868	2621	4465
	B	1390	2522	3697
	C	1019	2308	4822
	Total	1418	2491	4266
Magnesium	A	625	851	620
	B	560	976	639
	C	552	855	902
	Total	578	910	750
Sulfate	A	16.0	11.3	16.0
	B	8.4	7.6	9.0
	C	7.3	8.1	9.0
	Total	10.5	9.0	11.6

Table 5 (cont'd.). Summary of Average Analysis Values

		Plot		
Analysis	Depth[1]	Bordeaux	L'Esperance	Hawksnest
Micronutrients				
			ppm	
Zinc	A	7.72	1.32	1.27
	B	7.97	1.85	0.53
	C	5.68	1.47	1.20
	Total	7.11	1.55	0.98
Iron	A	146	45	30
	B	527	101	15
	C	751	134	21
	Total	481	91	22
Copper	A	2.56	3.39	2.97
	B	5.61	5.53	2.70
	C	6.13	5.77	3.85
	Total	4.81	4.85	3.09
Manganese	A	21.8	6.7	7.3
	B	20.4	6.2	2.7
	C	17.0	5.4	2.6
	Total	19.7	6.1	4.4
Other				
Sodium	A	79	123	85
	B	94	101	77
	C	107	121	59
	Total	94	115	76
			%	
Sand Content	A	69	66	67
	B	65	np	59
	C	56	57	61
	Total	63	62	61
Silt Content	A	22	23	19
	B	23	np	23
	C	26	26	21
	Total	24	25	21
Clay Content	A	9	11	14
	B	12	np	18
	C	17	17	18
	Total	13	14	17
Texture[2]	A	sl	sl	sl
	B	sl	sl	sl
	C	sl	sl	sl
	Total	sl	sl	sl

---

[1] A = 0-3 inches, B = 3-8 inches, C = 8-12 inches

[2] sl = sandy loam, np = not preformed due to minimal sample

Available Sulfate. All of the plots have low levels of sulfate available. This is consistent within all plots as well as over depth.

Available Zinc. A low level of zinc is available within all of the plots and over depth within the plots. There is no significant difference between plots.

Available Iron. The iron content is consistent within plots but not between plots or over the depth of plots. The variations found could influence the selection of vegetative species growing in the areas.

The Bordeaux plot is high to very high in iron. The high level of iron in the Bordeaux plot is most likely due to differences in the mineralogy of the parent materials of the plot. The increase in availability with depth in this plot is significant.

The L'Esperance plot has a low-medium iron content while the Hawksnest plot has a low iron content.

Available Copper. The copper content is consistently low within all of the plots. The difference between plots is not significant. There is a decrease in copper content over depth; however, it is not significant.

Available Manganese. Both the Hawksnest and L'Esperance plots are consistently low in manganese. The amount available decreases with depth but is not significant. The Bordeaux plot has consistently low-medium levels of available manganese. The difference between plots may be due to the mineralogy of the soils. This difference, may but most likely would not, influence plant species found within the plots.

Sodium. There is no significant difference in the levels of sodium occurring between plots or over depth within plots.

Texture. The soil texture at all sites averaged a sandy loam but closely verging on a clay loam texture. The percent sand, percent silt and percent clay are all consistent within a plot and over the depth of sampling.

Discussion

The initial soil analysis was performed to gather baseline data and to determine whether or not significant differences in nutrient availability occurred between plots. The results have demonstrated that there are relative differences in soil nutrient availability between plots which could have a direct effect on plant selection and growth. Therefore, further investigative efforts are encouraged.

The soils within each plot have been identified as Cramer. However, further characterization is needed to verify the actual soil series located at each site. This is particularly true for the Hawksnest plot where the soil is identified as a Cramer-Isaac gravely clay loam which is classified as a Lithic Argiustoll/Udic Argiustoll (Rivera et al. 1970). However, the high stone content makes this classification very questionable. In addition, the epipedon does not meet the requirements for a mollic epipedon, for inclusion into the Mollisol order.

Further, the soil series classification (Rivera et al. 1970), on St. John in particular, is based almost exclusively on aerial photogrammetry, with a minimal amount of ground truthing. Thus, it is perhaps inevitable that substantial discrepancies have arisen. The Soil Conservation Service intends to re-survey the soils of St. John and the other U.S.V.I. beginning in 1988 (G. Acevedo, SCS, Puerto Rico, pers. commun. 1987).

The geological materials from which soils develop can influence the resulting soil physical properties, which in turn could influence the natural selection of plant species. The texture of a developing soil is dramatically influenced by the parent material. In comparing the determination of soil texture by field texture evaluation as opposed to particle-size analysis, Collins and Craft (1988) found that lab analysis resulted in higher sand contents than determined in the field. The highly weathered rock fragments found in soils throughout the U.S. Virgin Islands easily crumble to sand-size particles with minimal pressure. Further evaluation of soil physical properties between the plots may indicate significant differences which could influence plant growth.

Soil sampling was performed only to a depth of 12 inches. However, the influence of the subsoil could prove important. The steep topography of the islands lends itself to dynamic land forms which remain mobile. As observed by Squires (1940), the steep hillsides are basically talus slopes derived from highly inclined stratified metamorphic beds, whose tops have been frayed off and scattered down the slopes in the form of rocks of various sizes, mixed with soil derived from them. These rocks lend themselves well to terrace construction, thus having made extensive conversion of the hillsides to agriculture possible when labor was cheap -- and soil conservation was not recognized as a need.

In an evaluation of certain soils of the Virgin Islands, Collins and Craft (1987) found that many soils had lithologic discontinuities. Colluvial material (moved by gravity) were identified in the upper soil portions and often overlaid residual.

Determining the genesis of these soils becomes complicated due to the occurrence of several of these colluvial events, creating layers of various-sized particles within a profile. These events can be separated by analyzing relative particle sizes and locations of stone lines. The occurrence of the layers can influence many soil physical properties, including aeration and water movement, which modify the rooting environment for plants. Natural selection of plant species could be influenced by the occurrence of these colluvial layers and the depth to bedrock.

In a geochemical survey of St. John and St. Thomas for the U.S. Geological Survey, Tucker et al.(1985) found high levels of heavy metals in the areas where the plots are located, but particularly in the Bordeaux Mountain area. These elements should be evaluated to determine availability and potential influence on selection and phytosociological attributes. Ramos-Perez et al. (1987) studied heavy metal export, both in the dissolved and suspended form, to marine near-shore environments of St. John with a view to estimating possible toxicity of the heavy metals on marine biota. In order of decreasing concentration, the metals found, both in the stream water and marine sediment samples, were: magnesium, iron, manganese, copper, nickel and zinc. All values were considerably lower than those normally found in bays receiving industrial and domestic pollution.

The preliminary baseline data gathered in this study provides only a first step towards assessing the actual plant-soil relationships within these plots and in ecosystems within the U.S. Virgin Islands. To more fully understand these ecosystems and the influence which soil properties and nutrient distribution have on the resulting plant growth, further soil and plant analyses must be performed. For the influence of topography and site location on plant selection and/or growth to be better understood, the soils should be further characterized, including soil physical properties, to evaluate their effect on root distribution, aeration and water relations.

CONCLUSIONS AND RECOMMENDATIONS

Three permanent study plots have been identified and established on St. John, with the overall long-term objective of monitoring representative components of secondary forest development on a small dry-to-moist tropical island. The plots are in representative ecological zones -- upland moist forest (Bordeaux), gallery moist forest (L'Esperance) and dry evergreen woodland (Hawksnest) -- and are situated on watersheds of critical importance to the park: Reef Bay, Fish Bay, and Hawksnest Bay, respectively. The near-offshore areas of these bays are the subject of several long-term marine studies by VIRMC and other research groups.

The implementation of vegetation and soil studies on these watersheds will allow specific aspects of the association of land and marine systems on this island to be evaluated for the first time. The regenerating forest is an intriguing mixture of native and exotic species. Comparative study of the interaction between these two groups, and their relative development is likely to be most instructive, and of high relevance to other islands, especially in the Neotropics.

Clearly, a wide spectrum of primary and secondary studies could justifiably be undertaken on the three permanent forest monitoring plots on St. John, described herein. These include: (1) autecological aspects and physiognomic features and patterns -- e.g., bark, leaves, roots, stratification, epiphytes, parasites; (2) community ecology -- primary and secondary productivity; nutrient distribution and cycling; phenology; reproductive biology (e.g., Flores and Schemske 1984); dominance and diversity; forest succession and dynamics; and (3) soil and water relationships, including land-use, erosion, and sediment movement studies; and nutrient-plant distribution assessments.

Some specific recommendations for further investigation, and related observations, are presented below.

Terrestrial Vegetation

Information needs are here considered in four sections: (a) analyses needed on plot data currently available; (b) future research needs specifically associated with the long-term plots; (c) suggested work on other aspects of VINP terrestrial vegetation, and its management; and (d) soils and nutrient relationships.

A terrestrial ecology subcommittee of VIRMC should be set up to advise the park research biologist and superintendent. This group would review research proposals associated with the long-term vegetation monitoring plots and could be available for consultation on management decisions. There is a need to coordinate research and insure, for example, that destructive sampling does not occur within the plot (e.g., soil samples should be taken outside the plots). The establishment of this formal group might also better insure that there is regular monitoring and maintenance of the plots.

Establishment and Initial Inventory Data Follow-up. Data acquired in these plots are in the process of being analyzed on a subplot and species basis to begin to look at the following sorts of questions, some of which will be the subject of future publications (e.g., Earhart, Prance and Reilly, in prep.):

1. What is the nature of the trends in vegetation distribution relative to position in the landscape (proximity to ridges, guts, etc.)? In this connection, Weaver and Chinea-Rivera (1987) recently reported work on a series of 16 plots in the Cinnamon Bay Watershed on St. John, from sea level to summit, located on ridge, slope and gut topography, to explore relationships via reciprocal averaging ordinations. They showed that there are correlations not only with topography but also elevation.

2. How important is the role of seed source, as modified by relief and prevailing winds?

3. What species-to-size relationships are there, and is there significance to preliminary observations on the paucity of smaller (younger) trees of currently important species like A. muricata and G. fragrans in Bordeaux and G. fragrans in L'Esperance? Do these reflect developmental trends from a deciduous to an "evergreen" forest?

4. Are there interactions of nutrients and metals with respect to forest species? Is there an association with a threshold of soil organic matter, or are canopy and seed source more important, as a preliminary assessment might indicate?

Long-term Vegetation Monitoring. Additional data collection on the following aspects would be useful in evaluating the relative significance of determinants of forest composition and developmental patterns (also, see soils and nutrient relationships section below).

1. A collection of voucher specimens needs to be completed for definitive identification and reference. Such a collection is being assembled in connection with the Flora of St. John project of the NYBG (A. Reilly, pers. commun. 1987).

2. Preliminary observation indicates a disease may be affecting _G. fragrans_. The causal organism of this needs to be determined and its influence on the paucity of smaller trees and seedlings needs to be evaluated. Microorganisms may be significant in disease and may also be significant as beneficials in mycorrhizal and rhizobial associations.

3. A baseline survey of other organisms in the plots and their interaction with the flora should be undertaken. This would involve birds and pollination, and seed distribution, including the distribution of _Clusia rosea_, which seems to be significant in treefall. Insects and their role in pollination and predation may be significant.

4. Arthropods have a strong direct and indirect influence over plant productivity and nutrient cycling. For example, the standing crop of fecal pellets from macroarthropod detritivores such as millipedes may locally exceed annual litterfall inputs (Seastedt and Crossley 1984). Studies on herbivore-plant and detritivore-detritus interactions would shed vital information on nutrient cycling.

5. Research information is needed on the differential growth of island vegetation. Aspects of this line of inquiry are being pursued on the 16 permanently marked plots on St. John by the ITF (Weaver, pers. commun. 1987).

6. The long-term study of developmental patterns in these forests is predicated on the ecological dynamics of successional generations. The single subplot in which sapling trees 3 - 5 cm are found has demonstrated some interesting trends. Of even more significance is seedling germination and survival. Seedlings and saplings should be surveyed to elucidate the effects of various environmental stresses on the different species. Duke's (1965) key on identification of seedlings of major forest types in Puerto Rico could be usefully modified in this regard.

General Terrestrial Plant Management Needs. Besides specific research related to the long-term plots, there are several priority needs for data which would be useful to park managers, to the neighboring community, or the visiting public. For example:

1. Numerous requests have been made of the park regarding the possibility of harvesting traditionally used plant products from the park. Work needs to be undertaken to define the ecological abundance and location and to determine the effect of cutting and harvesting birch (_Eugenia biflora_, and _E. monticola_) which is used in the construction of fishpots, or hoop vines(_Trichostigma octandra_ and _Serjania polyphylla_) and on bay leaves (_Pimenta racemosa_ var. _racemosa_).

2. Similarly, there is a significant threat to the island's herbaceous vegetation, being harvested for ornamental use in landscaping. This is particularly true of the Orchidaceae, Bromeliaceae, Cactaceae, Araceae and Urticaceae. Especially important in this group are studies of the endemics Tillandsia lineataspika, Anthurium sellosium, and Pilea santaecrucis. Probably as vulnerable are the dancing lady orchids Oncidium spp., and Philodendron giganteum. Studies on the propagation of these, especially on the possibility of utilizing tissue culture for mass propagation, might be a way to prevent their seemingly inexorable loss.

3. Related research on the propagation of tree species, especially uncommon ones, which are thought to have been abundant at one time, such as Manilkara balata, Masticodendron foetidisimum and Roystonea borenquena, should also be undertaken, if possible on site. Seed sources of these trees need to be identified and ecologically appropriate sites selected. There are also plants which were originally recorded from St. John which can no longer be found. Among these are Zanthoxylum flavum and Acromedia media. The selected culling of "weedy" or dominant exotic species may be necessary and desirable on reintroduction sites.

4. The park may want to consider the creation of a nursery for the propagation of plant materials and the staffing of a professional forester/horticulturist. Alternatively, the park may find it desirable to contract out this work or at least perform preliminary studies on propagation requirements. The UVI is one possibility for undertaking such a study. Another is the Caneel Bay Resort. The resort already has an excellent horticultural staff and may be able not only to investigate propagation requirements, but also to undertake the actual propagation and distribution.

5. The rare, endemic and "new" species of St. John all need to be more thoroughly studied including their distribution, abundance, and ecological and propagation requirements. A priority should be given to the production of a document detailing their descriptions and abundance.

6. Finally, a modern flora and botanical key to the plants of St. John are needed. A commitment to such a project has been made by the NYBG. Accompanying such a work, and very useful when interpreted for public use, would be checklists of the trails and high-use areas like the beaches.

Soils and Nutrient Relationships

In areas which, based on the existing soils data (Appendix I-V), show patterns of nutrient correlation with species composition, more extensive soil testing should be undertaken. What is the significance of the Mg/K, Fe/Zn or Fe/Mn interactions, for example? Similarly, in conjunction with this, it may be worthwhile to undertake a tissue testing program to identify indicator plants and to look at nutrient uptake by different species. This would allow for testing within the plots without the significant impact which excavation would involve. To do this, it is necessary to determine "normal" levels and define a specific methodology regarding what tissue to test and when it should be sampled. Nutrients are utilized and stored at different levels by different tissues and this compartmentalization is variable depending upon the age and physiological condition of the plant.

Lack of equipment at the time of analysis, prevented determination of nitrogen levels in any form. Thus, nitrogen availability, which is so closely related to the rate of litter decomposition, and can in turn indicate rates of mineralization and soil leaching, should be analyzed in the near future to have as a reference base. The contribution of nitrogen-fixing plants located within the plots and surrounding areas should also be evaluated.

While this study determined the amount of exchangeable nutrients, it must be noted that the total amount of elements present, particularly metals, can also influence plant growth due to chemical interactions. Thus, analysis for the total element levels may provide useful insights into nutrient availability and/or toxic influences.

The present study did not attempt to address the question of plant productivity and nutrient cycling in relation to soil chemistry within and between the plot ecosystems. An evaluation of the nutrient distribution between soil, plant tissue, litter, soil flora and fauna is needed. Other aspects such as the potential for nutrient and mineral movement due to surface run-off or leaching (particularly in the stony soil at the Hawksnest plot) should be evaluated. The St. John study on transport of bedrock-derived metals by Ramos-Perez <u>et</u> <u>al</u>. (1987) is of interest in this regard.

In addition, assessing nutrient accumulation from allochtonous sources, such as stream flow deposition or throughfall (dust, rain, leaves from upwind sources, etc.) would be beneficial. Airborne input of minerals essential for a plant growth is considered a major source of nutrients for the Amazonian rain forest; Sahara dust carried by the trade winds is considered to provide the bulk of this input (Reichholf 1986). In the Virgin Islands, airborne particle deposition appears to be high, and it is generally assumed that Sahara dust is a main contributor.

The influence of litter decomposition rates on soil nutrient status was not considered in this study either. Decomposition rates via standard decomposition bag techniques or other means should be evaluated to determine how the plant species composition is influencing the rate of nutrient cycling.

Community Education

Many public education opportunities exist in connection with the forest monitoring project. Some of these are along the line in which the V.I. Cooperative Extension Service has already developed programming with its Terrestrial Flora Awareness effort, such as on plant pressing techniques and related crafts projects, native plant recognition and use; historical interrelationships of people and plants. VICES community education programs broadcast via radio and television have included descriptions of the forest monitoring project.

Other interpretive programming needs to be developed relating to the ecosystem services of the forest. Information and insights gained from the project will be useful in increasing public appreciation of watershed management as an important element in maintenance of land, forest, soil, water, wildlife and coastal ecosystems. Additional opportunities exist to address such potential enterprises as agroforestry and cottage industries related to plant materials-based handicrafts (e.g., U.S. Congress 1987).

The interested reader is also referred to related broader recommendations dealing with institution-building, land and watershed management, and integrated renewable resource management in the Caribbean (Lugo and Brown 1984, U.S. Congress 1987).

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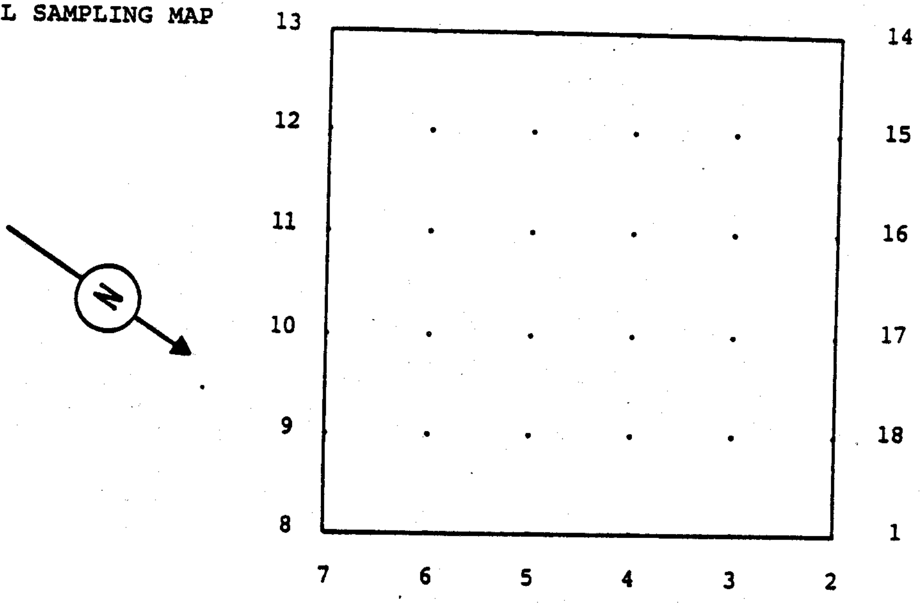
APPENDIX I. Soil Sampling Maps for the Bordeaux, Hawksnest and L'Esperance Plots, St. John, U. S. Virgin Islands

Note: The Location of the Sites Averaged 3 m Outside the Perimeter of the Plots, and 20 m apart. L'Esperance Site 12 (E12) and Hawksnest Site 3 (H3) were taken along the embankment of their respective streambeds (guts) directly below the plots. The distance from the perimeter is not to scale.

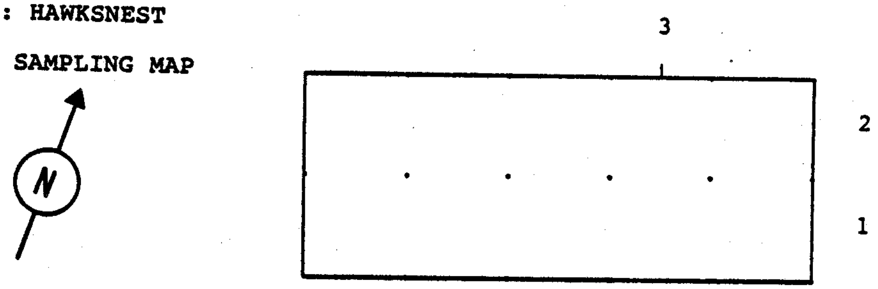
PLOT: BORDEAUX

SOIL SAMPLING MAP



PLOT: HAWKSNEST

SOIL SAMPLING MAP



PLOT: L'ESPERANCE

SOIL SAMPLING MAP

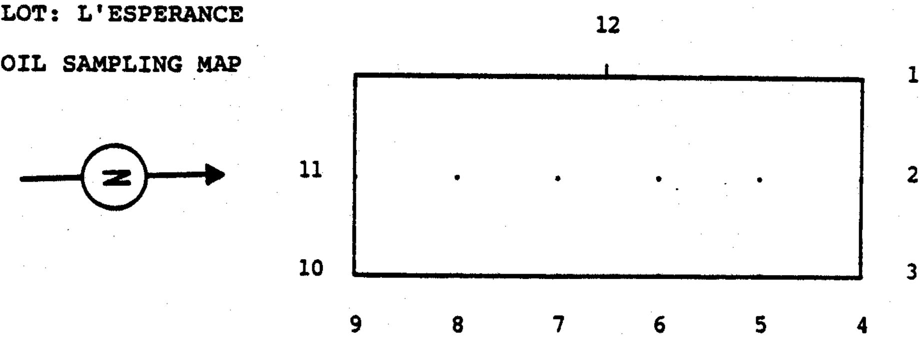


Figure 4. Relative Location and Spacing of the Soil Sampling Sites Along the Exterior of the Three Plots. The Distance Between the Dots Represents 20 meters. In Each Case, Down Slope is Towards the Top of the Figure.

APPENDIX II. Tabulations of Individual Values of Soil Analysis Data for all Plots and Sampling Sites.

Table 6. Individual soil analysis values for all samples at each depth for pH, organic matter, copper(Cu), manganese(Mn), iron(Fe), and zinc(Zn).

Plot[1]	No.	Depth[2]	pH	Organic Matter	Cu	Mn	Fe	Zn
				%	- - - - - - - - - -		ppm	- - - - - - - -
E	1	A	6.47	4.50	5.30	9.50	108.10	1.50
E	1	B	5.64	3.70	7.80	8.80	287.00	6.00
E	1	C	5.16	4.40	10.50	10.10	695.10	1.20
E	2	A	6.44	6.70	5.30	8.60	76.80	1.20
E	2	B	6.29	4.80	5.10	5.30	36.30	0.80
E	2	C	5.81	3.20	5.90	6.10	75.40	7.00
E	3	A	6.46	6.50	3.10	6.00	43.10	1.10
E	3	B	5.79	4.80	6.30	9.80	323.00	1.90
E	3	C	5.93	2.10	7.10	11.90	95.20	0.70
E	4	A	6.62	6.50	3.50	11.20	54.70	1.80
E	4	B	6.22	2.60	5.70	4.50	67.50	0.80
E	4	C	6.69	4.80	5.90	3.20	58.80	0.90
E	5	A	6.80	6.90	1.80	3.90	30.60	1.10
E	5	B	6.82	4.00	6.80	8.20	64.40	0.50
E	5	C	6.69	2.60	5.70	7.30	65.10	1.00
E	6	A	6.73	7.30	3.40	5.40	41.50	1.60
E	6	B	6.67	5.20	5.20	6.90	62.80	3.40
E	6	C	6.97	3.30	4.70	5.80	61.80	0.90
E	7	A	6.73	3.50	3.80	6.50	48.00	1.30
E	7	B	6.16	5.50	5.60	5.80	107.40	2.40
E	7	C	6.02	1.90	6.30	5.60	174.20	1.00
E	8	A	7.28	6.50	2.60	6.60	36.00	0.70
E	8	B	6.80	5.20	3.10	3.80	29.40	0.50
E	8	C	6.44	2.70	4.60	5.60	69.10	0.80
E	9	A	7.00	6.00	3.10	7.50	48.90	1.80
E	9	B	6.35	3.00	6.10	7.50	67.50	1.00
E	9	C	6.17	3.20	7.10	3.80	71.70	0.80
E	10	A	7.48	9.70	0.90	5.20	12.00	1.30
E	10	C	6.23	5.70	1.80	0.60	25.90	0.50
E	11	A	6.98	7.30	2.60	6.50	19.70	1.40
E	11	B	6.82	5.30	4.40	3.10	25.80	1.80
E	11	C	6.14	4.20	3.80	1.20	18.10	0.90
E	12	A	7.44	3.50	5.30	3.70	25.50	1.00
E	12	B	6.39	6.00	4.60	3.10	80.40	2.20
H	1	A	7.08	5.00	3.70	4.40	34.80	1.70
H	1	B	6.56	5.70	3.80	0.90	19.70	0.40
H	1	C	7.01	4.50	5.40	4.20	28.40	1.70
H	2	A	7.06	5.00	2.60	5.50	29.50	0.80
H	2	B	7.27	2.80	2.50	2.70	9.80	0.50
H	2	C	7.31	4.70	2.30	0.90	12.60	0.70
H	3	A	7.25	4.50	2.60	11.90	26.40	1.30
H	3	B	7.44	4.40	1.80	4.40	15.00	0.70

Table 6. (cont'd). Individual Soil Analysis Values.

Plot[1]	No.	Depth[2]	pH	Organic Matter	Cu	Mn	Fe	Zn
				%	- - - - -	- - - - -	ppm	- - - -
B	1	A	5.54	7.70	0.80	23.00	63.50	8.80
B	1	B	5.28	6.20	1.60	30.40	436.00	16.50
B	1	C	5.68	6.00	1.60	30.60	649.60	11.80
B	2	A	5.57	7.30	1.00	32.30	90.90	8.00
B	2	B	5.27	6.50	1.80	24.10	675.00	8.50
B	2	C	5.40	4.50	2.10	13.20	660.00	6.40
B	3	A	5.58	7.30	4.70	25.40	582.40	11.00
B	3	B	5.25	9.00	12.50	20.10	992.00	11.20
B	3	C	5.16	4.40	13.60	10.50	956.00	5.80
B	4	A	5.90	9.50	1.70	42.70	36.10	20.90
B	4	B	4.92	5.30	5.70	34.70	456.00	13.10
B	4	C	5.08	3.60	6.90	21.30	1047.00	7.80
B	5	A	6.67	5.30	3.50	8.10	54.40	7.90
B	5	B	6.52	4.50	8.00	3.80	58.90	11.10
B	5	C	5.58	3.00	10.00	18.60	473.00	8.80
B	6	A	6.03	9.70	1.70	11.50	92.00	8.20
B	6	B	5.68	4.80	3.40	13.10	503.00	10.70
B	6	C	5.61	4.50	4.90	9.70	494.50	7.50
B	7	A	5.65	7.30	2.60	17.90	98.20	8.00
B	7	B	5.50	7.70	5.50	12.80	743.40	9.10
B	7	C	5.75	4.40	7.90	13.30	1122.00	6.70
B	8	A	6.16	5.40	3.50	9.10	47.30	8.90
B	8	B	5.35	4.80	6.80	9.60	494.00	10.10
B	8	C	5.32	2.80	7.50	8.70	1051.00	7.80
B	9	A	5.79	7.80	1.40	31.80	61.10	2.40
B	9	B	5.59	5.70	2.30	12.70	401.00	2.10
B	9	C	5.59	4.50	1.70	9.80	309.00	1.40
B	10	A	6.11	10.20	1.70	31.00	54.70	4.80
B	10	A	6.24	7.60	3.80	16.10	325.00	6.20
B	10	C	6.89	5.80	6.10	18.40	530.00	5.40
B	11	A	5.33	6.00	8.70	19.80	534.00	2.90
B	11	B	5.54	3.60	15.40	13.70	800.00	2.80
B	11	C	5.66	3.20	14.70	7.80	857.00	1.50
B	12	B	5.41	5.40	12.20	24.10	1478.00	7.30
B	12	C	5.28	3.30	13.10	24.60	1380.00	5.90
B	13	A	5.93	5.50	4.20	26.70	446.50	7.10
B	13	B	5.20	7.10	9.40	26.10	107.20	4.80
B	13	C	4.91	6.80	8.30	21.00	1348.00	2.50
B	14	A	6.23	6.80	1.50	8.80	63.90	4.40
B	14	B	6.69	4.00	5.20	10.60	85.70	4.90
B	14	C	5.65	2.20	2.10	10.10	465.00	3.30
B	15	A	6.74	6.20	1.50	8.40	57.10	2.90
B	15	B	5.84	5.20	1.00	5.90	105.80	4.10
B	15	C	5.66	2.80	4.80	13.10	488.00	5.50
B	16	A	6.14	7.60	2.50	9.40	49.50	6.10
B	16	B	5.69	4.80	2.60	17.00	542.50	4.30
B	16	C	5.51	6.40	1.20	13.30	494.00	3.70
B	17	A	5.57	6.70	1.10	34.60	67.50	8.70
B	17	B	5.54	8.20	1.50	67.50	685.30	6.50
B	17	C	5.48	4.50	1.10	43.70	596.40	5.00
B	18	A	5.89	8.70	1.40	29.20	86.70	10.30
B	18	B	6.18	6.20	2.20	24.70	599.20	10.20
B	18	C	5.68	4.40	2.80	17.40	602.50	5.40

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[1] B = Bordeaux, E = L'Esperance, H = Hawksnest plots

[2] A = 0-3 inches, B = 3-8 inches, C = 8-12 inches

Table 7. Soil analysis results for all samples at each depth for soluble salts, phosphorus(P), sulfate(SO_4), potassium(K), calcium(Ca), magnesium(Mg), and sodium(Na).

Plot[1]	No.	Depth[2]	Soluble Salts	P	SO_4^-	K	Ca	Mg	Na
			- - - - - -	- - - - - -	- - - - - -	ppm	- - - - - -	- - - - - -	- - - - - -
E	1	A	125	8	19	297	1672	549	71
E	1	B	50	4	7	278	1895	745	84
E	1	C	0	4	15	157	1721	676	141
E	2	A	100	8	11	299	1929	630	108
E	2	B	100	8	6	165	2198	838	89
E	2	C	0	4	11	178	2166	911	127
E	3	A	100	8	11	312	2704	695	112
E	3	B	50	5	7	215	1778	548	80
E	3	C	0	4	11	169	2096	914	142
E	4	A	100	8	11	259	2176	822	75
E	4	B	50	5	3	176	2066	898	83
E	4	C	0	8	3	146	2402	756	90
E	5	A	100	11	6	173	2378	639	83
E	5	B	100	4	6	98	2123	1200	106
E	5	C	100	4	6	131	2090	1044	123
E	6	A	150	7	11	148	2217	1054	80
E	6	B	50	5	6	119	1798	1009	75
E	6	C	0	7	6	114	1764	999	104
E	7	A	100	11	8	173	2314	780	130
E	7	B	0	8	15	85	1377	993	54
E	7	C	100	5	6	55	1205	991	117
E	8	A	300	11	6	254	1875	1728	142
E	8	B	150	5	11	182	4375	1756	191
E	8	C	50	3	8	79	2013	1697	154
E	9	A	150	8	8	222	4360	1198	49
E	9	B	50	5	6	165	2077	1144	213
E	9	C	0	7	0	140	2214	872	111
E	10	A	300	14	21	246	3090	750	87
E	10	C	50	4	13	109	3516	654	75
E	11	A	200	10	11	357	4920	549	52
E	11	B	100	5	15	229	6105	836	45
E	11	C	0	4	8	124	3984	553	112
E	12	A	500	7	13	120	1711	822	495
E	12	B	100	10	3	170	2378	702	106
H	1	A	100	4	6	282	5165	1059	90
H	1	B	50	9	6	206	3140	860	98
H	1	C	100	3	11	160	5515	1168	40
H	2	A	100	8	27	259	3460	620	76
H	2	B	100	7	8	252	4164	511	63
H	2	C	100	4	7	214	4130	542	77
H	3	A	300	11	15	368	4770	689	97
H	3	B	100	8	13	417	3786	547	69

Table 7. (cont'd). Soil analysis results.

Plot[1]	No.	Depth[2]	Soluble Salts	P	SO_4^-	K	Ca	Mg	Na
			- - - - - - - - - - - -			ppm	- - - - - - - - - - - -		
B	1	A	100	13	11	172	1841	560	73
B	1	B	100	10	7	151	1781	622	73
B	1	C	50	8	3	110	1226	541	90
B	2	A	150	13	19	163	1935	538	54
B	2	B	100	5	6	118	1258	496	83
B	2	C	50	8	7	112	861	474	113
B	3	A	100	9	11	163	1763	671	71
B	3	B	100	6	3	105	1238	546	73
B	3	C	0	6	6	47	508	410	69
B	4	A	250	31	18	133	1952	642	101
B	4	B	100	6	7	148	1105	481	102
B	4	C	0	6	7	162	1033	484	59
B	5	A	200	4	15	300	1693	599	29
B	5	B	150	8	0	110	1904	845	92
B	5	C	50	6	7	104	1007	712	151
B	6	A	100	6	11	266	1910	1046	83
B	6	B	100	4	3	155	1546	1077	115
B	6	C	50	5	7	101	971	1101	170
B	7	A	150	10	19	251	1804	556	96
B	7	B	100	13	7	223	1172	496	40
B	7	C	0	6	3	87	736	455	41
B	8	A	100	13	32	161	1958	495	64
B	8	B	100	6	7	170	1448	556	82
B	8	C	50	6	3	144	882	595	89
B	9	A	100	18	15	283	1895	731	80
B	9	B	50	5	3	116	1295	656	81
B	9	C	50	4	7	114	906	766	92
B	10	A	200	15	19	315	2110	541	116
B	10	A	200	6	10	135	2241	511	92
B	10	C	300	8	15	86	3398	886	187
B	11	A	50	5	7	152	1457	456	102
B	11	B	50	6	3	138	869	411	128
B	11	C	0	5	11	102	533	296	101
B	12	B	50	5	45	165	1115	482	58
B	12	C	75	8	15	167	653	367	70
B	13	A	150	10	15	236	1663	552	79
B	13	B	100	1	7	183	1014	389	145
B	13	C	75	6	15	171	1060	290	77
B	14	A	200	8	15	258	1681	526	61
B	14	B	150	8	11	234	1425	428	54
B	14	C	0	185	3	132	688	474	97
B	15	A	200	9	19	272	1888	652	45
B	15	B	75	6	7	168	1603	482	119
B	15	C	0	9	11	148	1364	468	60
B	16	A	100	7	13	112	2308	612	85
B	16	B	100	8	7	157	1264	451	50
B	16	C	0	6	6	91	818	516	86
B	17	A	150	14	19	170	2026	709	96
B	17	B	100	9	15	170	1426	593	159
B	17	C	100	8	3	58	915	540	195
B	18	A	150	9	15	238	1876	733	110
B	18	B	100	8	3	129	1322	558	145
B	18	C	50	6	3	52	786	560	174

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[1] B = Bordeaux, E = L'Esperance, H = Hawksnest plots
[2] A = 0-3 inches, B = 3-8 inches, C = 8-12 inches

Table 8. Soil analysis results for all samples at each depth to determine texture class by partial size analysis for sand(S), silt(Si), and clay (C) content.

Plot[1]	No.	Depth[2]	Texture Class	S	Si	C
				- -	%	- -
E	1	A	SL	67	22	11
E	1	B	SL	64	23	13
E	1	C	L	45	30	25
E	2	A	SL	57	27	16
E	2	B	SL	64	23	13
E	2	C	SL	60	27	13
E	3	A	SL	64	27	9
E	3	B	SL	64	25	11
E	3	C	SL	56	26	18
E	4	A	NP	NP	NP	NP
E	4	B	NP	NP	NP	NP
E	4	C	SL	59	25	16
E	5	A	SL	59	26	15
E	5	B	NP	NP	NP	NP
E	5	C	NP	NP	NP	NP
E	6	A	NP	NP	NP	NP
E	6	B	NP	NP	NP	NP
E	6	C	NP	NP	NP	NP
E	7	A	SL	67	25	8
E	7	B	NP	NP	NP	NP
E	7	C	NP	NP	NP	NP
E	8	A	NP	NP	NP	NP
E	8	B	NP	NP	NP	NP
E	8	C	NP	NP	NP	NP
E	9	A	NP	NP	NP	NP
E	9	B	NP	NP	NP	NP
E	9	C	SL	59	27	14
E	10	A	SL	78	15	7
E	10	C	SCL	53	26	21
E	11	A	NP	NP	NP	NP
E	11	B	NP	NP	NP	NP
E	11	C	SL	67	21	12
E	12	A	SL	72	17	11
E	12	B	SL	61	18	21
H	1	A	NP	NP	NP	NP
H	1	B	SL	47	22	31
H	1	C	NP	NP	NP	NP
H	2	A	SL	67	19	14
H	2	B	SL	63	23	14
H	2	C	SL	61	21	18
H	3	A	NP	NP	NP	NP
H	3	B	SL	67	25	8

Table 8. (cont'd). Soil analysis results.

Plot[1]	No.	Depth[2]	Texture Class	S	Si	C
				- -	%	- -
B	1	A	SL	72	18	10
B	1	B	SL	70	24	6
B	1	C	SL	57	30	13
B	2	A	SL	72	24	4
B	2	B	SL	61	25	14
B	2	C	SL	55	28	17
B	3	A	SL	64	24	12
B	3	B	SL	59	25	16
B	3	C	SL	47	25	28
B	4	A	SL	73	16	11
B	4	B	SL	60	22	18
B	4	C	SL	61	24	15
B	5	A	SL	74	21	5
B	5	B	SL	49	28	23
B	5	C	L	48	32	20
B	6	A	SL	71	19	10
B	6	B	SL	65	23	12
B	6	C	L	50	30	20
B	7	A	SL	72	22	6
B	7	B	SL	67	18	15
B	7	C	SL	59	23	18
B	8	A	SL	66	23	11
B	8	B	SL	64	24	12
B	8	C	SL	56	26	18
B	9	A	SL	62	28	10
B	9	B	SL	68	18	14
B	9	C	SL	57	24	19
B	10	A	SL	71	24	5
B	10	A	SL	69	25	6
B	10	C	L	47	32	21
B	11	A	SL	57	26	17
B	11	B	SL	66	25	9
B	11	C	SCL	49	25	26
B	12	B	SL	75	14	11
B	12	C	SL	67	16	17
B	13	A	SL	70	23	7
B	13	B	SL	77	13	10
B	13	C	SL	67	18	15
B	14	A	SL	69	23	8
B	14	B	SL	59	29	12
B	14	C	SL	62	25	13
B	15	A	SL	79	16	5
B	15	B	SL	65	23	12
B	15	C	SL	68	25	7
B	16	A	SL	61	26	13
B	16	B	SL	66	27	7
B	16	C	SL	57	28	15
B	17	A	SL	72	18	10
B	17	B	SL	67	24	9
B	17	C	SL	61	27	12
B	18	A	SL	66	26	8
B	18	B	SL	59	30	11
B	18	C	L	46	36	18

[1] B = Bordeaux, E = L'Esperance, H = Hawksnest plots

[2] A = 0-3 inches, B = 3-8 inches, C = 8-12 inches

APPENDIX III. Bordeaux Plot: Test Results in Relation to Sampling Sites.

Tests:

- pH
- Organic Matter, Percent
- Soluble Salt Content, ppm
- Phosphorus, ppm
- Potassium, ppm
- Calcium, ppm
- Magnesium, ppm
- Sulfate, ppm
- Zinc, ppm
- Iron, ppm
- Copper, ppm
- Manganese, ppm
- Sodium, ppm
- Texture

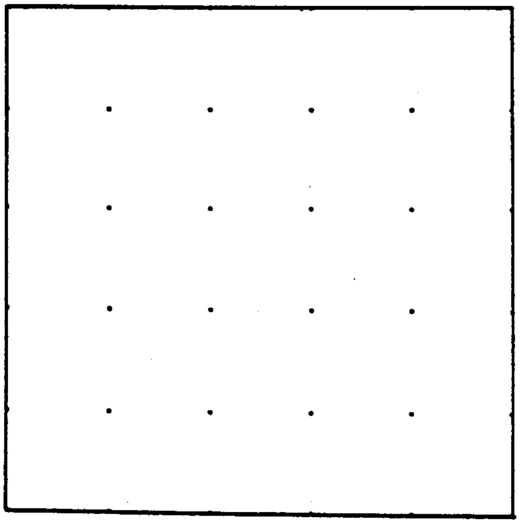
PLOT: BORDEAUX

TEST: pH

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = below 6.00, m = 6.00 - 7.00, h = 7.01 +

A	B	C
5.93	5.20	4.91
	5.41	5.28
5.33	5.54	5.66
6.11^{m}	6.24^{m}	6.89^{m}
5.79	5.59	5.59
6.16^{m}	5.35	5.32



A	B	C
6.23^{m}	6.69^{m}	5.65
6.74^{m}	5.84	5.66
6.14^{m}	5.69	5.51
5.57	5.54	5.48
5.89	6.18^{m}	5.68
5.54	5.28	5.68

A	5.65	6.03^{m}	6.67^{m}	5.90	5.58	5.57
B	5.55	5.68	6.52^{m}	4.92	5.25	5.27
C	5.75	5.61	5.58	5.08	5.16	5.40

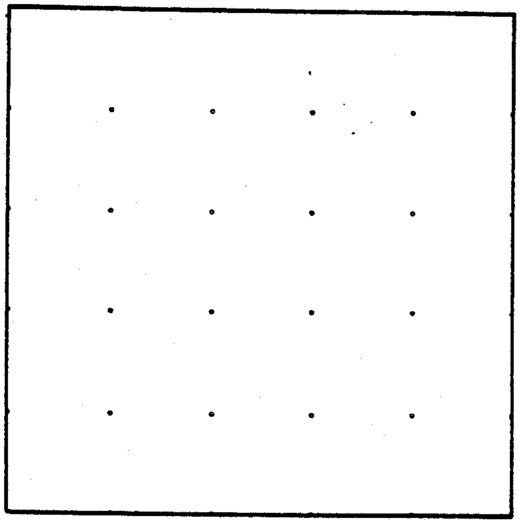
PLOT: BORDEAUX

TEST: ORGANIC MATTER, PERCENT

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
5.5^h	7.1^h	6.8^h
	5.4^h	3.3^m
6.0^h	3.6^m	3.2^m
10.2^h	7.6^h	5.8^h
7.8^h	5.7^h	4.5^m
5.4^h	4.8^m	2.8



A	B	C
6.8^h	4.0^m	2.2
6.2^h	5.2^h	2.8
7.6^h	4.8^m	6.4^h
6.7^h	8.2^h	4.5^m
8.7^h	6.2^h	4.4^m
7.7^h	6.2^h	6.0^h

A	7.3^h	9.7^h	5.3^h	9.5^h	7.3^h	7.3^h
B	7.7^h	4.8^m	4.5^m	5.3^h	9.0^h	6.5^h
C	4.4^m	4.5^m	3.0^m	3.6^m	4.4^m	4.5^m

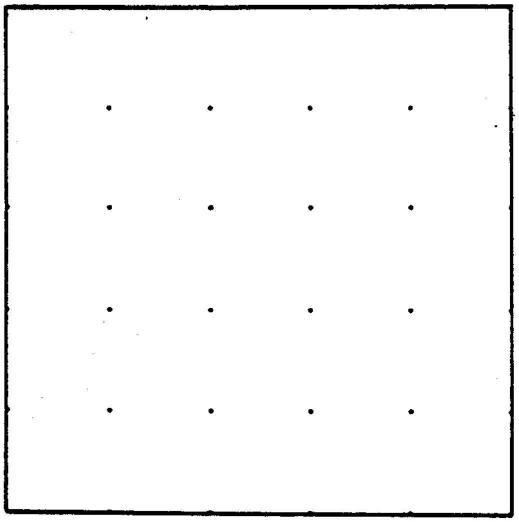
PLOT: BORDEAUX

TEST: SOLUBLE SALT CONTENT, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
150	100	75
	50	75
50	50	0
200	200	300
100	50	0
100	100	50



A	B	C
200	150	0
200	75	0
100	100	0
150	100	100
150	100	50
100	100	50

A	150	100	250	250	100	150
B	100	100	150	100	100	100
C	0	50	50	0	0	50

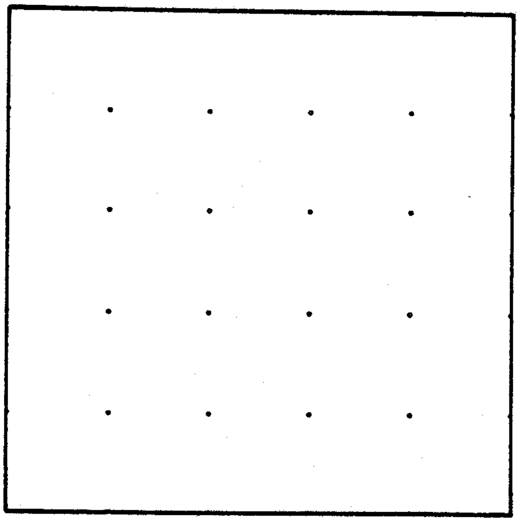
PLOT: BORDEAUX

TEST: AVAILABLE PHOSPHORUS, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
10	1	6
	5	8
5	6	5
15	6	8
18	5	4
13	6	6



A	B	C
8	8	185^h
9	6	9
7	8	6
14	9	8
9	8	6
13	10	8

A	10	6	4	31	9	13
B	13	4	8	6	6	5
C	6	5	6	6	6	8

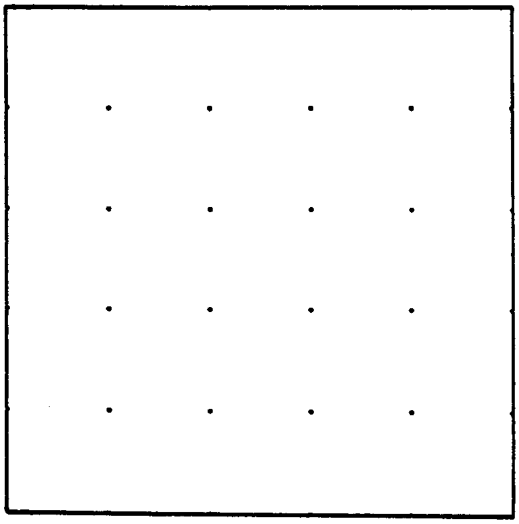
PLOT: BORDEAUX

TEST: AVAILABLE POTASSIUM, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
236^{m}	183^{m}	170^{m}
	165^{m}	167^{m}
152^{m}	138	102
315^{h}	135	86
283^{m}	116	114
161^{m}	170^{m}	144



A	B	C
258^{m}	234^{m}	132
272^{m}	168^{m}	148
112	157^{m}	91
170^{m}	170^{m}	58
238^{m}	129	52
172^{m}	151^{m}	110

A	251^{m}	266^{m}	300^{h}	133	163^{m}	163^{m}
B	223^{m}	155^{m}	110	148	105	118
C	87	101	104	162^{m}	47	112

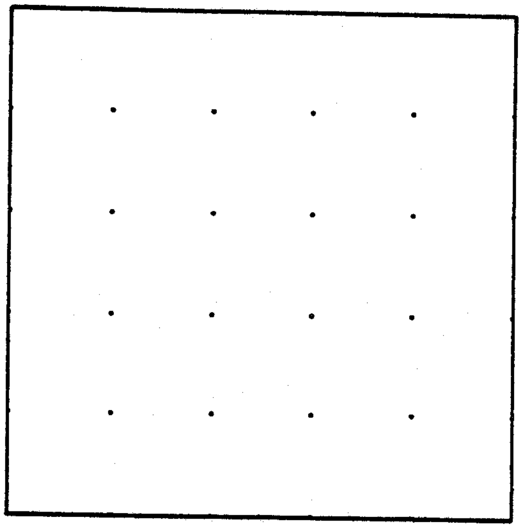
PLOT: BORDEAUX

TEST: AVAILABLE CALCIUM, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
1663	1014	1060
	1115	653
1457	869	533
2110	2241	3398
1896	1295	906
1958	1448	882



A	B	C
1681	1425	688
1888	1603	1364
2308	1264	818
2026	1426	915
1876	1322	786
1841	1781	1226

A	1804	1910	1693	1952	1763	1935
B	1172	1546	1904	1105	1238	1258
C	736	971	1007	1033	508	861

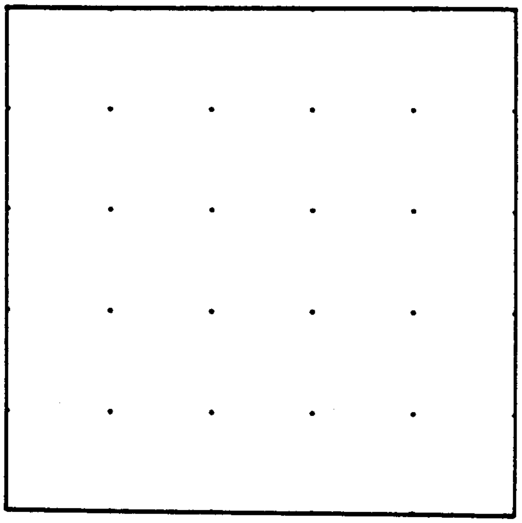
PLOT: BORDEAUX

TEST: AVAILABLE MAGNESIUM, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
552	389	290
	482	367
456	411	296
541	511	866
731	656	766
495	556	595



A	B	C
526	428	474
652	482	468
612	451	516
709	593	540
733	558	560
560	622	541

A	556	1046	599	642	671	538
B	496	1077	845	481	546	496
C	455	1101	712	484	410	474

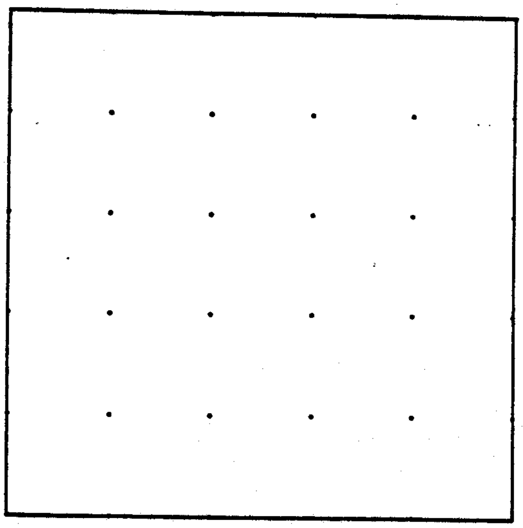
PLOT: BORDEAUX

TEST: AVAILABLE ZINC, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
7.1	4.8	2.5
	7.3	5.9
2.9	2.8	1.5
4.8	6.2	5.4
2.4	2.1	1.4
8.9	10.1	7.8



A	B	C
4.4	4.9	3.3
2.9	4.1	5.5
6.1	4.3	3.7
8.7	6.5	5.0
10.3	10.2	5.4
8.8	16.5	11.8

A	8.0	8.2	7.9	20.9^{m}	11.0	8.0
B	9.1	10.7	11.1	13.1	11.2	8.5
C	6.7	7.5	8.8	7.8	5.8	6.4

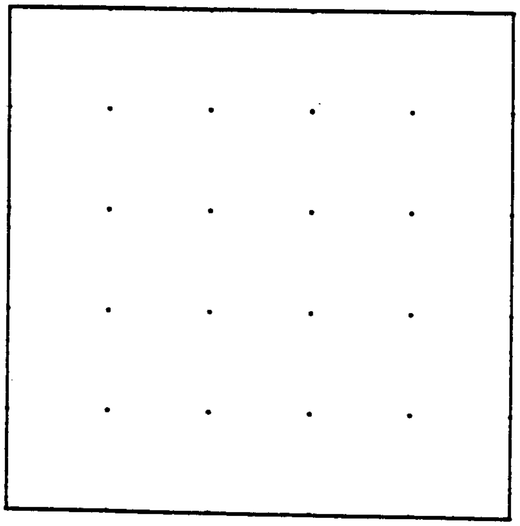
PLOT: BORDEAUX

TEST: AVAILABLE IRON, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
446.5^h	107.2	1348.0^h
	1478.0^h	1380.0^h
534.0^h	800.0^h	857.0^h
54.7	325.0^m	530.0^h
61.1	401.0^h	309.0^m
47.3	494.0^h	1051.0^h



A	B	C
63.9	85.7	465.0^h
57.1	105.8	488.0^h
49.5	542.5^h	494.0^h
67.5	685.3^h	596.4^h
86.7	599.2^h	602.5^h
63.5	436.5^h	649.6^h

A	98.2	92.0	54.4	36.1	582.4^h	90.9
B	743.4^h	503.0^h	58.9	456.0^h	992.0^h	675.0^h
C	1122.0^h	494.5^h	473.0^h	1047.0^h	956.0^h	660.0^h

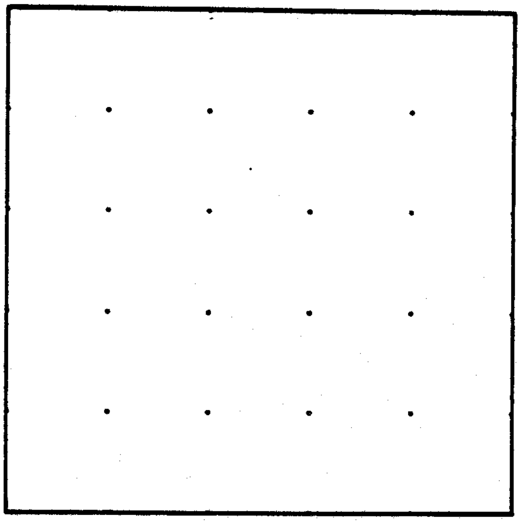
PLOT: BORDEAUX

TEST: AVAILABLE COPPER, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
4.2	9.4	8.3
	12.2^m	13.1^m
8.7	15.4^m	14.7^m
1.7	3.8	6.1
1.4	2.3	1.7
3.5	6.8	7.5



A	B	C
1.5	5.2	2.1
1.5	1.0	4.8
2.5	2.6	1.2
1.1	1.5	1.1
1.4	2.2	2.8
0.8	1.6	1.6

A	2.6	1.7	3.5	1.7	4.7	1.0
B	5.5	3.4	8.0	5.7	12.5^m	1.8
C	7.9	4.9	10.0^m	6.9	13.6^m	2.1

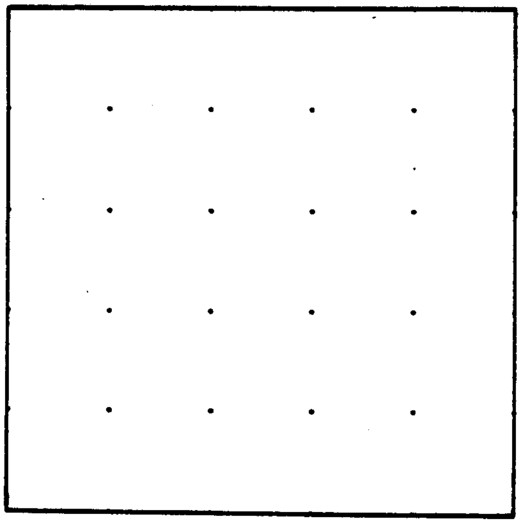
PLOT: BORDEAUX

TEST: AVAILABLE MANGANESE, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
26.7	26.1	21.0
	24.1	24.6
19.8	13.7	7.8
31.0	16.1	18.4
31.8	12.7	9.8
9.1	9.6	8.7



A	B	C
8.8	10.6	10.1
8.4	5.9	13.1
9.4	17.0	13.3
34.6	67.5	43.7
29.2	24.7	17.4
23.0	30.4	30.6

A	17.9	11.5	8.1	42.7	25.4	32.3
B	12.8	13.1	3.8	34.7	20.1	24.1
C	13.3	9.7	18.6	21.3	10.5	13.2

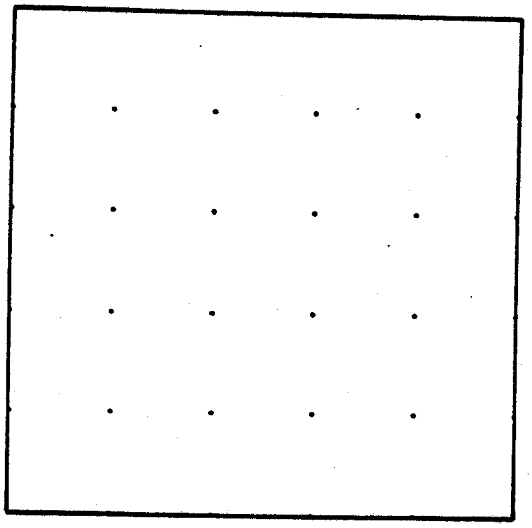
PLOT: BORDEAUX

TEST: AVAILABLE SULFATE, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

Superscript: none = low, m = medium, h = high

A	B	C
15	7	15
	45	15
7	3	11
19	10	15
15	3	7
32	7	3



A	B	C
15	11	3
19	7	11
13	7	6
19	15	3
15	3	3
11	7	3

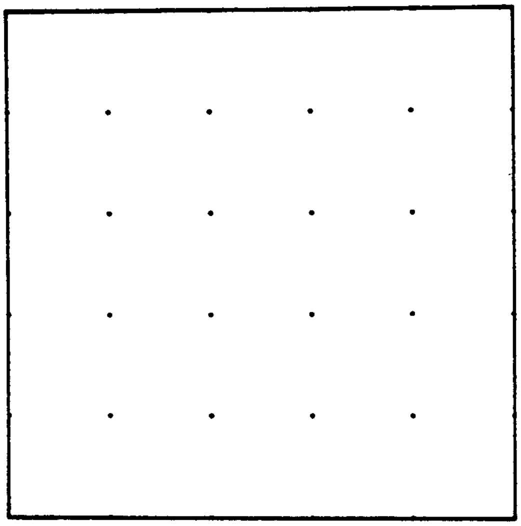
A	19	11	15	18	11	19
B	7	3	0	7	3	6
C	3	7	7	7	6	7

PLOT: BORDEAUX

TEST: SODIUM, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

A	B	C
79	145	77
	58	70
102	128	101
116	92	187
80	81	92
64	82	89



A	B	C
61	54	97
45	119	60
85	50	86
96	159	195
110	145	174
73	73	90

A	96	83	29	101	71	54
B	40	115	92	102	73	83
C	41	170	150	59	69	113

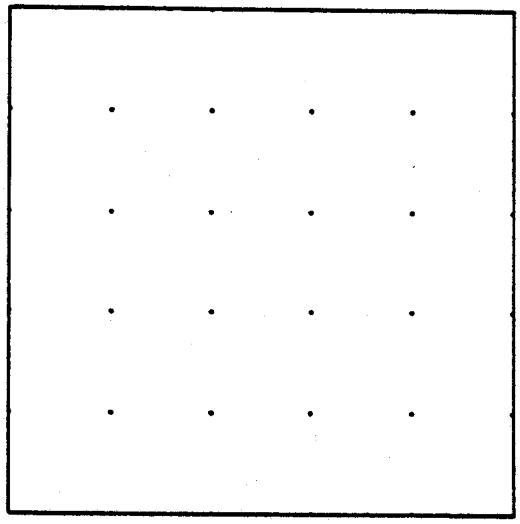
PLOT: BORDEAUX

TEST: TEXTURE CLASS

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES

SL = SANDY LOAM, SCL = SANDY CLAY LOAM, L = LOAM

A	B	C
SL	SL	SL
	SL	SL
SL	SL	SCL
SL	SL	L
SL	SL	SL
SL	SL	SL



A	B	C
SL	SL	SL
SL	SL	SL
SL	SL	SL
SL	SL	SL
SL	SL	L
SL	SL	SL

A	SL	SL	SL	SL	SL	SL
B	SL	SL	SL	SL	SL	SL
C	SL	L	L	SL	SL	SL

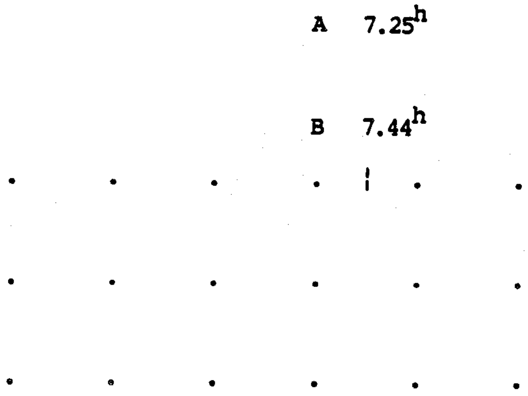
APPENDIX IV. Hawksnest Plot: Test Results in Relation to Sampling Sites.

Tests:

- pH
- Organic Matter, Percent
- Soluble Salt Content, ppm
- Phosphorus, ppm
- Potassium, ppm
- Calcium, ppm
- Magnesium, ppm
- Sulfate, ppm
- Zinc, ppm
- Iron, ppm
- Copper, ppm
- Manganese, ppm
- Sodium, ppm
- Texture

PLOT: HAWKSNEST
TEST: pH

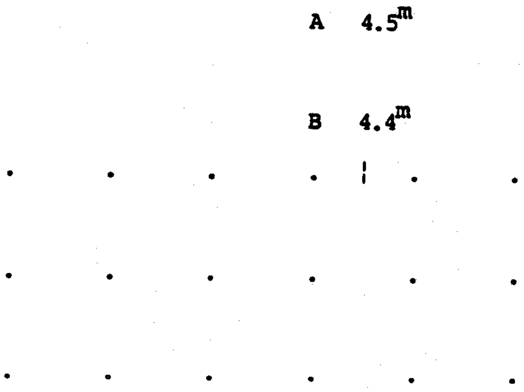
A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = below 6.00, m = 6.00 - 7.00, h = 7.01 +



A	B	C
7.06^h	7.27^h	7.31^h
7.08^h	6.56^h	7.01^h

PLOT: HAWKSNEST
TEST: ORGANIC MATTER, PERCENT

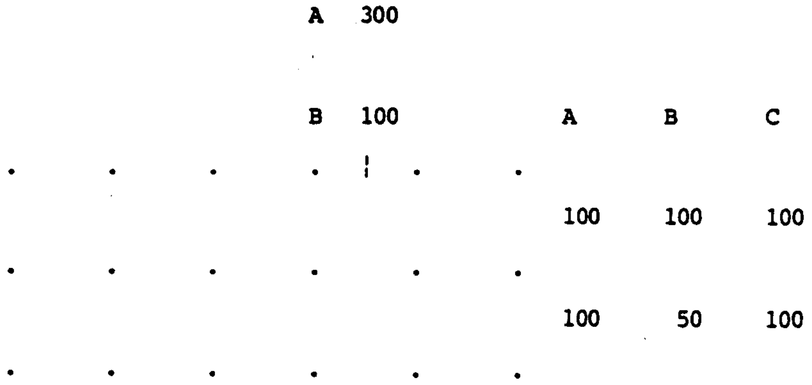
A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high



A	B	C
5.0^h	2.8	4.7^m
5.0^h	5.7^h	4.5^m

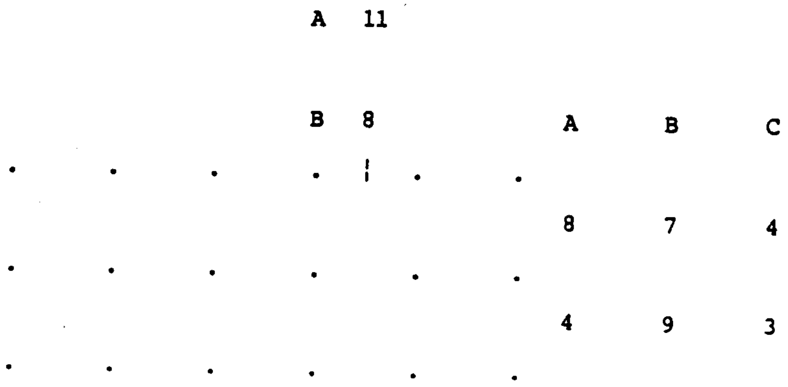
PLOT: HAWKSNEST
TEST: SOLUBLE SALT CONTENT, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high



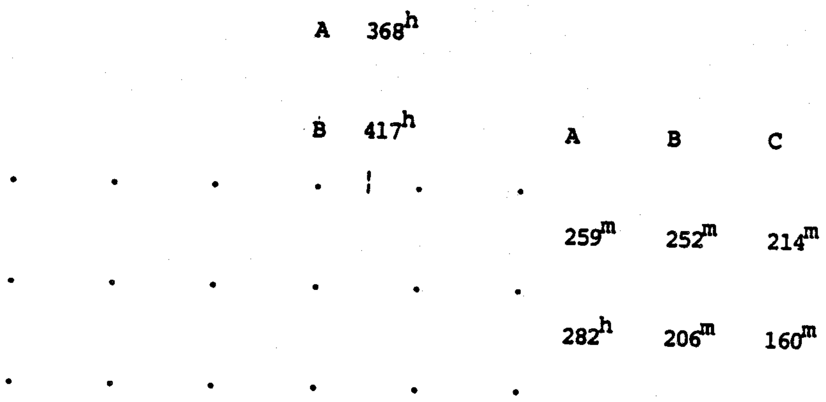
PLOT: HAWKSNEST
TEST: AVAILABLE PHOSPHORUS, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high



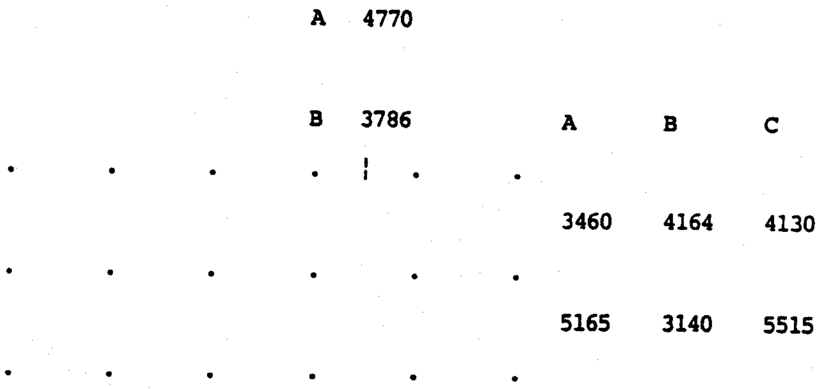
PLOT: HAWKSNEST
TEST: AVAILABLE POTASSIUM, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high



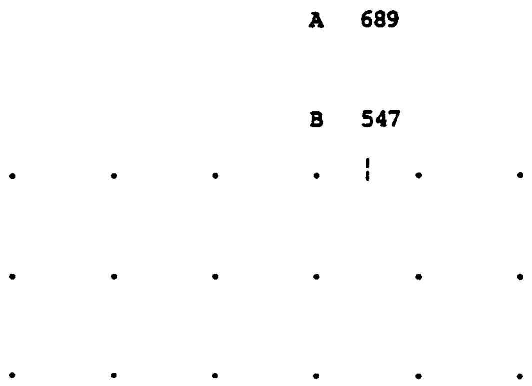
PLOT: HAWKSNEST
TEST: AVALIABLE CALCIUM, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high



PLOT: HAWKSNEST
TEST: AVAILABLE MAGNESIUM, ppm

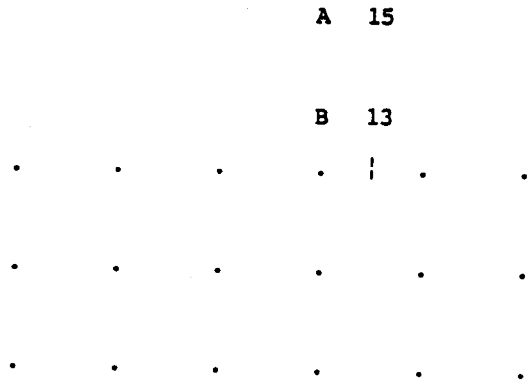
A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high



A	B	C
620	511	542
1059	860	1168

PLOT: HAWKSNEST
TEST: AVAILABLE SULFATE, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high



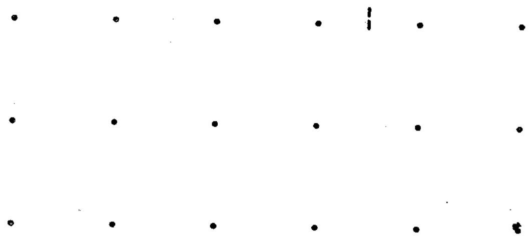
A	B	C
27	8	7
6	6	11

PLOT: HAWKSNEST
TEST: AVAILABLE ZINC, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

A 1.3

B 0.7



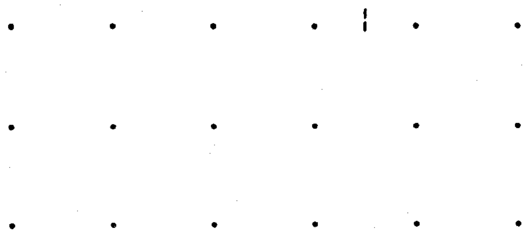
A	B	C
0.8	0.5	0.7
1.7	0.4	1.7

PLOT: HAWKSNEST
TEST: AVAILABLE IRON, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

A 26.4

B 15.0



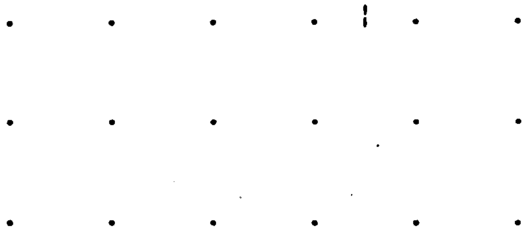
A	B	C
29.5	9.8	12.6
34.8	19.7	28.4

PLOT: HAWKSNEST
TEST: AVAILABLE COPPER, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

A 2.6

B 1.8



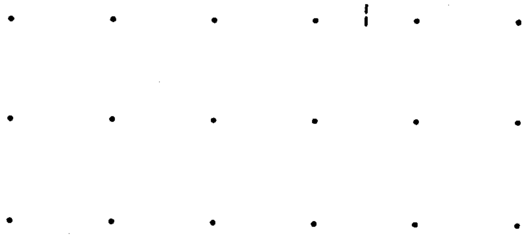
A	B	C
2.6	2.5	2.3
3.7	3.8	5.4

PLOT: HAWKSNEST
TEST: AVAILABLE MANGANESE, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

A 11.9

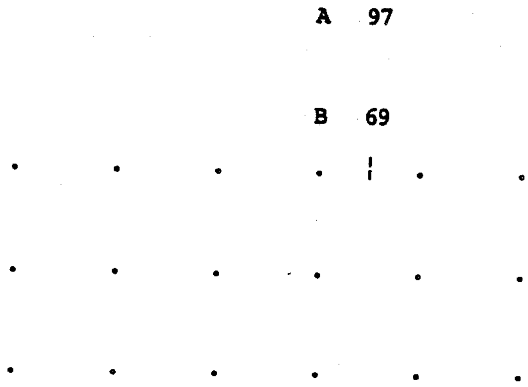
B 4.4



A	B	C
5.0	2.7	0.9
4.4	0.9	4.2

PLOT: HAWKSNEST
TEST: SODIUM, ppm

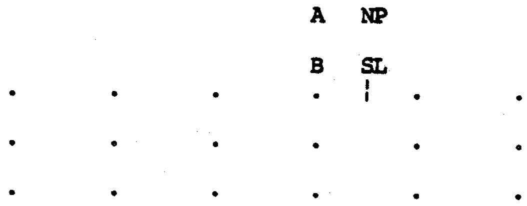
A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high



A	B	C
76	63	77
90	98	40

PLOT: HAWKSNEST
TEST: TEXTURE CLASS

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
SL = SANDY LOAM, NP = NOT PERFORMED DUE TO MINIMAL SAMPLE



A	B	C
SL	SL	SL
NP	SL	NP

APPENDIX V. L'Esperance Plot: Test Results in Relation to Sampling Sites.

Tests:

- pH
- Organic Matter, Percent
- Soluble Salt Content, ppm
- Phosphorus, ppm
- Potassium, ppm
- Calcium, ppm
- Magnesium, ppm
- Sulfate, ppm
- Zinc, ppm
- Iron, ppm
- Copper, ppm
- Manganese, ppm
- Sodium, ppm
- Texture

PLOT: L'ESPERANCE
TEST: pH

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = below 6.00, m = 6.00 - 7.00, h = 7.01 +

						A	7.44					
						B	6.39					
A	B	C								A	B	C
				.	.	.	.	.	.	6.47	5.64	5.16
6.98	6.82	6.14		.	.	.	.	.	.	6.44	6.29	5.81
7.48		6.23		.	.	.	.	.	.	6.46	5.79	5.93
			A	7.00	7.28	6.73	6.73	6.80	6.62			
			B	6.35	6.80	6.16	6.67	6.82	6.22			
			C	6.17	6.44	6.02	6.97	6.69	6.69			

PLOT: L'ESPERANCE
TEST: SOLUBLE SALT CONTENT, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

						A	500					
						B	100					
A	B	C								A	B	C
				.	.	. ¦	.	.	.	125	50	0
200	100	0		.	.	.	.	.	.	100	100	0
300		50		.	.	.	.	.	.	100	50	0
			A	150	300	100	150	100	100			
			B	50	150	0	50	100	50			
			C	0	50	100	0	100	0			

PLOT: L'ESPERANCE
TEST: ORGANIC MATTER, PERCENT

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

					A	3.5					
					B	6.0					
A	B	C							A	B	C
			.	.	.	.	.	.	4.5	3.7	4.4
7.3	5.3	4.2	.	.	.	.	.	.	6.7	4.8	3.2
9.7		5.7	.	.	.	.	.	.	6.5	4.8	2.1
		A	6.0	6.5	3.5	7.3	6.9	6.5			
		B	3.0	5.2	5.5	5.2	4.0	2.6			
		C	3.2	2.7	1.9	3.3	2.6	4.8			

PLOT: L'ESPERANCE
TEST: AVAILABLE PHOSPHORUS, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

						A	7						
						B	10						
A	B	C									A	B	C
				.	.	.	¦	.	.	.	8	4	4
10	5	4		.	.	.		.	.	.	8	8	4
14		4		.	.	.		.	.	.	8	5	4
			A	8	11	11		7	11	8			
			B	5	5	8		5	4	5			
			C	7	3	5		7	4	8			

PLOT: L'ESPERANCE
TEST: AVAILABLE POTASSIUM, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

A 120

B 170

A	B	C							A	B	C
			.	.	.	.	.	.	297	278	160
357	229	124	.	.	.	.	.	.	299	165	178
246		109	.	.	.	.	.	.	312	215	169
		A	222	254	173	148	173	259			
		B	165	182	85	119	131	175			
		C	140	79	55	114	99	146			

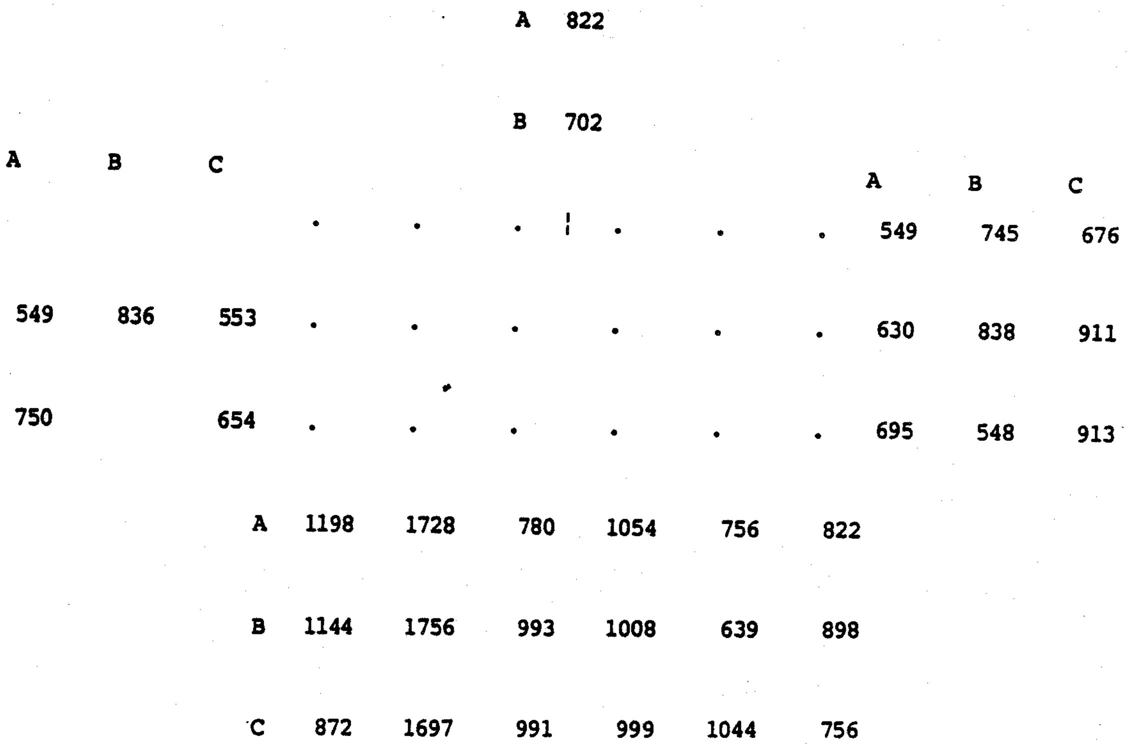
PLOT: L'ESPERANCE
TEST: AVAILABLE CALCIUM, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

						A	1711							
						B	2198							
A	B	C										A	B	C
				.	.	.	¦	.	.	.	.	1672	1895	1721
4920	6105	3984		.	.	.		.		.	.	1929	2198	2166
3090		3516		.	.	.		.		.	.	2704	1778	2096
			A	4360	1875	2314		2217		2378	2176			
			B	2077	4375	1377		1798		2090	2066			
			C	2214	2013	1205		1764		2123	2402			

PLOT: L'ESPERANCE
TEST: AVAILABLE MAGNESIUM, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high



PLOT: L'ESPERANCE
TEST: AVAILABLE SULFATE, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

						A	3						
						B	6						
A	B	C									A	B	C
				.	.	.		.	.	.	19	7	15
11	15	8		.	.	.		.	.	.	11	6	11
21		13		.	.	.		.	.	.	11	7	11
			A	8	6	8		11	6	11			
			B	6	11	15		6	6	3			
			C	0	8	6		6	6	3			

PLOT: L'ESPERANCE
TEST: AVAILABLE ZINC, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

					A	1.0					
					B	2.2					
A	B	C							A	B	C
			.	.	. ¦	.	.	.	1.5	6.0	1.2
1.4	1.8	0.9	.	.	.	.	.	.	1.2	0.8	7.0
1.3		0.5	.	.	.	.	.	.	1.1	1.9	0.7
		A	1.8	0.7	1.3	1.6	1.1	1.8			
		B	1.0	0.5	2.4	3.4	0.5	0.8			
		C	0.8	0.8	1.0	0.9	1.0	0.9			

PLOT: L'ESPERANCE
TEST: AVAILABLE IRON, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

						A	25.5					
						B	80.4					
A	B	C								A	B	C
				.	.	. ¦	.	.	.	108.1	287.0	695.1
19.7	25.8	18.1		.	.	.	.	.	.	76.8	36.3	75.4
12.0		25.9		.	.	.	.	.	.	43.1	323.0	95.2
			A	48.9	36.0	48.0	41.5	30.6	54.7			
			B	67.5	29.4	107.4	62.8	64.4	67.5			
			C	71.7	69.1	174.2	61.8	65.1	58.8			

PLOT: L'ESPERANCE
TEST: AVAILABLE COPPER, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

						A	5.3					
						B	4.6					
A	B	C								A	B	C
				.	.	.	.	.	.	5.3	7.8	10.5
2.6	4.4	3.8		.	.	.	.	.	.	5.3	5.1	5.9
0.9		1.8		.	.	.	.	.	.	3.1	6.3	7.1
			A	3.1	2.6	3.8	3.4	1.8	3.5			
			B	6.1	3.1	5.6	5.2	6.8	5.7			
			C	7.1	4.6	6.3	4.7	5.7	5.9			

PLOT: L'ESPERANCE
TEST: AVAILABLE MANGANESE, ppm

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
Superscript: none = low, m = medium, h = high

						A	3.7						
						B	3.1						
A	B	C									A	B	C
				.	.	.	¦	.	.	.	9.5	8.8	10.1
6.5	3.1	1.2		.	.	.		.	.	.	8.6	5.3	6.1
5.2		0.6		.	.	.		.	.	.	6.0	9.8	11.9
			A	7.5	6.6	6.5		5.4	3.9	11.2			
			B	7.5	3.8	5.8		6.9	8.2	4.5			
			C	3.8	5.6	5.6		5.8	7.3	3.2			

PLOT: L'ESPERANCE
TEST: TEXTURE CLASS

A = 0-3 INCHES, B = 3-8 INCHES, C = 8-12 INCHES
SL = SANDY LOAM, SCL = SANDY CLAY LOAM, L = LOAM

					A	SL					
					B	SL					
A	B	C							A	B	C
			.	.	.	.	.	.	SL	SL	L
		SL	.	.	.	.	.	.	SL	SL	SL
SL		SCL	.	.	.	.	.	.	SL	SL	SL
		A	NP	NP	SL	NP	SL	NP			
		B	NP	NP	NP	NP	NP	NP			
		C	SL	NP	NP	NP	NP	SL			